

PERCEPTIONS OF TECHNOLOGY EDUCATION

A CROSS-CASE STUDY OF TEACHERS
REALISING TECHNOLOGY AS A NEW SUBJECT OF TEACHING

Berit Bungum

Thesis submitted in partial fulfilment for the degree
Doctor Scientiarum

NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
Faculty of Science and Technology, Department of Physics

2003

PREFACE AND ACKNOWLEDGEMENTS

This thesis is the material result of a doctoral study conducted at Department of Physics at the Norwegian University of Science and Technology in the period 1999-2003. I am grateful for the trust and interest the department has shown in giving me the opportunity and grants for working with a project on education quite atypical from the usual affairs of a Physics department.

The study has been carried out under the supervision of Dr. Per Morten Kind. I thank him for having introduced me to the field of science education, for his enthusiasm and friendship, for our good discussions and for allowing me to grow through my work. Per Morten's patience, which has been enormous at times when my frustration in fact has turned into aggression, has been of crucial importance during the entire process and is highly appreciated.

I am also indebted to the Research Council of Norway for kind financial support that made it possible for me to attend NITO's course on technology teaching at the College of Ripon and York, St. John in 1999. This facilitated a fruitful commencement of my research project.

Although doing a doctoral study is in essence a lonely process, it cannot be undertaken in a vacuum. During my four years as a doctoral student I have enjoyed getting to know and gradually becoming part of a growing research community of science education in Norway as well as internationally. In this regard I warmly thank the staff and students at Department of Teacher Education and School Development (ILS) at the University of Oslo for always welcoming me and for having provided me with courses, new contacts, new concepts and invaluable coffee breaks.

In 2001 I was granted a Marie Curie Fellowship from the European Union (despite the fact that I am not a member of that union!). This involved a seven months stay at the Marie Curie training site at the Centre for Studies in Science and Mathematics Education, University of Leeds, where I had the pleasure of working with Dr. Jim Donnelly as my supervisor. I am grateful for having been given the privilege to work in this vibrant research community of science education, and for the hospitality I enjoyed from all members of the centre. In particular, I thank Jim for his support, commitment and eagerness in reading and guiding my work, for having pointed me to new sources of knowledge and inquiry and for having taught me about the significance of language. His contribution has been fundamental in enabling me to

complete this thesis. I also thank my fellow doctoral students in Leeds for stimulating and supportive fellowship and for all the fun we had. Keep in touch!

Besides the supervision I have received from Per Morten and Jim, my work has also benefited from comments and suggestions from other people, who have kindly read and commented upon drafts of chapters. Those are (in the order of appearance): Rolf V. Olsen, Professor Doris Jorde, Astrid B. Eggen, Professor Emeritus Edgar W. Jenkins, Professor Emeritus David Layton, Guðrún Jónsdóttir and finally my cousin Brita Bungum. Stubborn as I am, I haven't always followed their advice, but their comments and suggestions have broadened my perspective and deepened my understanding of what I am doing. I am especially grateful to Doris Jorde who has, with her usual enthusiasm, done the considerable job of reading the entire product in the final phase, pointing to weaknesses in language as well as in logic and adding s's to verbs. I also thank Doris for our excellent co-operation in a different project running parallel to the one manifested in this thesis, for her cheerful and encouraging phone calls and for keeping me going whenever the going gets tough.

I also owe much to my parents Sigrid and Ivar. Their support and practical help have been very important to me in the process of doing a doctoral degree. I thank them for their care and their never-ending patience with a daughter who cannot stop educating herself, and for having taught me early on that putting effort into a job makes the job more enjoyable.

Finally, I wish to express my gratitude to the teachers who kindly have contributed to this study. The study, as well as the development of technology in Norwegian schools, relies on their enthusiasm and will to share.

When attending the 5th European Science Education Summerschool for doctoral students in Gilleleje September 2000, I had the pleasure of listening to a lecture given by Søren and Søren (Kruse & Dragsted 2000). They gave us useful advice on how to deal with all kinds of problems and dilemmas one encounters in "living life as a PhD student in Science Education". Their final and most important advice, however, was formulated as "*Enjoy your project!*". I am proud to say that I certainly did.

Trondheim, June 2003,
Berit Bungum

CONTENTS

CHAPTER 1	
INTRODUCTION AND OVERVIEW OF THE THESIS	1
PART I. CONCEPTUAL FRAMEWORK	5
CHAPTER 2	
TECHNOLOGY	5
Meanings of technology	5
Technological knowledge.....	8
Relationships between science and technology	9
Technology as a cultural and societal force.....	13
CHAPTER 3	
GATEWAYS TO TECHNOLOGY EDUCATION	16
Fundamentals of a school subject	17
The structure of a discipline	18
Classification, framing and educational knowledge codes.....	20
Some fundamental tensions in formation of curriculum	21
A framework of curriculum design models.....	23
Political perspectives: Arguments and stakeholders for technology education....	27
Approaches to technology teaching in schools.....	32
Design & Technology in England and Wales.....	32
Technology in a Science framework.....	39
STS – Science, Technology and Society.....	41
Technology from craft	43
Technology from traditions of vocational training	44
Final remarks – what counts as technology education?	45
CHAPTER 4	
PERSPECTIVES ON TEACHERS AND REALISATION OF CURRICULUM	46
Teachers as curriculum creators.....	46
Aspects of teachers’ professionalism	48
Teachers’ professional autonomy	48
Teachers’ professional knowledge.....	51
Teachers’ beliefs and professional frames.....	53
PART II. CONTEXTUAL FRAMEWORK	56
CHAPTER 5	
TECHNOLOGY IN THE CURRICULUM FOR COMPULSORY EDUCATION	
IN NORWAY	56
The structure of the curriculum.....	57

Technology within the general parts of the curriculum.....	58
The Creative human being	59
The Working human being.....	60
The Environmentally-aware human being	61
Principles for teaching	62
Technology in the specifications for subjects.....	63
Technology in the Science curriculum.....	64
Technology in the Social Studies curriculum.....	68
‘Technology’ in the Art and Crafts curriculum	69
Interdisciplinarity, project work and optional subjects in L97	70
Concluding remarks	72

CHAPTER 6

THE TiS PROJECT ON TECHNOLOGY TEACHING	74
Background of the TiS project.....	75
Aims of the TiS project	76
Implementation of the TiS project	78

PART III. THE EMPIRICAL STUDY 81

CHAPTER 7

THE EMPIRICAL STUDY: RESEARCH DESIGN AND METHODS	81
Design of the study	81
Collecting data	83
Interviews.....	83
Observations.....	86
Data analysis.....	87
Transcribing and managing data.....	87
Data display and coding.....	87
Analysis within and across cases.....	88
The significance of multiple sources of evidence.....	89
Presenting results	90
Presenting results through stories	91
Principles for presenting quotations.....	92
Modifications of data material for presentation.....	94
Presenting results to informants	96

CHAPTER 8

THE PROJECT IN SCHOOLS. ITS REALISATION AND MEANING.....	97
Organisational aspects of realisation.....	97
The meaning of the TiS project for teachers.....	98
The TiS project as an activity account?	98
<i>FIRST STORY. ANN’S BUGGY PROJECT</i>	105
<i>SECOND STORY. BENNY’S BUGGY PROJECT</i>	110
Same activity – different content.....	115

CHAPTER 9

TEACHERS' AIMS FOR TECHNOLOGY TEACHING	117
Departing from the economic argument: Pointing pupils to technology.....	118
Exposing the joy of technology	118
Opening doors to technological careers	120
Proceeding beyond the arguments	122
'Making school more practical'	125
Improving the teaching context: 'Practical' as opposed to textbooks	126
Building experiences	128
Introducing pupils to the technologist's knowledge	130
<i>THIRD STORY. 'THE PUPIL AS TECHNOLOGIST'</i>	131
Familiarising pupils with technological surroundings	137
Extending the horizon of registration.....	137
Humanising technology	139
Engaging with technology: Building pupils' confidence	141
Knowledge about industry and production.....	144
Critical consumerism: Sustaining environmental awareness.....	147
How things work: Understanding everyday technology	149
<i>FOURTH STORY. TEACHING TECHNOLOGICAL PRINCIPLES</i>	154
Cultivating the pupil.....	157
The pupil as a creator: Nurturing pupils' pride and self-esteem	158
Fostering the pupil's agenda.....	161
Maintaining general educational goals.....	165
Summary and concluding remarks.....	167

CHAPTER 10

FRAMING THE SUBJECT	170
What does 'technology' embrace?	171
Framing technology towards existing subjects	175
Art and Crafts.....	175
Social Studies.....	177
Science.....	178
Conceptions of design	179
Technology as a process.....	181
<i>FIFTH STORY. A SWEET INTRODUCTION TO TECHNOLOGY</i>	182
Broadening the technology concept.....	189
Perceptions of a design process.....	193
Technology teaching as a working method.....	195
Technology as interdisciplinary teaching	197
Technology – not essentially a new subject?.....	197
Covering the curriculum through interdisciplinary teaching.....	201
'Much inter and little discipline'; Problems with interdisciplinary project work... ..	204
Technology teaching as a catalyst	206
Summary and concluding remarks.....	208

CHAPTER 11	
RELATING TECHNOLOGY TEACHING TO SCIENCE	210
Associating technology with science	212
Meanings of technology as ‘supporting Science’	213
<i>SIXTH STORY. REVITALISING SCIENCE TEACHING.....</i>	<i>214</i>
Broadening the scope of school science.....	224
Technology as learning opportunities.....	224
Technology as application opportunities.....	229
Summary: Technology as response to limitations of school science	232
Positioning technology with regards to school science	234
A relationship between science and technology? Teachers’ perceptions as educationally situated.....	238
Summary and concluding remarks.....	245
CHAPTER 12	
RECONSTRUCTING EDUCATION	247
<i>SEVENTH STORY. TECHNOLOGY AS ‘DIFFERENT’</i>	<i>247</i>
Fighting ‘the grammar of schooling’	257
CHAPTER 13	
FINAL DISCUSSION AND CONCLUSIONS	266
Teachers’ perception and realisation of technology as a subject of teaching..	266
What is technology teaching <i>for</i> ?	266
What is technology teaching <i>about</i> ?	268
“‘We teach children – not subjects!’”	270
Rehabilitating the practical pupil.....	273
Transferring a subject?.....	274
Influences on the realisation of ideas from Design & Technology in Norwegian schools	277
Influences from the project policy and implementation.....	277
Influences from the curriculum L97	279
Teachers’ subject background as significant?	281
Cultural influences.....	283
Teachers’ interaction with ideas	287
Implications of the study	290
Implications for curriculum development and implementation	290
Implications for research.....	292
EPILOGUE	294
REFERENCES.....	295
APPENDIX 1	
CAST OF CHARACTERS IN THE EMPIRICAL STUDY	314
APPENDIX 2	
OVERVIEW OF FIELDWORK IN THE EMPIRICAL STUDY	319

CHAPTER 1

INTRODUCTION AND OVERVIEW OF THE THESIS

Education has become internationalised. Educational trends, concerns and debates exceed national and cultural borders, and ideas and innovations are being exchanged and transferred. Many curriculum programmes and reforms in education are influenced by international trends and by curricular ideas developed in a different educational context than the one in which they are put into practice. How does this affect the process of realisation and their effects in schools?

Technology as a subject in compulsory education is one field where perspectives, concerns and ideas to a large extent are exchanged and transferred on the international arena. The importance of technology as a component of education for all is increasingly recognised, and the concept of technological literacy has emerged (Lewis & Gagel 1992, Liddament 1994, Barnett 1995, Ferreyra 1997, Jenkins 1997a, Jenkins 1997b, Petrina 2000). Though drawing on a variety of different traditions, technology as a specific and independent subject is a newcomer in the school curriculum in many countries. A range of curriculum initiatives is thus made in order to establish and develop technology as a subject of teaching.

In Norway, one important initiative of this kind is the project '*Technology in Schools*' ('Teknologi i Skolen', which will be abbreviated TiS in this thesis) initiated by the Norwegian Society of Engineers (NITO). The project aims at introducing technology as an area of teaching in Norwegian compulsory schools. The rationale and implementation of the project is inspired by ideas embedded in the school subject *Design & Technology*, which was established as a compulsory subject for all pupils in England and Wales in the late 1980s. The TiS project hence provides an opportunity to study the introduction of technology as a subject of teaching in schools, and how educational ideas transfer across national and cultural borders.

Internationally, there is a rapidly growing body of research on technology as a component of general education. In countries where technology is a defined subject in the school curriculum, the policy, implementation and development of the subject have been studied (McCulloch *et al.* 1985, Layton 1995, Lewis 1995, Riis 1996, Andersson *et al.* 1997). Research has also attended to innovative practice in technology teaching (e.g. Barnes *et al.* 1987, Black & Atkin 1996). When realising educational ideas and intentions in schools, it is generally accepted that the

teachers constitute a crucial factor. Accordingly, several studies are undertaken to elicit what teachers see as important aspects of technology as a school subject (Lindblad 1990, Aubusson & Webb 1992, Mittell & Penny 1997, Rowell *et al.* 1999, Davies & Rogers 2000, McRobbie *et al.* 2000, Mattsson 2002). Some report a *mismatch* between curriculum policy and teachers' perceptions and teaching of the subject (Jarvis & Rennie 1996, Mittell & Penny 1997), and strategies for producing *change* in teachers' beliefs and practice (Aubusson & Webb 1992, McRobbie *et al.* 2000).

Research has also investigated how teachers comprehend the nature of technology and its relationship with science (van den Berg 1986, Rennie 1987, Zoller & Donn 1991, Jarvis & Rennie 1996, Tairab 2001). Some of these studies report that particularly science teachers tend to look upon technology as merely applications of science. It is further indicated that teachers interpret technology teaching in terms of their own subjects' subcultures (Jones & Carr 1992, Hepburn & Gaskell 1998, Jones 1999). This means that craft teachers may teach technology with focus on technical skills, teachers of social studies may emphasise societal aspects of technology whereas science teachers may see technology as a "vehicle for teaching science" (Jones & Carr 1992, p. 231).

Studies as those referred above, with a focus on educational policy and teachers, add to a range of studies on *pupils'* and *students'* comprehension of technology and their learning in technology teaching (e.g. McCarthy & Moss 1990, Griffiths & Heath 1996, Hendley & Lyle 1996, Levinson *et al.* 1997).

Though studies within technology as a subject of teaching in schools are plentiful, little research is undertaken on how ideas in technology education transfer to new educational contexts, and how they then transform under various influences. The present study contributes to the field by investigating the introduction of technology as a subject in Norwegian schools. It explores how teachers participating in the TiS project interact with ideas from Design & Technology inherent in this project and how various influences contribute to the shaping of technology teaching adapted to a Norwegian school context.

The study is carried out as an explorative cross-case study involving classroom observations and interviews with teachers. The research has been guided by the following two questions:

1. How do the teachers participating in the TiS project perceive and realise technology as a subject of teaching?
2. What are important influences on the realisation of ideas from Design & Technology in Norwegian schools?

Question 1 has two components: the teachers' *perceptions* and their *realisation* of technology teaching. The former entails the teachers' interpretations of technology as a subject: what it embraces, its intrinsic aims and objectives and justifications of its inclusion in the school curriculum. More specifically, it will address the teachers' view of the nature of the subject Design & Technology taught in England and Wales as well as its potential in Norwegian schools. The question also deals with how the teachers conceptually relate technology teaching to existing subjects in the curriculum. Of reasons that will be clarified later, special emphasis is given to Science in this regard. The latter component of the question concerns how technology teaching associated with the TiS project is realised in practice. This comprises characteristic features of organisation, pedagogy and 'content' in terms of what the teachers and their pupils *do* in technology sessions, and how aspects of Design & Technology are adopted in the teachers' realisation of technology as a new subject of teaching.

Question 2 addresses the dynamics of the transfer of educational ideas across national and cultural borders. It attempts to identify the major *influences* that shape the realisation of ideas on technology teaching in schools participating in the TiS project, and how these ideas thus transform into a Norwegian educational context. The TiS project attempts to introduce ideas from Design & Technology in Norwegian schools, but provides the participating schools and teachers with high degrees of freedom in how these ideas are to be realised. It is thus relevant to investigate how specific aspects of the project itself influence the formation of technology as a new subject of teaching. Aspects that will be considered in this regard, and whose influence may differ in character and significance, include NITO's explicit policy for the TiS project, the project's underlying rationale and the resources and training offered to the participating teachers. Further, the realisation of ideas conveyed by the TiS project may be influenced by specific institutional settings such as the incitements of the national curriculum for compulsory education and by the shared beliefs of the educational community as well as the surrounding culture more generally. Finally, as studies referred above have indicated, individual teachers' educational background, their affiliation with specific school subjects and the subcultures associated with these subjects may influence how technology as a subject of teaching is realised in schools.

'Influences' as addressed in Question 2 clearly don't lend themselves easily to observation, and are only able to be studied indirectly. This is sought resolved by comparing results on teachers' perceptions and realisation of technology teaching gathered from Question 1 with essential aspects of the potential influential factors indicated above. This way, the present research study seeks to identify the nature

and relative importance of influences on how ideas from Design & Technology are realised in schools participating in the TiS project.

The chapters in this thesis form three distinctive parts. The first part, consisting of Chapters 2 - 4, presents the *conceptual framework* for analysis and discussion of the empirical data presented in this thesis. This framework consists of three components, representing perspectives on technology, education and teachers respectively. Chapter 2 presents perspectives and views on *technology*; its various meanings, its basis of knowledge and relation with science as well as its role in culture and society. Chapter 3 presents possible gateways to *technology education*, and it will be shown how the conceptualisation of technology as a school subject may draw on philosophical, ideological and political perspectives on education. It also gives an overview of specific approaches to technology teaching in schools. These two chapters provide the analytical tools that will be utilised in interpreting the teachers' perceptions and realisation of technology as a new subject of teaching in Norwegian schools. The presentation attempts to capture the span of 'available positions' for the teachers in this study, and thus presents a variety of different views on technology and technology education as well as conceptual tools for describing this variety. The third component of the conceptual framework, given in Chapter 4, presents perspectives on teachers' work and their role in the realisation of curricular ideas, including conceptualisations of teachers' knowledge, beliefs and professional frames.

Part II, consisting of Chapters 5 and 6, presents the *contextual framework*, which describes two essential components of the context in which the empirical study is situated. Chapter 5 gives an account of the formal curriculum for compulsory education in Norway. It investigates how its various parts deal with the concept of technology, and what place there is for technology teaching within the framework of the formal curriculum. Chapter 6 presents the specific project TiS in which the teachers who constitute the cases in this study participate. This includes the background of the project, its aims and the means by which it is implemented.

The third part of the thesis presents the *empirical study*. Chapter 7 describes the methodological design of the research and methods employed for data collection, analysis and presentation. Results and their interpretations are presented in Chapters 8 - 12. The thesis concludes with a final discussion in Chapter 13, which draws on the analysis in the previous chapters in addressing the two questions posed in this introduction. Finally possible implications of the study are discussed.

PART I

CONCEPTUAL FRAMEWORK

CHAPTER 2

TECHNOLOGY

*When does science become technology
- it is like asking
When does paint become art?*

(Jørgensen 2000, my translation)

This chapter gives a very brief account of the meanings associated with technology and technological knowledge, views on how technology relates to science and perspectives on the role of technology in human life and society. It draws on the work of a limited number of writers within the philosophy of technology, and makes no attempt to a complete coverage of perspectives in this extensive field. The selection is made with the purpose of providing a conceptual basis on which the subsequent and more comprehensive presentation of technology education will be built, and introducing concepts and perspectives of significance for the analysis of empirical data in this thesis.

Meanings of technology

What is technology? The concept of technology is familiar to most people and brings about a variety of associations. Yet, formulating a precise definition of the concept or a functional description that captures the essence of these associations is not a straightforward matter.

Etymologically, the term stems from the Greek word *techne*, which is commonly translated as art, craft or skill, linking the term to human practical activity and creation. In technology, *techne* is joined with *logos*, whose meaning is in the direction of words, speech and reason (Mitcham 1994) but also consciousness (Mitcham 1979) or argument, explanation and principle (Herschbach 1995).

Various meanings can in fact be drawn from the conjunction of the two terms *techne* and *logos* (see Mitcham 1994), yet it is commonly interpreted in direction of the study and systematic knowledge of practical arts.

Techne is also the origin of the related terms *technique* and *technic(s)*. The former usually denotes specific skills of some particular activity (Mitcham 1994). However, 'technique' also figures with corresponding meaning as does 'technology', for example in the writing of Ellul (e.g. Ellul 1970, worth noting in translation from French: *La Technique*). The latter term, *technic(s)*, is commonly not used in English language, yet used by the American philosopher Lewis Mumford (e.g. Mumford 1966). The term finds its equivalent in the German term *technik* and *teknik/k* used in Scandinavian languages, which Fores and Rey (1979) have pointed out as a 'missing concept' in English language. According to Ropohl (1997), technics refers to fields of engineering work and its products, while technology denotes the science of these technics. This distinction between technic and technology parallels the one Espinas makes between *technologie* as systematic organization of some technique and *Technologie* (with a capital T) as generalised principles of action (see Mitcham 1994, p. 33).

In Encyclopædia Britannica, technology is defined as:

the application of scientific knowledge to the practical aims of human life or, as it is sometimes phrased, to the change and manipulation of the human environment. (...)

(Encyclopædia Britannica, online version)

Hence technology is presented as the action of *applying* knowledge rather than as a *form* of knowledge in itself. The definition strongly links technology to *science*, as scientific knowledge is that which is to be applied. Among historians and philosophers of science and technology, however, there is extensive agreement on the view that technology can not adequately be understood as merely applications of scientific knowledge (E. Layton 1977, Skolimowski 1983, Staudenmaier 1985, Mitcham 1994). Alternative conceptions of how technology then relates to science will be presented later in this chapter.

The concept technology does, however, carry other meanings than a type of knowledge or applications of knowledge. Mitcham (1994) captures these meanings, in addition to knowledge, as *object*, *activity* and *volition* respectively. Technology as *object* is often associated with material devices such as tools, machines, structures (e.g. bridges) and instruments, designed and manufactured to make human activities easier or possible (Tiles & Oberdiek 1995). It also embraces

products of technological activity, meaning all humanly fabricated material artefacts (Mitcham 1994).

Technology as *activity* (also denoted technology as *process*, see Custer 1995) refers to the human engagements with these devices, such as inventing, designing, constructing, operating and maintaining them. The view of technology as activity may also go beyond those associated with the devices indicated above. This is the case in how Kranzberg and Pursell (1967) have described technology in what they denote “its simplest form”:

Technology is man’s efforts to cope with his physical environment – both that provided by nature and that created by man’s own technological deeds, such as cities – and his attempts to subdue or control that environment by means of his imagination and ingenuity in the use of available resources.

(p. 5)

Further, they present a broad comprehension of what is meant by the notion ‘environment’, stating that technology “is nothing more than the area of interaction between ourselves, as individuals, and our environment, whether material or spiritual, natural or man-made” (ibid., p. 11). Though they themselves point to the impracticality of definitions of technology being so broad and loose that they encompass many items that scarcely can be considered as technological (p. 5), their own description referred above has laid itself open to criticism in this regard. As Mitcham (1979) has pointed out, if technology is ‘nothing more’ than they suggest, it is hard to imagine anything that would be left out (p. 172).

Broad definitions of technology as the one above will necessarily make the concept include the development of non-material inventions such as language, music, sports and political systems. The extension of the meaning of ‘environment’ thus extend the meaning of ‘artefact’ toward what Custer (1995) denotes a holistic / expressionist approach where technology represents any outcome of human ingenuity without respect to form (p. 223). Custer asks whether the meaning of technology should be restricted by a criterion of *utility* of the produced artefact, and discusses the problems that then arise from defining the artefacts’ *scope* (e.g. music may be a useful artefact in helping people relax).

The meaning of technology is, however, often comprehended as restricted to human interaction in the *material* world in a much more strict sense. A description of technology in this direction is given by Raat and de Vries (1987), who identify three ‘pillars’ connected with technology: *matter*, *energy* and *information*. They characterise technology as always concerned with an alteration in shape and/or position of these three pillars. This characterisation restricts technology to human

action that causes changes in the material world, and links it to *alteration* of essential entities in this materiality.

Technology as *volition* reflects the human motivation for developing technology. Drawing on the work of a range of philosophers of technology, Mitcham (1994) summarises technology as volition as the will to control or power, the will to freedom, the pursuit of or will to efficiency and the will to realise the *Gestalt* or self-concept of the worker. An understanding of technology as volition can also go in the direction of Heidegger's conception of technology as a kind of truth and a revealing of what is (Heidegger 1993).

Technological knowledge

As we have seen, the notion of technology may be taken as referring to a specific area of *knowledge*. The meaning of technology as objects, activity and volition also carry some association to knowledge necessary for creating and using objects, pursuing activity and realising desires. What then constitutes technological knowledge, and how can it be systematically conceptualised?

By analysing an extensive number of writings in the philosophy of technology, Staudenmaier (1985) has identified four interrelated characteristics of technological knowledge; scientific concepts, problematic data, engineering theory and technical skills. *Scientific concepts* is represented as one characteristic of technological knowledge, though this does not mean that scientific knowledge can be 'applied' in technological activity and development in a straightforward manner. In order to contribute to technological knowledge, it must be appropriated and restructured according to the specific demands of the design problem at hand. *Problematic data* in Staudenmaier's analysis addresses this practical nature of technology. It represents problems and phenomena that have not been recognised on a theoretical level or that have been considered unimportant. The new questions and new answers that arise in confrontation with problematic data contribute to new technological (and scientific) knowledge. Though technology is always related to practical purposes, its knowledge base also encompasses a component of generalised knowledge based on practice, that is, what Staudenmaier denotes *engineering theory*. This represents a body of knowledge using experimental methods to construct a formal and mathematically structured intellectual system. This characteristic forms the theoretical base of technological knowledge, and is only indirectly related to the solution of specific problems. The final characteristic, *technical skills*, represents the experimental basis for making technical judgement that cannot be reduced to purely theoretical knowledge.

Others have conceptualised technological knowledge in terms of related categories. Ropohl (1997) suggests four types of technological knowledge; technological laws, functional rules, structural rules, technical know-how and socio-technological understanding. While the first four roughly match Staudenmaier's characteristics, *socio-technical understanding* brings in a new aspect to what is meant with technological knowledge. Ropohl describes socio-technical understanding as systemic knowledge about the interrelationship between technical objects, the natural environment, and social practice. This understanding must clearly involve knowledge on which *economic* considerations in inventive practice are based. These considerations may be at least as important as the components of technological knowledge addressed above. Riedler (cited in Staudenmaier 1985, p. 46) considers the making of an invention 'markfähig' as the most important stage in a process consisting of making it work (being 'gangbar'), making it useful ('brauchbar') and making it marketable in the existing economic system ('markfähig').

What is marketable is clearly not a given, but culturally negotiable. Andersen and Sørensen (1992) describe technology as an intermediary between nature and culture. Nature, and also our knowledge about nature, sets up a framework of what is technically possible. Culture, on the other hand, defines what is culturally possible. Technological possibilities from a technical point of view may be culturally impossible in the sense that they are socially unacceptable or economic unprofitable. Technological inventions may, however, be renegotiated with culture by redefining their cultural interpretations and contexts of use, improving security or efficiency characteristics or by improving cost-benefit ratios. On the other hand, what is desirable and possible in culture but currently technically impossible may be renegotiated with nature to find compromises or new technical solutions. In this model, the crucial knowledge an engineer possesses is knowledge of how to perform the process of negotiation between nature and culture.

Relationships between science and technology

How does technology relate to science? The question in itself anticipates that science and technology can be distinguished, and it may hence be helpful to start the exploration of possible answers with an account of the *differences* between the two.

A common way of distinguishing science and technology is to point to their different *purposes*. Science is seen as aiming at knowledge of the natural world for the sake of the knowledge itself, while technology aims at utilising knowledge in

solving practical problems. This difference in purpose leads to a difference in what constitutes the *objects* of the activity; natural phenomena versus human-made structures and artefacts (Ropohl 1997). Further, there are differences in what is recognised as valid *results* of scientific and technological activity, and in their *criteria of quality* (ibid.) and the notion of what constitutes *progress* in the field (Skolimowski 1983). Skolimowski formulates technological progress as, in addition to inventing new objects, *improving* objects by making them more durable, more reliable, more sensitive, faster in performing its function, and also by shortening the time and costs of production. This differs from progress in science, signified by improvement of theories, where improvement means theories that are simpler, more universal, more detailed or of greater explanatory power. Finally, progress is manifested by approval in the scientific community versus the community of engineering and industrial practice (Ropohl 1997). These constitute different social institutions with different ‘internal sociologies’ (Ziman 1984). In addition to these differences in essential features of science and technology as activities, their dissimilar *origin* is also conventionally upheld as a fundamental difference between them. While science is seen as having its roots in ancient (Greek) philosophy, the origin of technology is equated with traditions of craft.

How the relationship between science and technology should best be described has been subject to much scrutiny and debate (Barnes 1982, Staudenmaier 1985, Hughes 1986, Layton 1991, Narin & Olivastro 1992, Gardner 1994, Bungum 2003). With an eye on representation of the relationship in school curricula, Gardner (ibid.) has provided a framework of four main positions on the relationship between science and technology that captures the various conceptions of the relationship. These positions are a view of technology as applied science, a demarcationist view, a materialist view and a interactionist view. The view of technology as *applied science* implies that science precedes technology in a chronological as well as in an epistemic sense, and that technology is basically applications of science knowledge to practical purposes. Though this position is extensively contested, Staudenmaier (1985) claims that it remains a “salient formula” in the discourse among philosophers of technology (p. 99).

The second position in Gardner’s analysis, the *demarcationist* view, treats science and technology as distinct fields with different goals and methods and involving different social groups. This view may be supported by examples from history where technological proposals, artefacts and procedures have existed side by side with incompatible scientific knowledge. According to Gardner, the demarcationist view may be legitimate in ancient and medieval times, but have become increasingly blurred in modern times. On the other hand, Barnes (1982) suggests a model for the science/technology relationship that – without repudiating the

‘occasional creative use of science’ and vice versa – claims that the major resource in inventing new technology is *old* technology. Similarly, the major resource for developing new science is *old* science.

The *materialist* view, representing the third position in Gardner’s framework, claims that technology precedes science and functions as a prerequisite for it. This prerequisite of technology to science is manifested in two ways; firstly by the necessity of technical devices in doing scientific investigations and secondly by how technology provides new conceptual frameworks that generate new scientific questions.

Gardner’s fourth position is the *interactionist* view. In this position, science and technology are recognised as distinguishable fields, but it is emphasised how scientists and technologists learn from each other, use each other’s results and products in an interactive way and rely on each other for further progress. These interactions may be seen as connecting science and technology to each other in a ‘seamless web’ (Hughes 1986). The interactionist view is also embedded in the notion ‘technoscience’ (Latour 1987), often associated with large scale projects connected to political and economic interests such as the Human Genome Project (HUGO) and space research programmes like those run by ESA and NASA.

Each of Gardner’s positions can easily be supported by means of examples from history or contemporary science and technology. More remarkable, however, is that the *same* examples are often used to justify *different* positions. A classical example is the invention of the steamer in the 18th century. It has been used for defending the *demarcationist* view, seeing it as an example of fairly advanced technology not building on scientific knowledge, but existing alongside contradictory scientific theories (e.g. Sundin 1991). Or, it might as well be an example of technology being a prerequisite for science represented in the *materialist* position, as the steamer required new concepts and new theories for its full scientific understanding (e.g. Ellul 1979). Holding this position, one may claim that thermodynamics owes more to the steam engine than the steam engine owes to thermodynamics (see D. Layton 1988). Gardner, on the other hand, uses the steamer – or at least James Watt’s improvement of it – as an illustration of the *interactionist* view. Watt himself however, upheld his inventions as independent of the science being developed by Joseph Black about the same period of time (see Nielsen *et al.* 1996).

The same phenomenon also occurs in analysis of more recent products of science and technology. This may be illustrated by the two projects ‘Project Hindsight’ and ‘Project TRACES’, undertaken in the USA in the 1960s (see E. Layton 1977 or

D. Layton 1991). The former involved major work on classifying the development of several hundred research 'events' in the development of military technology as either 'scientific' or 'technological'. Only 9 % of the events were classified as resulting from science, and only two single events fell into a category of basic science. This miserable result seen from the scientists' point of view gave birth to a new project, 'Project TRACES', run by the National Science Foundation. This project traced a much higher percentage (72 %) of a comparable number of technological events back to scientific knowledge and research.

These contradicting results are clearly not only a result of different definitions and diverging views on the relationship between science and technology. It is reasonable to expect that they are influenced by the economic interests of the involved professionals. They may identify themselves as scientists or technologists respectively, and are likely to hold an interest in how the state invests money in research and development. According to Edwin Layton (1977), the divisions between science and technology are not structural differences in types of knowledge or between knowing and doing; the differences are related to deviation in how different social groups *identify* themselves, and how they *value* knowing and doing. Both science and technology may be regarded as socially constructed cultures whose boundaries are organisational and cultural, rather than epistemological.

The above may be taken as a sign of a invalidity of the anticipation of science and technology as distinguishable that was made in the beginning of this section, and one might hence reject the discussion of a relationship between them. Such a rejection is made by Mayr (1976), who states that the discussion assumes the existence of two mutually exclusive categories whereas practical usable criterion for making a sharp distinction between these categories simply does not exist (p. 668). The distinction is also blurred by how Ziman (1984) challenges common views on what characterises science as a human enterprise. He has pointed out that the discourse on the nature of science tends to anticipate science as equivalent to what he denotes 'academic' science, whereas most scientific activity today is about solving specific problems rather than acquiring knowledge for its own sake. This activity is strongly linked to capital, industry and technological development.

Though Gardner's framework may be challenged by arguments like those indicated above, it captures essential aspects of the different ways in which technology is seen as relating to science. It will therefore be used as a basis for analysing how the teachers who represent cases in the empirical part of this study look upon the relationship between technology and science. It is clear that a complete analysis of

this relationship would require a further examination not only of characteristics of technology, but also of science. Such an analysis, however, is beyond the scope of this thesis.

Technology as a cultural and societal force

Thus far mainly the *technical aspect* of technology has been considered, that is, what Pacey (1983) refers to as *the restricted meaning of technology*. This aspect embraces knowledge, skills and techniques of technology, as well as technological objects such as tools, machines and products, but does not capture the motive forces of technological development or its societal and cultural significance. The general meaning of technology, according to Pacey, also involves an organizational and a cultural aspect. The *organizational aspect* embraces technology as economic and industrial activity, professional activity and characteristics of users, consumers and trade unions. The *cultural aspect* represents goals, values and ethical codes involved in technological practice, as well as human awareness, creativity and belief in progress. Thus this aspect partly covers the meaning Mitcham (1994) assigns to technology as *volition*.

Technology itself can clearly be seen as a significant *part* of culture, even as the key characteristic of a culture (Sundin 1991). However, comprehending 'culture' more narrowly as shared values and ideas among members of a community as Pacey (1983) does, allows us to consider how technology interacts with culture. On one hand technology is a product of the culture where it is developed. It reflects values and priorities in the culture; what counts as valid needs and desires and for whom as well as what is considered appropriate and acceptable means to fulfil them. The use, meaning and consequences of technological objects are determined by the cultural context in which they are situated (Pacey 1983). On the other hand, development of technology *shapes* the culture and society in which it takes place. The development of technology associated with the industrial revolution in England in the late 18th century illustrates this two-way interaction. The intensification of the textile industry was not so much a result of new technology in an isolated sense, but rather a consequence of economic and social changes, such as available resources of cotton through colonialism and changes in organisation of work structures (Sundin 1991). In turn, the rapid developing industry caused profound changes in society by development of infrastructure and centralising of production, and cultural changes due to alteration of family life and power relations.

What characterises technology as a force in the development of human culture and society? Philosophers of technology provide differing views in this regard. The

view of technology as a distinctive human endeavour has led to discussions of whether technological development in fact is comparable to evolution in a Darwinian sense (Basalla 1988, Ziman 2000). Viewing technology this way positions technology as 'natural', desirable and inescapable, and represents one strand of what is denoted *technological determinism*, involving a view of technological development, and thus human development, as predetermined to follow a specific trajectory. Technological development seen as inescapable may lead to *fatalism* (Tiles & Oberdiek 1995) and the view of technology as *autonomous* (Ellul 1970, Winner 1977). This means that technology possesses the potential of 'running amok' like a Frankensteinian monster, that is, becoming completely out of control within the human culture in which it was developed.

An alternative to technological determinism is represented in the view of technological development as *socially constructed*, which has given rise to a field of inquiry denoted 'sociology of technology' (see Bijker *et al.* 1987). In this field, parallels are drawn to paradigms, consensus and Kuhn's notion of 'normal science' familiar from the sociology of science. Clear echoes from Kuhn (1962) are also evident in writings on 'the structure of technological revolutions' (e.g. Wojk 1979). Seeing technology as socially constructed involves a view of technological development as resulting from negotiation and transformation of human problems, purposes and achievements. Further, a technology exceeding 'normal technology' will be *stabilised* when consensus is arrived at among the social groups involved in designing and using the technology (Bijker 1987). This means that a society's technological development will reflect the society's values and power relations.

The above may be seen as an opposition between technological pessimism and optimism (see Tiles & Oberdiek 1995). While technological *pessimists* see humans as enslaved by technology, those advocating the *optimist* view assert that technology and its products are in principle value neutral; they merely represent human possibilities and can be used for good or for bad. This differs from the former (pessimism) not essentially in views on whether the results of technological development are good or evil; it is rather a question of whether technological development can be *controlled* or not. There is, however, space for a middle ground between these positions. Tiles and Oberdiek (*ibid.*), assert that technology in itself may not be autonomous and out of control, but that it may be out of control for individuals and their governments due to industries' accumulated political and economic power. Feenberg (1991) also offers a position in a middle ground in his development of a '*critical theory of technology*'. His distinction between instrumental theories and substantive theories parallels the optimist / pessimist dichotomy described above. *Instrumental* theories, which Feenberg asserts is dominant of modern governments, treat technology as subservient to values

(political or cultural). Technologies represent ‘tools’ ready to serve the purposes of their users, and are neutral in the sense that they are indifferent to the variety of ends it can be employed to achieve. Instrumental views also see technology as indifferent with respect to politics and as carrying a universal ‘rational’ character independent of social and political contexts and norms. *Substantial theories* of technology, on the other hand, see technology as an autonomous cultural force overriding traditional or competing values. It represents an expansive dynamic that shapes the whole of social life. Feenberg’s critical theory of technology represents an alternative to both these views of the characteristics of technology. It involves seeing technology as an *ambivalent* process of development suspended between different possibilities. This ambivalence is distinguished from neutrality by the role it attributes to values in the design, not only the use, of technical systems (ibid., p. 14). Ambivalence entails that technology can, on one hand, have a *preserving* and *reproducing* function for the society’s power relations. This accounts for what Feenberg describes as a surprising continuity in societal hierarchies over the last generation despite enormous technical changes. On the other hand, new technology can act as *democratically rationalising*. It can be used for undermining the existing hierarchy or to force it to meet needs, such as environmental protection or empowering of workers, that have previously been ignored. Hence Feenberg’s critical theory represents neither an optimist nor a pessimist view of technology, but attends to consequences of technological development envisaged by both.

CHAPTER 3

GATEWAYS TO TECHNOLOGY EDUCATION

Whenever a specific technology curriculum appears to you as the only possible one, take this as a sign that you have neither understood the nature of that curriculum nor the educational purpose it was intended to achieve.

(Layton 1993, p. 64)

The previous chapter has provided some divergent views on what ‘technology’ means, its role in culture and society, what constitutes technological knowledge and how technology relates to science. The diversity of interpretations of technology as such implicates a corresponding range of possibilities of what should be the rationale and content of technology as an educational subject. Internationally, there has been a rising attention towards technology as a component of compulsory education during the last decades. There seems to be extensive agreement about the importance of technology as an educational subject, but apparently also dissension and a lack of clarity on what the content and objectives of the subject should be (Lewis 1991, Hansen & Froelich 1994, Sjøberg 1995, Wicklein 1997, Petrina 1998). This situation can, to use the phrases of Hansen and Froelich (*ibid.*), be regarded not primarily as a crisis, but rather as a cause for celebration as it represents unique opportunities for educators to consider a range of possibilities in shaping a new school subject.

This chapter explores possible gateways to the formation of technology as a school subject from various perspectives. It first presents *philosophical* perspectives on what constitutes and characterises a school subject and concepts by which the nature of a school subject can be described. Then *ideological* perspectives are presented in terms of some fundamental tensions between educational stances. This includes a presentation of a conceptual framework of curriculum design models, which captures the different ideological stances and conceptualises various underlying rationales of technology education. Creating a school subject is also a political act, and the chapter proceeds with an account of *political* perspectives in terms of arguments for technology as part of compulsory education and stakeholders likely to play a part in the political process of shaping it. The final part of the chapter addresses some specific approaches to technology teaching in schools, and presents some major traditions and movements that exist internationally.

One reasonable interpretation of technology teaching is the use of modern *information technology*. The use of computers provides rich opportunities and challenges for teaching, and these are currently subject to much attention in many schools and in curriculum development. This thesis does not, however, to any considerable extent deal with the implementation of information technology in schools. One reason is that education in information technology, as the field of mastering the use and programming of computers, has clear boundaries with other interpretations of technology education, and may hence be regarded as a specific topic worth dealing with on its own. On the other hand, information technology can also be used as an effective and motivating tool in working with other subjects in the school curriculum. When technology plays this role in education, it may be classified as *educational technology*, as distinct from *technology education*. As a consequence, the field of information technology is not considered specifically as a gateway to technology education in this chapter.

Fundamentals of a school subject

Many subjects in the school curriculum have a long history and rich traditions in schools. They are often based upon academic *disciplines*, which encompass even longer traditions in universities. Science, for example, may be seen as reflecting the disciplines of biology, chemistry, physics and possibly geo-science, while social studies usually contains history, geography and social science and reflects these disciplines. (However, as Stengel (1997) has shown, the relationship between disciplines and corresponding school subjects may in fact be more diverse than simply the one that the school subject reflects the discipline in a one way relationship.) Though curriculum developers may intend to integrate the disciplines in meaningful units for pupils, the related disciplines and their mutual boundaries are often still visible in curriculum specifications, textbooks and in teaching (for evidence of this claim in a Norwegian context of science teaching, see Nergård 1994). Further, subject teachers often represent a conservative factor in maintaining the connection to their disciplines. From their education, they are often well acquainted with academic disciplines, and may hence maintain an affiliation with the discipline and its associated traditions and culture (Siskin 1994).

Conversely, technology as a subject of teaching in compulsory education has neither its own traditions in schools to lean on, nor does it have a well-established unified academic discipline in higher education that can serve as a model and contribute to the definition of curricular content. This also means that teachers who are to teach technology as a new subject do not bring with them a shared culture of experiences, beliefs and expectations of the meaning of technology as a component

of general education. In a new subject they also lack the initial assimilation of particular teaching models during time spent as a pupil and thus the possibility to activate a latent culture acquired by ‘apprenticeship of observation’ (Lortie 1975).

The structure of a discipline

Even if a specific school subject is intended to reflect a traditional academic discipline, this does not automatically provide curriculum developers with the full content of the subject. A school curriculum can not, by any means, cover the products of all human inquiry in a given discipline, like for example chemistry or history. This means that a challenge of identifying content that is representative for the discipline and appropriate for the learner still remains. Schwab (1964, 1974) has upheld the importance of identifying the *structure of the disciplines* and suggested to use this as a basis for curricular development. This approach is also associated with the work of Bruner, with frequent references to his book ‘The Process of Education’ (Bruner 1960) where he maintains that fundamental ideas and structures of a discipline can be taught to learners on any level. The underpinning idea is that no discipline is constituted by ‘catalogues’ of facts, concepts and principles within an area of knowledge. Rather than being characterised by such ‘catalogues’, a discipline is characterised by its intrinsic patterns, that is, what Schwab refers to as its conceptual and syntactical structure. The *conceptual* structure of a discipline determines what those working in the discipline seek the truth about and in what terms that truth is to be couched. The *syntactical* structure of a discipline is concerned with the operations that distinguish the true, the verified, and the warranted in that discipline from the unverified and unwarranted (Schwab 1974, p. 174).

Schwab asserts that the identification of a discipline’s conceptual and syntactic structure is important for the formation of a school subject for two reasons. Firstly, it is required for curriculum planning and development of teaching material in order to create a subject that captures the essential characteristics of the discipline. Secondly, knowledge of the discipline’s structures might be an element of what is taught in the school subject, that is, a learning target in itself. An example of how curriculum thinking and development acknowledge the latter reason is the recent emphasis on teaching the ‘Nature of Science’ (NOS, see e.g. McComas 1998) or ‘ideas *about* science’ (Millar & Osborne 1998) as part of the science curriculum. Though the academic rationalism on which Schwab’s work is based might be seen as outdated as a rationale for curriculum development, the NOS movement reinforces the relevance of analysing the structure of a discipline, in the sense that understanding of the characteristics of science as a human enterprise is upheld as a learning target. This movement has also initiated and reinforced debates on what does in fact characterise disciplines, whether it is feasible to identify a structure that

unifies the disciplines covered by the notion 'science', and how this should be represented in the teaching of school science (e.g. Alters 1997, Donnelly 2001a, Hodson 1998, Jenkins 1999).

For technology, there is a continual debate on whether this area of knowledge constitutes a discipline and, if so, how this structure can be conceptualised and contribute to the formation of technology as a school subject (Skolimowski 1972, Lewis 1991, Waetjen 1993, Hansen & Froelich 1994, Herschbach 1995, Petrina 1998, Lewis 1999). Waetjen (ibid.) proposes four "things" (p. 8) which need to be specified in order to make technology an academic discipline. Firstly, an intellectual domain of credible organised knowledge needs to be identified. Further, technology as a discipline will need a history of organising concepts that constitutes its domain. It also requires a clear delineation of the modes of inquiry by which the discipline validates itself, creates new knowledge and advances as a discipline. Finally, the definition of the discipline must be instructive in nature, that is, it must facilitate curriculum contents to be derived from its intellectual domain. Attempts to identify the intellectual domain, the organising concepts and the modes of inquiry in technology are often built on conceptualisations of technological knowledge such as those presented in Chapter 2. Petrina (1998) reviews a range of these attempts, including school curriculum initiatives that articulate a body of knowledge and a structure of technological fields such as industrial technology and art education. Many of these initiatives date back to the 1960s and 70s, but Petrina maintains that what he calls the "enterprise of disciplinary doctrine" (p. 113) is also embedded in the more recent and prosperous project 'Technology for All Americans' (ITEA 1996, see also ITEA 2000 for a more recent version of the project). As an alternative to the 'disciplinary doctrine', Petrina proposes a model for technology education denoted *Multidisciplinary Technology Education*. In his model knowledge is organised through questions and inquiry within four areas denoted as the interdisciplines of technology; technological practice, design, technology studies and criticism of technology.

The problems in conceptualising technology as a discipline appear to be due to two main characteristics of technology as an area of knowledge and practice. Firstly, the notion 'technology' captures a range of fields of activity, where knowledge and practice in each field are highly contextualised and related to specific purposes. Formulating a disciplinary structure and basis of knowledge requires generic and coherently organised concepts, and this may inevitably lead to a conceptualisation so general that their meaning loses its value in describing the knowledge inherent in each associated field. Secondly, the fact that technological knowledge is always related to human activity and involves a significant tacit component (see Polanyi 1967) makes it problematic to categorise and codify it in purely intellectual manners (Herschbach 1995). Arguing that it is through *activity* in specific practical

domains that technological knowledge is defined and finds its meaning, Herschbach maintains that technology is therefore not a discipline, but is fundamentally interdisciplinary in its selective use of formal knowledge for practical purposes. He further asserts that this interdisciplinary character represents the most important potential educational value of technology education, and that to conceive of technology primarily as a discipline is not only erroneous but limiting for curriculum development (ibid., p. 36).

The relevance of the 'technology as discipline' debate has also been questioned from the perspective that school subjects do not need to reflect a discipline, regardless of whether this discipline can be clearly defined or not. It is argued that the impetus for the formulation of a school subject is nonetheless quite distinct from the one developing an academic discipline (Stengel 1997), and that the focus of developing technology as a school subject needs to be upon the *children*, not the technology (Lewis 1999). Addressing education more generally, Noddings (1992) has asserted that curricula should be structured around centres of *care* rather than around traditional disciplines.

Classification, framing and educational knowledge codes

Though a school subject may be detached from the structure of a 'parent discipline', it may still be described by its *intrinsic* structure. From the perspective of sociology of education, Bernstein (1971, see also Bernstein 2000) offers a theoretical framework for the conceptualisation and understanding of the nature of a school subject. Characteristic to Bernstein's approach is that the focus is not so much on the content of the subject in itself, but rather on *relationships*, in the sense of strength of *boundaries*, between content elements. In analysing such relationships, he has introduced the concepts classification and framing. *Classification* denotes the relationship between contents within the subject, where 'contents' simply describes how time units for teaching are used. In a subject with *strong* classification, contents are well insulated from each other by strong boundaries (Bernstein 1971, p. 49). This means that content elements can be identified and clearly distinguished from other elements within the subject. *Weak* classification, on the other hand, implies that boundaries between content elements in the subject are weak or blurred. The concept of classification also gives rise to what Bernstein denotes *educational knowledge codes* of a subject. A subject with strong classification produces a *collection code*, while reducing the strength of classification gives rise to an *integrated code* for the subject. Integration in this sense is not to be understood as combining contents from various disciplines into one subject, or incorporating applications of contents from one subject to another; it implies that the boundary between the contents of the subject is itself blurred. The subject as a total then carries an underlying structure that unifies its content elements. In a

subject with an integrated code, contents may be replaced with others without altering the unifying structure. For a subject characterised by a collection code, on the other hand, contents can not be replaced without altering the subject itself.

While classification describes the relationship between content elements of the subject, the concept *framing* refers to the nature of the relationship between the subject as a total and its curricular surroundings. It expresses whether there is a strong boundary between what may be taught and what may not be taught under the headline of the subject, that is, what Bernstein denotes the pedagogical relationship. *Strong* framing means that there is a strong boundary between what belongs and what does not belong to the subject. If the framing is *weak*, the subject entails a range of options regarding its content elements. Frame thus refer to the degree of control teacher and pupil possess over the selection, organisation and pacing of the knowledge transmitted and received in the pedagogical relationship (ibid., p. 50).

Bernstein relates the concept of classification and framing to *power* and *identity* of those involved in realising the curriculum. To teachers of a subject, strong *classification* implies that their power over content to be taught is reduced, as boundaries between contents need to be maintained. Strong classification is also associated with a strong sense of identity in relation to the subject. Strong *framing* of a subject defines for a teacher what can legitimately be included in the subject, but increases the teacher's power over the *pupil* in what to be taught in the pedagogical relationship.

Some fundamental tensions in formation of curriculum

The previous sections have presented some perspectives on the philosophical foundation for identifying, structuring and describing the contents of a school subject. Building a curriculum for a school subject does, however, involve more than identifying the nature of the knowledge to be taught and prescribing effective methods to teach it. Curriculum development necessarily entails more fundamental assumptions. These include assumptions of *who* the learner is, the *purpose* of learning and which agent education serves, as well as ideas on what *learning* means and how it takes place. In short, a curriculum conveys a rationale for what education is all about.

What education is all about is, however, disputable and subject to important ideological tensions, whereof some will be briefly reviewed in the following. None of them should be taken as entirely dichotomous, though they will be presented as such in the following for clarity reasons. A real curriculum will of course most

often carry aspects of both ends of the tensions presented, yet with varying emphasis.

A classical tension in curricular development is the one between a *pupil-centered* and a *society-centered* curriculum (Eisner & Vallance 1974). This distinction elicits a question of educational responsibility; whose needs does education intend to fulfil, the needs of the learner or those of the society? And next, what constitutes the needs of the learner and those of society? Both ‘pupil-centered’ and ‘society-centered’ are notions that carry ambiguity, and examining them reveals new tensions in educational thinking. A related – and more often referred – tension is the one between a pupil-centered and a *subject-centered* curriculum. A pupil-centered curriculum is often associated with progressive movements and educational thinking built on Rousseau and Dewey, and is seen as a reaction towards what is denoted a ‘traditional’ approach, or a subject-centered curriculum where the focus is on the subject to be taught. Though the distinction between subject-centered and pupil-centered curricula may be seen as over-simplified as well as outdated, it reflects the division between competing perspectives that still remain and contribute to shape attitudes (Hoyle & John 1995), and continues to be an issue of educational research (see e.g. Eggen & Knain 2003).

A pupil-centered curriculum often carries ambitions of giving pupils education that is *relevant* to them, yet relevance is also an indefinite concept. The relevance may build on an intention of enabling the child to deal with ‘here and now’, emphasising their ‘lived in experience’ (Eisner & Vallance 1974, p. 5), or it may be positioned in the future, with underlying anticipations of what will be relevant to the pupil’s future life.

As the pupil’s future is essentially uncertain, and compulsory education is to serve pupils who will meet *different* futures, this perspective of relevance reveals a new tension between education for work purposes and education fulfilling the needs and rights of citizens of the society. This tension is not only about *who* the education is for (education for an elite contra education for all), but also heavily affects the *content* of education – as citizenship may imply significantly different knowledge and skills than those required for work within the subject or related areas. Considering education for *citizenship* clearly involves new challenges for curriculum development; what kinds of knowledge does a citizen need and for what purposes? Identifying possible answers to this question may give rise to tensions between instrumental and utilitarian perspectives on one hand and cultural perspectives related to liberal education on the other (Ødegaard 2001).

Returning to the notion of a society-centered curriculum, corresponding tensions emerge when conceptualising what it means to ‘serve the society’ (Taba 1962). At

one end we find education seen as a *preserver* of societal structures and a *transmitter* of the cultural heritage to new generations. On the other, education functions as an instrument to *change* societal structures and to *transform* culture. The aim of education from the pupil's perspective then carries the tension between adapting to the conditions offered by contemporary society on one hand and being empowered to change them on the other.

The tensions briefly sketched here provide a potential for fundamentally different curricula of a school subject. In the following, we will see how these differences are articulated through different curriculum design models and how they come to concrete expression in existing traditions of technology education internationally.

A framework of curriculum design models

Educational theorists have developed various models for analysing and classifying curricula and curricular thinking according to tensions as those discussed in the previous section. Specifically for technology education, Zuga (1989) offers a framework in synthesising curricular models into five main categories based on Eisner and Vallance (1974) and others. These main categories, denoted *curriculum design models*, consist of the *academic* curriculum design, the *technical* curriculum design, *intellectual processes* as curriculum design, the *social* curriculum design and the *personal* curriculum design. She also shows how each curriculum design model is related to educational goals, source of content and structuring elements, as summarised in Table 1 on the next page. The following brief presentation of the ideologies represented by each curriculum design model is, unless otherwise specified, based on Zuga (ibid.).

Design	Goals and Purposes	Content Source	Structuring Elements
Academic	Transmit cultural heritage	Constructs and concepts	Taxonomies
Technical	Develop occupational proficiency	Observable behaviours	Task analyses
Intellectual Processes	Improve thinking and problem solving abilities	Cognitive processes	Problem solving and trouble-shooting processes
Social	Reconstruct or adapt to society	Societal needs or successful work behaviours	Social problems or work adjustment skills
Personal	Motivate, personal interest in learning	Student interest – within subject content	Student research and projects

TABLE 1. Curriculum design models on technology education. (Zuga 1989, p. 12).

The *academic curriculum design* is based on academic rationalism and represents traditional approaches to academic fields of study (Eisner & Vallance 1974). It focuses on a body of knowledge that is grouped into disciplines, subject matter or broad fields, and may hence be seen as embracing subject-centered approaches to education. The curricular content in the academic curriculum design model is identified by fundamental constructs and concepts in the disciplines, organised by the discipline's 'taxonomies' (Bloom 1956) or its conceptual and syntactical structures (Schwab 1974) earlier discussed.

These approaches have been subject to major criticism for failing to place the learner at the focus of education. This criticism was particularly strong among progressive educators in the 1970s; promoting approaches that can be characterised as based on social or personal curriculum design models. Nevertheless, the academic curriculum design is still predominant in many school curricula today.

A *technical curriculum design*, also entitled a competency-based approach (Herschbach 1992), is highly influenced by behaviour psychology. The emphasis is on performance or processes. These may be practical or cognitive, but both content and evaluation rely on observable behaviours.

The organising elements of a technical curriculum design are the description and sequencing of behaviour outcomes, rather than the subject matter found in the academic design. The design of a curriculum within the technical or competency-based paradigm follows an 'end-means' model (Herschbach 1992), and starts with identifying the objectives or the desired 'end product' in which education aims. Following Tyler's (1949) ideas for curriculum construction, the other elements of the curriculum, that is, selecting appropriate content, organising instruction, and criteria for assessment will follow from the objectives.

Though subject matter, understood as content knowledge from various disciplines, appears in a technical curriculum design as well as in the academic one, the *role* of this knowledge is different. In a technical curriculum design the content knowledge is a means rather than end, and the selection of content will depend on what is needed for reaching the specific performance or competence represented by the decided objectives.

The technical curriculum design has been the foundation of traditional vocational education, where the main objective is to prepare people for specific jobs. However, ideas from this type of curricular thinking do appear in education far outside what we denote as 'technical education'. Its emphasis on what the learner should be able to *do* as a result of the teaching, rather than what subject matter the teaching should *cover* can be recognised in the current curriculum for compulsory education in Norway, which reveals the policy of steering by means of goals (see Klette 2000).

Intellectual processes as a curriculum design has its main focus on the development of cognitive processes, with less emphasis on the context and content of the learning situation. The ideas underpinning this design have arisen as a reaction to curricula that encourage rote memorisation of a vast number of facts and concepts. Further, the rapid changes in the knowledge and skills needed by workers have promoted a search for conceptualisations of more general intellectual skills (Johnson 1992). Teaching based on this curriculum design aims at developing generic process skills such as understanding and defining problems, abilities in problem-solving and critical thinking and also human traits such as creativity, ability to learn and self-confidence. The role of the teacher in a curriculum with focus on intellectual processes is not to transmit information to the learner, but to facilitate learning experiences that support the learning of the desired process skills. The underlying assumption of this curriculum design model is the transferability of these process skills across various contexts. In the case of science education, intellectual processes as curriculum design may be recognised within approaches to the teaching of a 'scientific method' and 'science processes'. These

approaches have been subject to extensive criticism (e.g. Millar and Driver 1987, Hodson 1996, Murphy & McCormick 1997), questioning the assumptions that intellectual processes can be identified and learnt, that they are generic and content free, and their transferability across different contexts and knowledge domains. As will become evident in a later section, similar criticism has been raised against the process approach that was developed within Design & Technology as a subject in England and Wales.

The *social curriculum design* concentrates on realistic or real-world situations and the relevance of knowledge in these. It covers different assumptions, which may be represented by the extremes of the tension between preserving society and transforming society described earlier in this chapter. One assumption, inherent in theories of social reconstructivism, is that educating young people can change the future of society. A curriculum based on this assumption will address current societal problems and encourage and stimulate pupils to engage actively with them. The focus is more on the society than on the individual, and education becomes an agent for social change. A contradictory assumption is the students' need for adapting to the same society and conforming to existing social values. This focus on adaptation is commonly found in curricula of vocational education with the aim of preparing students for occupations. It may also be present in more general curricula that attempt to provide the tools for individual survival. Both of these interpretations of a social curriculum design will have social problems as structuring elements. The content knowledge addressed in the teaching will depend on what is considered relevant for solving, or living with, the social problems.

The *personal curriculum design* is learner-centered and focuses on the pupils' needs and interests. The emphasis is on personal growth, self-actualization and on giving the pupils possibilities to discover their unique identities (Eisner & Vallance 1974). The nature of a personal curriculum design leaves much of the control of the curriculum to the individual learner, and the transfer of control is regarded as one of the primary goals of education. Hence, the structuring elements are the pupils' individual research and projects, and the role of the teacher becomes that of a facilitator, to help the learner identify interests and find appropriate learning resources. The development of learning experiences is governed by participation, integration and relevance and based on the goal of developing the whole person within a human society and on the view that 'the self' is a legitimate object of learning (Petrina 1992). According to Zuga, real representations of a personal curriculum design are rare, though its inherent ideas may be represented in the rhetoric of many curricular documents on technology and other subjects.

Zuga's framework of curriculum design models captures fundamental differences between the various educational ideologies underpinning curricula in technology education and more generally. In the empirical study presented in this thesis, it forms part of the analytical tools utilised for analysing how teachers express their rationale for technology teaching.

Political perspectives: Arguments and stakeholders for technology education

Creating a school subject and its curriculum is a highly political endeavour, perhaps more than it is an epistemological issue (Petrina 1998, Hargreaves *et al.* 2001). For technology as a newcomer in the curricular landscape it is especially important to consider the various arguments and stakeholders that may influence the political process of clarifying its place in compulsory education. The arguments used for introducing technology as a new subject are also fundamental in defining its content. Based on McCormick (1992) and Layton (1993), possible arguments for technology education for all pupils may be classified as follows.

The *economic argument* addresses the importance of technological knowledge in work life, and involves both an individual and a societal aspect. Technology provides important career opportunities for young people, and the *individual aspect* of the economic argument entails that technology should be represented in their general education for motivation purposes as well as for providing a basis of knowledge and skills on which to build further technological education. Additionally, pupils clearly need some *experience* of technological activity in order to make informed career choices (Medway 1989). In particular, this might be important for girls. As noted by Wajkman (1991), women as a group lack the practical experience upon which inventiveness depends, and are consequently excluded from ownership of capital. Technology teaching for all pupils may thus be promoted from a feminist perspective, as it may contribute to economic liberation of women.

The *societal aspect* of the economic argument involves promotion of technology teaching based on concerns for the society's overall economy. The view is that technology teaching in schools will enhance recruitment, and give pupils a 'head start' to technological careers and so contribute to the nation's economic competitiveness. It is, however, argued that international comparisons do not offer any clear evidence for the benefits of various forms of technology teaching on a nation's economic development (Medway 1989, McCormick 1992).

Another aspect of the argument concerns the status of practical subjects like technology in schools. Since practical work traditionally has a lower prestige than intellectual work, and the choice of practical subjects in schools is thus often associated with less able pupils, too few able students are recruited into technological education and industry. The inclusion of technology as a compulsory subject in schools may enhance the status of technology and hence make technological careers more attractive to young people. This aspect of the economic argument was of major concern in the process of placing technology on the educational agenda in English schools during the 1980s (see e.g. Medway 1989, Allsop & Woolnough 1990).

An argument described as *political* is added to the societal aspect of the economic argument (Layton 1993), with reference to those pupils who find meaning and relevance in their study only to the extent that these are practical and related to the world outside school. With these pupils in mind, technology teaching is seen as one way of making education in general more motivating and relevant. It is believed that technology as a school subject will counteract the rising number of unemployable, disillusioned and alienated young people who would constitute a socially destabilising force.

A *social argument* arises with the consideration of the societal impact of technological development. The ability to understand and control technology is seen as a crucial element of modern citizenship. This social argument is also widely used for the teaching of *science* to all pupils, as many challenges in controversial issues, like the use of natural resources, protection of the environment and judgement of health risks and safety, are seen as caused by scientific development. It is, however, argued that it is technology, not science, that is in question in these important societal issues, and that viewing them as based on science is equivalent to assuming an outdated view of technology as applied science (Layton 1988, p. 375).

The transformatory power of technology on lifestyles and human values also gives rise to a *cultural argument* for technology as a subject in general education. Recognition of the cultural aspect of technology (Pacey 1983) leads to the view of technology not only as an activity *influencing* culture, but also as a significant *component* of culture in itself. This clearly should allow technology a place in general education for cultural reasons. As Medway (1989) states, “*to be ignorant of technology is quite simply not to be fully educated*” (p. 3).

Technology teaching in schools is also promoted on the basis of *educational arguments* (Medway 1989, Gilbert 1992), and of the *intrinsic value* of technology as a school subject (McCormick 1992). Technology teaching is seen as providing

an arena for pupils to acquire general human abilities such as independence, self-esteem and co-operation skills and thus supporting the attainment of general educational goals (Gilbert 1992). The argument also includes a concern for pupils whose ability goes more in a practical than intellectual direction, as an enhanced appraisal of practical skills in school might provide for their motivation and be beneficial to their self-respect.

An argument of *practical utility* of technology education may be added to the arguments reviewed above. This argument has traditionally been used for justifying the position of *science* as a school subject for all pupils, and has in that connection been formulated in the following way:

The utilitarian argument:
everyone needs to understand some science to manage the technological objects and processes they encounter in everyday life.

(Thomas & Durant 1987, cited in Driver *et al.* 1995, p. 11)

The validity of this argument for science education is highly questioned. This is due to the paradox in the technology we encounter in everyday life: scientific knowledge may be important in developing principles and production of new technology, yet – as Chapman (1991) puts it – it does not follow that understanding the science of a technology is a necessary prerequisite for applying it (p. 53). Chapman ascribes the ignorance of this paradox to what he calls “the overselling of science education”. For similar reasons, Sjøberg (1997, 1998) points out that the argument of practical utility (and to some extent the economic argument) upheld for science education in fact is more valid for technology as a subject in schools. Hence, it seems reasonable that practical utility deserves a place on the list of arguments for the inclusion of technology in general education.

With a utilitarian perspective on technology, Hansen (1997) undertakes an interesting examination of the background for what he describes as the exclusion of technology education from the “curriculum mainstream” (p. 111). He claims that the “knowledge hierarchy” values academic curricula over utilitarian curricula, and that behaviourism has influenced educational thinking on the expense of learning through experience. The rather peculiar conclusion may hence be drawn that utilitarian arguments for technology education in fact can be *counteractive* to the establishment of technology in the school curriculum. Accordingly, Lewis (1995) has upheld that at a time when academic rigour is increasingly being called for in the school curriculum, technology “has to be positioned as an academic not a vocational subject” (p. 639). This mirrors what Tiles and Oberdiek (1995) have described as a conflict between utility and intellectual status in the 19th century

struggle for establishing the experimental sciences as disciplines alongside the classics at universities. They claim that attempts to push for status on utilitarian grounds tended to *undermine* their credentials as intellectual disciplines suitable for inclusion in universities (p. 74).

The various arguments for technology teaching reviewed above are upheld by different social, political and professional interest groups. These groups, or 'stakeholders', have different motives for advocating the advancement of technology as part of compulsory education for all pupils. As their motives differ, their influence on the process of shaping technology as a school subject will be exerted in correspondingly divergent directions. Consideration of potential stakeholders is thus important for understanding the process of establishing technology as a school subject. Layton (1994) gives an overview of potentially important stakeholders in this regard. A major group of stakeholders is classified as *economic instrumentalists*, advocating the economic argument. These may include a country's government, industrial companies and other public or private institutions concerned about a nation's economy. They see education in general – and technology education in particular – as an appropriate instrument to maintain or improve economic competitiveness. Influence by economic instrumentalists may support technology education with a strong vocational profile, but it may also encourage technology as a more general educational subject, in order to enhance the cultural status of technology as a societal agent. *Communities of professional technologists* may support technology education in terms of the same economic instrumentalism, but they may also see it as an opportunity to improve the professional image of technology and the standing of engineering in society and thus strengthen the support for their activities (Jenkins 1997a). Of special interest to technologists is countering the view of technology as merely applied science, and hence improving their status as autonomous professionals.

Stakeholders may also be found among various community groups such as *environmental protectors*, *liberal educators* and *defenders of gender equity*. Their concern will be both to enhance the rights of people to participate and control technology, and the responsibility of every individual to contribute to the well-being of our common world. These stakeholders are likely to support technology teaching with a strong societal and critical profile.

Another important stakeholder is represented by *teachers and teachers' organisations*. They may promote the inclusion of technology in the curriculum for a variety of reasons, including those presented above. Their interests may also be more specifically directed towards the everyday work situation for themselves and their pupils. They may emphasise the intrinsic values of technology (McCormick 1992),

and experience technology teaching involving practical activities as an excellent way of bringing variety into a commonly academic school agenda. In addition, they may appreciate technology teaching as a general motivational factor for the school as a whole.

Internal fractions of the education community may also carry interests in technology education with regards to their specific disciplines. These interests are related to employment possibilities, prestige and resources within their field of work. For academic disciplines like mathematics, science and the humanities, involvement in technology education may have its source in *instrumental academic specialism* (Medway 1992). A demonstration of their relevance to modern technology may rehabilitate the educational legitimacy of classical disciplines. Traditional craft disciplines may encounter corresponding possibilities to modernise their subject and improve its status through technology teaching.

The formation of technology as a school subject in Sweden constitutes a noteworthy example of how interests related to existing subjects may influence the formation of a new subject. In an analysis of the process of defining technology as a compulsory subject in Swedish schools, Riis (1996) poses the question “can one own a school subject?” (“*kan man äga ett skolämne?*”). She describes how the shaping of the subject turned from being an area of curriculum development into a political ‘battle’ between conflicting interests of educators from a former technical subject, from science and from craft. A somewhat similar ‘battle’ between educational stakeholders could be seen in the process of establishing technology as a school subject in England and Wales in the 1980s (see e.g. Medway 1992, McCormick 1994).

On the other hand, representatives of existing subjects may also constitute stakeholders that *oppose* the establishment of technology as a subject, as they may find the position of their own subject threatened in terms of economic resources, prestige and recruitment of able students. Goodson and Dowbiggin (1994) give an example of the influence of such an opposition on the process of introducing technical subjects such as industrial education, commercial studies and domestic science in a secondary school curriculum in Canada. Although the case is around a century old, the mechanisms may still apply in today’s educational setting and it is worth considering in attempts to understand curricular development.

Approaches to technology teaching in schools

The philosophical, ideological and political perspectives presented in the previous sections provide for a variety of approaches to technology as a subject of teaching in schools. Accordingly, a range of traditions, movements and initiatives within technology teaching exist, each with their emphasis on different aspects of technology and its educational purposes. Though technology as a school subject is seen as a recent invention in many countries, its development often draws on traditions and movements that have gone before. This part of the chapter briefly reviews some international approaches to technology teaching, and the traditions and movements that have been their precursors.

The content and organisation of technology curricula in specific countries will not be surveyed, but are available elsewhere (e.g. UNESCO 1994, Williams 1996). The following presentation rather seeks to capture the underlying rationales of the different approaches to technology as an educational subject or topic. An exception is the specific school subject *Design & Technology*, taught in compulsory education in England and Wales. This subject has functioned as a model for the attempt to introduce technology as a subject of teaching represented by the TiS project. It is thus crucial for the analysis of empirical data in the present study to conceptualise the characteristic features and underpinning ideas of this subject. The following section attempts such a conceptualisation, and also presents the background of the subject and aspects of how the subject has developed since its introduction in the school curriculum in England and Wales 1990. The subsequent sections briefly reviews *other* main approaches to technology teaching in schools, including technology in a science framework, the STS movement and technology teaching developed from traditions of craft and vocational training.

Design & Technology in England and Wales

A design approach to the teaching of technology in general education arose with the subject '*Design & Technology*' developed as a compulsory subject in England and Wales in the late 1980s. With origins in the traditional subject areas Craft, Design & Technology (CDT), Science, Art & Design, STS and Home Economics, it developed in a rather radical direction through the process of curriculum development (see Black 1995, Layton 1995). The new way of thinking and implementing technology as a subject in general education functions as a model and inspiration for many educators concerned about technology education in other countries (de Vries 1994), including the Norwegian teaching project that constitutes the context for the empirical part of this study.

As is the case in other countries, technology in England and Wales lacked both a predestined place in school traditions and also a well-established academic field of study to draw upon. This made the construction of a curriculum on technology a long process influenced by a range of stakeholders with different and sometimes contradictory intentions (see e.g. Barnett 1992, Medway 1992, Layton 1995, Kimbell *et al.* 1996). Medway has proposed three possible main motivations for the establishment of technology as a compulsory subject that was given a relatively great prominence in the curriculum. Firstly, the motivation might have been of economic nature, due to a concern about the country's lack of competitiveness and enterprise. The curricular innovation might be influenced by a belief that the economic situation of the country would benefit from vocationalizing the secondary curriculum that so far had been dominated by academic subjects. This motivation might include an attempt to change attitudes represented in what Wiener (1981) has characterised as a prevailing gentlemanly culture where work related to industry and practical activity has low status, causing a decline of the industrial spirit and hence economic development and competitiveness. Secondly, the new subject might be an expression of an instrumental academic specialism, by replacing classical subjects with subjects with higher relevance to modern work life. Technology as a subject might meet a need for a subject which would be both intellectually taxing and legitimate in the eyes of a generation of career-minded students and their parents. Finally, Medway identifies the motivation for the subject as a concern for 'the rehabilitation of the practical' (Layton 1984), anticipating that technology as a compulsory practical subject for all pupils would contribute to an increased prestige of practical work and human abilities in practical rather than in intellectual directions.

During the development the name of the subject changed from 'Technology' to 'Design & Technology', and 'Information technology' was transferred from being an element of the technology subject to an independent subject in itself. This signalled an increased focus on the design part of the subject, due to what Medway (1992) refers to as a pressure from the 'design lobby' rather than a process of searching philosophical analysis.

The formulation of the subject also changed in other concerns. Barnett (1992) has shown how a rather broad view of technology as a field of teaching including societal aspects, knowledge about industry and realistic preparation for work life, was narrowed down to essentially designing and making artefacts. However, through designing and making, a wide range of knowledge and considerations was meant to be taken into account, not merely technical knowledge but also value considerations in technological development as well as communication skills.

When Design & Technology was first presented as a subject in the National Curriculum (DES/WO 1990) it had a strong process profile, corresponding to Zuga's (1989) category of 'intellectual processes' as curriculum design. The subject was defined and assessed in terms of pupils mastering of a *design process* and development of a *technological capability*. Kimbell (1997) defines this capability as the "combination of skills, knowledge and motivation that transcends understanding and enables pupils creatively to intervene in the world and 'improve' it" (p. 46). The knowledge and skills involved in the teaching activities were viewed as means rather than ends of the pupils' activities. Correspondingly, the intention with the subject was not to make pupils *study* technology as a body of knowledge, but rather *act* as technologists. The contexts in which pupils were to 'act as technologists' were to be identified in a range of differing contexts, making the subject cover activities within areas as diverse as cooking, electronics, textile work, architecture, mechanical constructions and urban planning. The unifying structure of the subject hence became the 'design process'. Process approaches are well known from other subjects like science and mathematics, and attempts to conceptualise a 'technological method' parallel to 'scientific method' for the purpose of teaching have also been made (see Cross *et al.* 1989). Unique for the technology curriculum developed in England and Wales compared to the above mentioned subjects, however, was that the process was *defining* technology as a discipline (Kimbell 1997, p. 47). In terms of Bernstein's (1971) concepts presented in Chapter 3, the process approach in Design & Technology can thus be seen as imparting an exceptionally strong integrated code to the subject.

As the curriculum for Design & Technology was developed in the period of establishing the National Curriculum with its focus on standardised assessment criteria and procedures, assessment procedures became essential for identifying the subject's identity. These issues were explored by the APU (Assessment of Performance Unit) group for Design & Technology, and are thoroughly treated by Kimbell (1997). The 'Attainment Targets', which constitute the elements of pupil assessment, were originally formulated as (DES/WO 1990):

- AT1: Identifying needs and opportunities
- AT2: Generating a design
- AT3: Planning and Making
- AT4: Evaluating

All four attainment targets were supposed to be represented, and assessed, in every teaching activity in Design & Technology. This means that pupils were supposed to identify needs and opportunities for a technological product in a specific area

(AT1), develop their ideas and a design for the product (AT2), plan their work and make their product (AT3) and finally evaluating their product (AT4) according to criteria set in their design and whether the product is appropriate to fulfil the needs identified. However, the attainment targets caused a major confusion among teachers, due to uncertainty on whether they were to be understood as subsequent steps in a design process, domains of knowledge or simply an organisation of learning activities.

The process approach also initiated a discussion on what is the nature of the design process. A variety of theoretical models of the process were suggested (see Johnsey 1995 for an overview). As shown earlier, the assumptions underlying intellectual processes as a learning target in itself have been highly questioned. This is also the case regarding the 'design process' promoted in Design & Technology. Questions regarding the existence and transferability of the design process have been raised by many (e.g. Chidgey 1994, Johnsey 1995, Murphy & McCormick 1997), with an inherent critique of the approach to technology teaching represented by the subject.

The focus on a specific design process has also been criticised from other perspectives. It has been argued that the subject fails to take into account the high degree of specialisation in the world of work and hence creates an artificial image of technology as a professional activity (Medway 1992), that different design tasks require different strategies and that the subject does not acknowledge pupils' individuality (de Vries 1996). It has also been suggested that the emphasis on a design process has caused an intellectualisation of the subject, and that, rather than contributing to the 'rehabilitation of the practical' (Layton 1984), the rise of technology as a school subject has been at the expense of practical subjects (Layton 1995). The latter may be due to the combined effect of the focus on design and the one on formal assessment. In order to provide evidence for the design process, pupils use a considerable proportion of time in the subject to make drawings, models, reports and other presentations of their work. It is argued that the design process thus evolved towards a series of products in the classrooms (Kimbell 1997).

Perhaps influenced by some of the critique referred above, the process approach in Design & Technology has been modified in later revisions of the National Curriculum for England and Wales (DfE/WO 1995, DfEE/QCA 1999, DfES/QCA 2000). The four attainment targets were reduced to two, denoted Designing and Making respectively. The connection to a design process was thus diminished, yet the issue is still being addressed in discourse related to the subject (see e.g. Sayers *et al.* 2002).

The curricular content in Design & Technology is specified as *Programmes of Study* in the curriculum guidelines. In the 1995 version of the guidelines¹, these were assigned within three main areas; Designing skills, Making skills and Knowledge and understanding (DfE/WO 1995). According to the specifications, pupils should be taught to develop their design and technology capability through combining Designing and Making skills with Knowledge and understanding in order to design and make products. With increased complexity during the school years, *Designing skills* entail skills such as development of ideas, clarification and communication of ideas, generation of design criteria and design proposals including consideration of properties of materials, costs, functionality, safety and aesthetics as well as the needs and values of intended users of the product. *Making skills* embrace skills such as selection, accurate use and combination of materials, tools, equipment and processes, evaluation of products according to specified criteria and simulation of industrial applications such as assembly lines and manufacturing in quantity. The curriculum area *Knowledge and understanding* specifies subject matter to be incorporated in the pupils' designing and making activities. Table 2 summarises the contents of this area at the four different Key Stages (KS 1 - 4) in schools. Examples of what they embrace will be given in the following.

KS 1 year 1 - 2 (age 5 - 7)	KS 2 year 3 - 6 (age 7 - 11)	KS 3 year 7 - 9 (age 11 - 14)	KS 4 year 10 - 11 (age 14 - 16)
mechanisms	materials and components	materials and components	materials and components
	control	systems and control	systems and control
structures	structures	structures	
products and applications	products and applications	products and applications	products and applications
quality	quality	quality	quality
health & safety	health & safety	health & safety	health & safety
vocabulary	vocabulary		

TABLE 2. Specifications of *Knowledge and understanding* as specified in the National Curriculum for England and Wales 1995 (DES/WO 1995).

¹ The 1995 version of the curriculum is given some attention here, as this curriculum applied when the TiS project was established.

Mechanism in KS1 is specified as the use of simple mechanisms such as wheels, axels and joints that allow movements. *Materials and components* contains the properties of materials, how they are classified and how they can be shaped and combined in the making of products. In Key Stage 4 it also involves how pre-manufactured standard components are used to improve the effectiveness of the manufacturing process. *Control* (KS 2) and *Systems and Control* (KS 3 and KS 4) address how movement and systems can be controlled by means of mechanical, electrical, electronic and pneumatic devices. This also includes concepts such as inputs, processes, output and feedback as well as strategies for investigating and ensuring the performance of systems based on these concepts. *Structures* involves the ability to recognise and use structures, to make them more stable and withstand greater loads and techniques for reinforcing and strengthening structures that have failed. *Products and applications* addresses intended purposes of products, the choice of materials and components as well as their availability, how products are produced and the scientific principles utilised, and consideration of alternative products and solutions. The purpose of products is also addressed in the area denoted *Quality*, which entails the products' fitness for purpose, its effectiveness and use of resources and possible impacts beyond its purpose, for example on the environment. *Health and safety* is about recognition of risks and hazards in the making and in the use of a product, how to utilise sources for safety information and how to respond to risks and hazards. In the two lowest Key Stages, *Vocabulary* is also included, involving teaching pupils appropriate use of vocabulary for naming and describing the equipment, materials and components they use.

The placement of *Knowledge and understanding* as a specific area in the Programme of study suggests that conceptual and technical knowledge is seen as intended learning outcomes in *themselves*, besides contributing to the pupils' designing and making skills. This represents a deviation from the original specification of the subject, where knowledge and skills were seen as means rather than ends. In the specifications of Design & Technology in the current curriculum guidelines (DfES/QCA 2000), many elements of the area *Knowledge and understanding* are incorporated into the specifications for what pupils should be taught in designing, making and also evaluating products. The curriculum elements are now grouped into four areas:

1. Developing, planning and communicating ideas
2. Working with tools, equipment, materials and components to make quality products
3. Evaluating processes and products
4. Knowledge and understanding of materials and components

The revision has not altered the contents of the subject significantly, but the organisational changes may signify that the curriculum now reflects a view where knowledge and understanding are more closely connected to the activities of designing and making.

Common to the versions of curriculum of Design & Technology reviewed above is the emphasis on pupils' development and communication of ideas for marketable technological products or improvement of existing products in a range of areas. This does not, however, imply that pupils constantly invent new types of products intended to solve yet unsolved problems. Teaching activities may, for example, involve the design of novelty chocolates (see RCA STP 1995), where pupils' design has to take into account existing products on the market, techniques for working with chocolate, safety regulations, the range of chocolate flavours available, the customer's wants, mass production and packaging of their product.

A related characteristic of the subject is the prominence given to the visual expression and communication of ideas for technological products. This entails a focus on drawing skills and pupils' development of 'design briefs' in the subject. This focus comes to expression in the pupils' 'folios', which are seen as an important aspect of Design & Technology by a majority of teachers (Mittell & Penny 1997). This emphasis on visual communication is grounded in the commercial rationale of the subject, which relates to the economic argument for introducing the subject in schools in England and Wales. Pupils are trained in evaluating and developing the commercial potential of their products, and in strategies for marketing products. These issues are heavily attended to in some textbooks in the subject (e.g. Clarkson *et al.* 2002).

The relation to *Science* has been an important tension in the development of Design & Technology as a subject in England and Wales. Science and aesthetic design can be seen as representing opposite ends of one dimension of the space occupied by technology in the curriculum (Donnelly 1992). An initial requirement of "always involving science and mathematics" (Barnett 1992, p. 86) suggests a placement of Design & Technology as a subject towards the 'science end' of this dimension. This was confirmed in early policy documents which stated that "links between science and CDT (Craft, Design and Technology) were vital at secondary level and that science and technology formed a continuum at primary level" (Layton 1995, p. 90). However, the placement along the mentioned dimension seems to have been subject to a radical shift during the decade the subject has existed, as later policy statements emphasise the "the distinctiveness of design and technology and its differences from science" (*ibid.*, p. 100). This lack of co-ordination between the

content of the two subjects is also found to be the case in the teaching practice in English schools. In direct contrast to how science and technology are related in the world outside school, a recent research report on the relation between Science and Design & Technology exposes an almost complete lack of connection between the two subjects (Barlex & Pitt 2000). One reason for this may be the fading of the relationship in policy statements and the formal curriculum. Further, the lack of interaction may be due to organisational factors that do not facilitate co-ordination across the curriculum. However, the situation described might also be a consequence of the fallacy of the idea that knowledge obtained in a general decontextualised form is applicable and transferable to new practical contexts, as pointed out by Layton (1991). These issues will be briefly discussed in the following section that regards technology teaching placed in a science framework.

Technology in a Science framework

The close relationship existing between modern science and technology may make the teaching of science and technology in a shared classroom a natural choice. Various approaches in curricula and teaching are identified and promoted, and their limitations and challenges discussed (Allsop & Woolnough 1990, Gilbert 1992, Layton 1993, Fensham & Gardner 1994, de Vries 1996, Cajas 2001).

The presentation in chapter 2 revealed a diversity of opinions on the nature of the relationship between science and technology. The diversity spans from a view of technology and science as distinct and mutually exclusive forms of activity and knowledge, through positions of treating technology as applied science, as preceding science or as forming a ‘seamless web’ with science, to the opinion that the two traditions are divided mainly as a result of social organisation. To the extent that the teaching of science and technology is to mirror the relationship of these areas of human endeavour in history or contemporary society (in itself not a matter of course), this span implicates a corresponding range of possible curricular approaches. Based on Gardner’s (1994) four different positions on the relationship between science and technology presented in Chapter 2, Fensham and Gardner (1994) synthesise teaching approaches into four categories, each reflecting one of the positions in Gardner’s framework.

The hierarchical dependence model of technology as *applied science* is reflected through teaching approaches labelled as *science before technology*. They often involve using technological artefacts and principles as *applications* of the scientific content in order to demonstrate its relevance. Technology may also serve as motivation for the science content. However, these applications are often added on without really acknowledging the entire knowledge base and the development of technology in itself. Thus Fensham and Gardner argue that these approaches may

be historically inappropriate, and that they seldom do justice neither to the wide range of knowledge inherent in technological advancement nor to the richness of science actually involved in many technological systems (ibid., p. 163).

The *materialist* view of science and technology views technology as preceding science. A corresponding teaching approach implies the teaching of *technology before science*. This approach differs substantially from the former, not only as a matter of order. It has major consequences for science curricular content, as the chosen technology will serve as a context that defines what science should be taught and what should be left out. According to Fensham and Gardner, the view of technology as preceding science is not frequently present in curricula and teaching, except as initial presentations of technology as motivational factors for the real agenda: the scientific content.

The *demarcationist* view of science and technology as two different fields of activity finds parallel school provisions in approaches Fensham and Gardner refer to as *science and technology as independent*. These approaches acknowledge the view of technology as having an independent knowledge base. They entail a separation not only of domains of knowledge and teaching activities, but also between social groups engaged in science education and technology education. These social structures may in turn lead to exclusion of relevant science from technology curricula, as well as a lack of substantial links to technology in science teaching.

Approaches to the teaching of *science and technology in partnership* attempt to reflect the *interactionist* view of science and technology. These teaching approaches seek to establish a balanced treatment of technology as constituting a task, and science as one resource for performing the task. Science knowledge is meant to be not only a learning target in itself, but also a resource in a technology context, and for developing what has been called pupils' task-action capability (Black & Harrison 1985, see also Black & Harrison 1994). A partnership approach may seem attractive, as it reflects the view of a 'seamless web' seen by many as an appropriate portrayal of the relationship between science and technology (Hughes 1986, Layton 1993). Its idea of integrating knowledge in meaningful context may also seem attractive from a pedagogical point of view. Considering the learning outcome for pupils, the effect of subject integration is, however, inconclusive in terms of conventional subject matter knowledge (Ross & Hogaboan-Gray 1998) as well as in terms of technological problem solving abilities (Childress 1996).

Some of the problems indicated within several of the approaches above appear to be attributable to a certain characteristic of conceptual knowledge of the kind

taught in school science. This characteristic has to do with the transferability of conceptual knowledge and its applicability in practical contexts. Although much modern technology is unalterably connected to science, knowledge learnt in school science is often on a general decontextualised form that pupils can not automatically apply in practical or technological settings in a straightforward way. Drawing on perspectives on cognition and learning as contextually situated (see Rogoff & Lave 1984), Layton (1991) suggests ‘translating’ or ‘reworking’ of scientific knowledge as more appropriate than the familiar expression of ‘applying’ science’ (p. 67). He proposes transformatory strategies in order to make scientific knowledge function as a resource for technology teaching. Firstly, the *level of abstraction* must be adjusted, making it appropriate for practical action rather than for theoretical understanding. The problem-centered nature of technology requires also a *repackaging of knowledge*. Practical tasks do not follow the academic boundaries of disciplines, and knowledge of several fields needs to be brought together and integrated before it can be used in a technological context. Scientific knowledge relevant for the context hence needs to be *reconstructed* according to the demands of the context. This reconstruction may include invention of new concepts that are more operational in a technological context than the academic ones. For science knowledge to be functional for technology, it also needs to be *contextualised*, bringing back the ‘problematic data’ (Staudenmaier 1985) and real-life ‘complications’ that normally are eliminated from the teaching of ‘pure’ science.

STS – Science, Technology and Society

STS (Science, Technology and Society) as a movement in science education has developed from several different origins and with different objectives. Common to the diversity of ideas for teaching and curriculum development under the label of STS seem to be attempts to meet the challenges brought about by the following paradox: as science and technology are becoming increasingly important in changing society and peoples' lives, many pupils simultaneously experience school science as irrelevant to their present and future lives.

The STS movement developed during the 1960s and -70s, as a result of the increasing consciousness on the importance of science and technology in social and environmental issues. The world had seen disastrous consequences of development in science and technology, like the use of nuclear weapons and destruction of the natural environment by industrial pollution. STS, initially brought to the scene as an academic field of study, is hence seen to be ‘born of war’ or as a reaction to the ‘rape of the environment’ (Solomon & Aikenhead 1994). The importance of knowledge, awareness and engagement among the public was addressed, and the crucial role of the educational system in this concern soon became unquestionable.

Concrete initiatives like the British teaching projects ‘Science in Society’ and ‘Science in a Social Context’ (SISCON and SISCON-in-schools) gave momentum to the STS movement in schools during the 1970s (see Solomon 1993). Aikenhead (2003) gives a thorough exploration of other contributors and influences on the STS movement.

From a science education perspective, the ideas inherent in the STS movement may be regarded as a movement along two dimensions. It represents a movement from the teaching of science for an elite, meaning the future scientists, to the teaching of science for all pupils. Changing the focus towards a broader vision of the receivers of school science knowledge initiates a movement along another dimension, the dimension of curriculum content and objectives. In STS, we find a movement from a content determined by science itself, to a content motivated by the need of society or of the pupil as an individual. In terms of Zuga’s (1989) framework as earlier described, this represent a shift from an academic curriculum design towards a social curriculum design.

A range of approaches to the teaching of science and technology has been identified under the headline of STS education, for example in the writings of Ziman (1980) and Fensham (1988). Some approaches mainly function as a way of making science teaching more relevant and appealing to pupils, while others have societal issues related to contemporary science and technology as a point of departure. Others again emphasise historical, sociological or philosophical aspects of science and technology. Teaching with a focus on the technical aspect (Pacey 1983) of technology is not considered among the approaches to STS education identified by Ziman. They are, however, included as what Fensham refers to as ‘technology-determined’ STS approaches which he contrasts to ‘science-determined’ and ‘society-determined’ approaches. This suggests a dissension on whether technical aspects are regarded as part of a STS curriculum. The STS movement has also been criticised for failing to consider technology in other regards. Arguing that technology has not gained its deserved position in the societal issues brought into focus by STS curricula and teaching material, Layton (1988) has advocated a ‘revaluing of the T in STS’. He maintains that STS activists have uncritically assumed an outdated view of technology as applied science, and underrated the importance of technology in societal issues. The relevance of viewing STS as a gateway to *technology* education may hence be questioned.

The STS movement has significantly influenced science curricula and science teaching world-wide, yet it has been argued that STS material has not altered school science substantially but rather served the function of supporting and enriching otherwise conventional schools science courses (Jenkins 1992). Ideas

from the STS movement can also be recognised within more current trends in science education associated with the catchwords ‘Science for Citizenship’, ‘Public Understanding of Science (and Technology)’, and ‘Scientific and Technological Literacy’ (see Aikenhead 1997 for a discussion of the common grounds of the latter and STS). The ideas underpinning STS are also evident in curricula for compulsory education in Norway (KUD 1987, KUF 1996).

Technology from craft

A view of technology as man’s effort to transform natural resources into useful artefacts may link technology teaching to craft. Hence, practical craft subjects may be seen as obvious forerunners for technology education (see Eggleston 1996, de Vries 1994). They customarily involve the use of materials and tools in purposeful activities of creating or maintaining artefacts or machines. The materials and tools may be traditional or of a more modern character.

The Nordic countries have long traditions in teaching a practical non-vocational subject called ‘sløyd’, commonly regarded a specific approach to technology education by international surveys (e.g. UNESCO 1994). This subject involves traditional handicraft and work with manual tools in creating artefacts mainly from wood (though ‘metal sløyd’ once was also an option at schools, as well as ‘physics sløyd’ which involved electrical devices and the like). The main identity of the subject has had little bearing on utilitarian aspects, industrial production or training for work. Rather, it has been directed towards upholding a cultural heritage of handicraft, and has – with a touch of irony – been labelled ‘Christmas present production’. The traditions and activities of ‘sløyd’ are now incorporated in the subject Art and Crafts in Norwegian schools.

In making comparisons or transfer of curricular ideas between countries, translation of the term ‘technology’ is a source of confusion. As briefly discussed in Chapter 2, the term has various meanings and also carries different connotations and associations in different languages. The incorporation of what is meant with *technik* in the notion technology in English language (Fores & Rey 1979, Hörner 1985) makes the meaning of ‘technology teaching’ correspondingly ambiguous.

Sjøberg (1995) indicates that these divergent meanings of a translated word contribute more to chaos than to diversity in international discussions on technology education, and he notes the absurdity of subsuming both ‘sløyd’ and the broader Norwegian subject ‘forming’ (a former version of Art and Crafts) under the concept of technology. These subjects can be regarded as covering some strands of *technik*, but they are commonly seen – in the words of Sjøberg – as the *opposite* of what many Norwegian pupils, teachers and parents would consider as

technology (p. 24). The opposition indicated signifies that ‘technology’ is commonly associated with *modern* and fairly *advanced* artefacts and activity, while the craft subjects in question carries a character of artefacts created by means of *traditional* and hence more simple techniques.

Technology from traditions of vocational training

Technology education understood as training for a technical occupation has a long tradition in post-compulsory education. The tradition carries the idea and practice of *apprenticeship* in acquiring the knowledge and procedural skills of a technical occupation, and often reflects a technical curriculum design (Zuga 1989). In addition to technical knowledge and skills, familiarity with the organisational aspect of the trade is also transmitted through the apprenticeship.

In compulsory education, technology teaching in terms of vocational training has usually been represented by electives available for pupils who decide early on to choose technical occupations. Organisational features of the school curriculum have often made it difficult to combine these electives with more academic options. This has led to a ‘streaming’ of pupils into different lines of compulsory education, also in an educational system that highly accentuates equality among pupils as is the case with the Norwegian educational system. The result has often been that the technical vocational options in compulsory school are left with a low reputation and commonly regarded as suitable for the ‘less able’ pupils, a reputation also held by some vocational lines in upper secondary school.

Traditionally, vocational training has been highly specialised, directed towards a specific occupation with a clearly identified basis of knowledge and skills. The rapidity of technological change in modern times has made such job-specific training somewhat inadequate, as present and future technological occupations require workers equipped with more general skills adequate for meeting the rapidly changing requirements in work life. Attempts to meet these challenges have led to a generalisation of vocational education (Layton 1993).

In post-compulsory education in Norway, this generalisation of vocational training was manifested through the major reform of post-compulsory education (year 10-12, now 11-13) in 1994 (KUF 1994a). The number of specialised directions was radically reduced, and general courses in science, mathematics, humanities and social studies now constitute a significant component of all educational lines.

The latest educational reform in compulsory education implemented in 1997 (KUF 1996) also entailed changes in this direction. The optional subjects, among which there were commonly technical vocational-based subjects such as metal work or

motor mechanics, were eliminated from the curriculum in lower secondary school, and – in the opinion of many – left a void.

Final remarks – what counts as technology education?

This chapter has explored the foundation for technology as a new subject of teaching in compulsory education from philosophical, ideological and political perspectives and exhibited several tensions concerning the content and purposes of technology education. The chapter has also reviewed some existing approaches in terms of traditions and movements that may function as concrete gateways to the formation of technology as a subject in schools, and the different directions in which these gateways lead.

The main picture that emerges from this exploration is the one of diversity. If we – by drawing a parallel to Roberts (1988) – ask the question ‘*What counts as technology education?*’, we will get a range of different legitimate answers with different underpinning assumptions and ideologies. This diversity serves as a background for the empirical study presented in this thesis. It also provides conceptual tools for interpreting how the teachers participating in the TiS project perceive and realise technology as a new subject of teaching in Norwegian schools. More specifically, the conceptualisation of ideas inherent in Design & Technology as a specific approach to technology teaching will be used in analysing how these ideas have transformed when realised in a Norwegian school context.

The diversity exhibited in this chapter is also essential to consider when attempting to develop technology as a subject of teaching in schools. A holistic approach, aiming at including all facets of technology and its educational purposes may appear as an appealing idea. However, consciousness, effort and discussion should be put into making explicit priorities, because the making of priorities is what curricular development is about.

CHAPTER 4

PERSPECTIVES ON TEACHERS AND REALISATION OF CURRICULUM

It may not be convenient, but we must adapt to a world in which teachers have minds of their own.

(With apologies to Lochhead & Yager (1996, p. 28),
originally speaking of *students*.)

The empirical part of this thesis explores the introduction of technology as a new subject of teaching in Norwegian schools. The underpinning foundation for the study is the appreciation of teachers as the key factor in a process of realising curricular ideas and intentions. This chapter presents perspectives on teachers in the process of curriculum realisation. Firstly, a view of teachers as curriculum creators adopted in this thesis will be presented. This is followed by a review of essential aspects of teachers' professionalism: teachers' autonomy in their work and teachers' professional knowledge. Finally, the concepts of teachers' beliefs and teachers' professional frames will be presented, and their relevance as analytical tools in the present research study will be considered.

Throughout the presentation of perspectives on teachers' work in this chapter, certain comparisons will be made between the educational systems in Norway and UK respectively. Though the study presented in this thesis is not directly comparative in nature, this is deemed relevant given that the study concerns how Norwegian teachers respond to educational ideas developed in UK.

Teachers as curriculum creators

The realisation of curricular ideas in schools is a complex process involving influences from several agents and conditions. Aspects of this process can be understood in terms of Goodlad's notion of *curricular levels* (Goodlad 1979). The first levels represent the intentions of what pupils should acquire in schools. These comprise an *ideological* as well as a *formal* curriculum, where the formal curriculum is the curriculum documents that guide work in school. Curriculum documents are expressions of the intentions and desires of the ideological curriculum, and often a result of mediation of various strands on the ideological level. When a formal curriculum is to be put into practice in schools, its meaning and the underpinning intentions are interpreted by teachers and other agents engaged

with work in schools, such as textbook writers. Their interpretation of the curriculum is denoted the *perceived* curriculum, while the *operational* curriculum refers to how teachers realise the curriculum in their teaching. The way the receivers of the curriculum, that is the pupils, interpret and experience the teaching represents the final curriculum level denoted the *experiential* curriculum.

Teachers play a crucial role in this process. They are active agents in the perceived and operational level of curriculum, that is, the transition between the intentions of education and its recipients. This transition does not imply merely a 'delivery' of content predefined in a formal curriculum. The intentions and the content are developed, contextualised and put in concrete terms by the teacher, whose beliefs and actions ultimately shapes the kind of learning that young people get (Hargreaves & Fullan 1992). The teachers' work in curriculum realisation does not only mean identifying appropriate means for presenting a given subject matter to pupils; it also involves interpreting what this subject matter actually represents and the purposes it is supposed to fulfil. Further, as Hoyle and John (1995) have pointed out, the fundamental uncertainties of education and teaching can only partially be reduced by official prescriptions, as the operating goals are set at the level of the school and the classroom. Thus teachers should not be considered as *delivers* of a predefined curriculum, but rather as *creators* of curriculum.

Though attempts have been made to standardise and control teachers' work by means of detailed curriculum specifications and centralised assessment, many have pointed at examples of educational reforms that have had little effect as they have failed to treat teachers as active and determining actors in the realisation process (Horsfjord 1982, Barnes 1992, Haney *et al.* 1996, Hansen & Olson 1996, Olson *et al.* 1999, Lumpe *et al.* 2000, van Driel *et al.* 2001). Policy makers may have fallen short in considering the teachers' working situation and what is possible to achieve under the actual school conditions. They might in fact also have disregarded the importance of teachers' *interpretations* of the curriculum, and possibilities for a divergence between the intentions teachers possess in their work and those represented in the ideological and the formal curriculum; in short, that teachers have minds of their own.

Aspects of teachers' professionalism

A rising awareness of the critical role of the teachers in realising curricula and educational reforms combined with an increasing pressure to steer schools in order to enhance standards has led to a debate on the *professionalism* of school teachers (Hargreaves & Evans 1997, Day *et al.* 2000, Hargreaves 2000, Donnelly & Jenkins 2001). This debate involves discussions on whether teaching constitutes a profession, and if so, how the nature of this profession can be understood and how teachers' development as professionals can be enhanced. The notion of professionalism is, however, in itself notoriously beset with conceptual difficulties and ambiguities (McCulloch 1997), and criteria for whether an occupation constitutes a profession have thus been given various expressions. For example, Klette (2000) has summarised the criteria this way:

- a specialised knowledge base and shared standards of practice (technical culture)
- commitment to meeting clients' need (a service ethic)
- strong identity with the profession (professional commitment)
- collegial as opposed to bureaucratic control over practice and profession (professional autonomy)

(p. 148)

Though characteristics of a profession have also been formulated in differing terms (see e.g. Hoyle & John 1995, Donnelly 2001b), two aspects appear to be principal in what is meant by a profession. Firstly, it is associated with *autonomy*, that is, control over the conduct of work for individual practitioners or for the professionals as a group. Secondly, a profession involves a *basis of knowledge and skills* specific to the profession, obtained by formal training or workplace apprenticeship. These two aspects of teachers' professionalism are highly relevant to the study of teachers realising a new subject presented in this thesis, and they will be briefly reviewed on basis of relevant research literature in the following.

Teachers' professional autonomy

How autonomous are teachers in their work? The degree of official and actual autonomy of schools and individual teachers has been subject to changes through the times. In many countries, recent development has involved a change from relatively strong formal independence towards increased standardisation by centrally given curricula and amplified governmental control over schools, for example by means of extensive testing of pupils' achievements. Many have pointed

to this tendency as undermining teachers' professionalism and degrading them to technicians and 'delivers' of curricular prescriptions defined by others (Woods 1990, Apple & Jungck 1992, Eisner 1994, Goodson 2000). In England and Wales, the change in centralised control of education has been exceptionally marked. The freedom teachers enjoyed in the post-war years have been denoted 'the golden age of professional control' (Helsby 2000) and a 'secret garden' (McCulloch 2000) signifying the privatised and individualised nature of teachers' work. The replacement of this 'secret garden' by a highly detailed centralised curriculum and associated governmental control through the introduction of the National Curriculum in the late 1980s has been seen by some as a major deprofessionalisation of teachers (see Helsby 2000). The actual freedom of teachers in the 'golden age of professionalism' has, however, been questioned. It has been argued that other control mechanisms, such as examination boards and entrance requirements to universities, have governed teachers' work extensively long before this control was formalised through the introduction of the National Curriculum (Helsby 2000, McCulloch 1997, McCulloch 2000). The change may hence be seen as being essentially about *how* and by *whom* education is controlled, not about the actual presence of control.

The development in Norway shows some parallel to the above, yet also very different features with regards to central curricula, control and autonomy of teachers. Though Norway has had a national curriculum in some form since 1890, its status and level of specification have varied over the years (see Gundem 1993). Throughout the 1980s, there was a swing from a centrally defined curriculum towards a decentralised model in terms of regulation, economic planning, steering and decision-making (Klette 2000). This decentralisation also applied to the *content* of the curriculum, which had to be locally adapted and specified on the basis of broad themes given in the governmental curriculum documents. Entrance to upper secondary and in turn higher education was (and still is) based on a combination of teacher-given grades and results of centralised exams. For compulsory education, the teacher-given grades are highly dominant in the selection process. Compared with the above description of the so-called golden age of teacher professionalism in England and Wales, the control mechanism represented by entrance requirements to further education may thus be weaker in the Norwegian system. Other mechanisms may, however, still shape teachers' work significantly. It is generally believed that textbooks and other teaching material have a strong impact on teaching. Further, professional socialisation in schools may imply a 'normative control' of teachers' relative autonomous work. The 'delivery' of students to higher levels in education, with expectations on what knowledge is needed to pass the next level, may also have a preserving effect on curricular content. Expectations, not only from colleagues but also from pupils and

parents, represent what Lindblad (1994) refers to as *external determinants* for teachers work in addition to the formal curriculum. These ‘determinants’ are essential aspects of the foundation for teachers’ actions and priorities, and, as Lindblad asserts, ignoring them makes a teachers work appear completely incomprehensible.

The current curriculum, implemented in 1997 (KUF 1996), represented a major shift in Norwegian educational policy. This shift is from a relatively high degree of freedom for teachers and individual schools, towards a centrally defined curriculum which specifies in detail what pupils should learn, and to some degree how they should be taught, on each level. (A more comprehensive presentation of the structure and content of the current curriculum will be given in Chapter 5, together with an audit of how technology is represented in its various parts.) A related shift in policy thinking is represented by the increased attention towards the potential of centralised testing of pupils as a means to control and enhance standards in schools, and a recent (January 2003) controversial release of the average grades given on every individual school in lower secondary level. The fact that these political actions are seen as *controversial* is perhaps a better illustration of the educational culture than the actions themselves are.

Contrary to its forerunners, the current curriculum document for compulsory education implemented in 1997 was statutory (Lovdata 1997). Though the document itself has not undergone changes, its legal status has later been altered in the direction of renewed decentralisation. In a controversial ‘reform of the reform’, the status of the curriculum’s content was altered from being prescriptions towards less rigorous guidelines (see Koritzinsky 2000). This means that subject elements can be transferred across school years and that subject elements can be removed or exchanged according to local adaptation, as long as the pupils’ education as a whole is well suited for fulfilling the common aims of the subject and the broad goals set up by the curriculum’s general guidelines. The explanation for this alteration of the curriculum’s status was given in terms of trust in teachers’ professionalism in their work and a desire to steer education by formulating goals for what schools should achieve, rather than by prescriptions of the *means* by which they should be achieved (Koritzinsky 2000, quoting Lilletun, Secretary of State for Education).

The above adjustment may, on the surface, appear as a ‘re-professionalisation’ of teachers in their work. However, as Klette (2000) has argued, it can also be seen as ‘imposed professionalism’ (Hargreaves 1994) or what she prefers to denote ‘arranged professionalism’. The latter implies that criteria of professionalism are

defined external to the profession itself. Klette (ibid.) has shown that the new working time agreement that has accompanied the recent educational reforms in Norway with the purpose of stimulating collegial co-operation and local development has not provided for teacher professionalism, but rather led to intensification of teachers' work and functioned as an instrument of control. Similar mechanisms are identified by Hargreaves (2000), who describes professional collaboration as a 'carrot' for English teachers, while the control of the purposes of their work are externally defined. Collaboration in what he refers to as the 'age of collegial professionalism' is thus reduced to technical tasks and co-ordination rather than working together for fundamental change.

Teachers' professional knowledge

How can the knowledge held by a professional teacher be conceptualised? The knowledge base of teaching clearly has many dimensions, including knowledge of the subject matter to be taught, knowledge of young people's development and cognition, skills in handling pupils in the classroom and strategies for planning and decision making. A wide range of research studies and perspectives on teachers' knowledge, skills and strategies have been presented. These include studies of teachers' practical knowledge (Elbaz 1983, Carter 1992, Beijaard *et al.* 2000, van Driel *et al.* 2001), teachers' 'craft knowledge' and ways of thinking and planning (Clark & Yinger 1987, Brown & McIntyre 1993, Davies & Rogers 2000) and characteristics of teachers as reflective practitioners (Schön 1983, 1987). Teachers' personal practical knowledge has also been portrayed in narrative forms, for example by accounts of 'teachers' professional knowledge landscapes' (Clandinin & Connelly 1995, Connelly *et al.* 1997).

The overall impression from the extensive body of literature whereof a few examples are referred above is that it mainly conceptualises knowledge associated with teaching in a *general* manner, focusing on the aspects of a teacher's knowledge that apply independently of the subject matter taught. This impression is confirmed by how Shulman (1986) maintained that educational thinking and policy have shifted from emphasising the teacher's knowledge of content towards a focus almost entirely on pedagogical knowledge and reflection. He has characterised this focus in educational research and policy in rewriting the familiar quotation from George Bernard Shaw: "*He who knows, does. He who cannot, but knows some teaching procedures, teaches.*" (ibid., p. 5). Further, he brings attention to what he denotes a 'missing paradigm'. This involves the *content dimension* of teaching, that is, the organisation of content knowledge in the mind of the teachers and in the classroom.

In an attempt to reinforce the 'missing paradigm', Shulman (1986, 1987) has developed a framework for teachers' content knowledge as a basis for teaching. In his framework, teachers' content knowledge can be divided into three categories: curricular content knowledge, subject matter content knowledge and pedagogical content knowledge. *Curricular content knowledge* involves knowledge and familiarity with the available tools for instruction, both in a physical and in a figurative sense. *Subject matter content knowledge* refers to the amount and organisation of subject knowledge *per se* in the mind of the teacher. This includes not only a factual 'catalogue' of information in the subject, but also awareness of the nature of the knowledge; how elements in the subject are built up and linked together, criteria for what is recognised as valid knowledge in the subject and how new knowledge is constructed. This parallels the substantive and syntactic structures of disciplines as discussed by Schwab (1964, 1974) and briefly reviewed in Chapter 3. '*Pedagogical content knowledge*' in Shulman's framework represents the particular aspect of a teacher's content knowledge that relates to how knowledge of subject matter can be presented in teaching. Teachers need knowledge and strategies on how to transform knowledge of the subject into instruction that makes it comprehensible to the learners. This includes the knowledge and choice of powerful learning activities, illuminating analogies, demonstrations and examples, as well as consciousness of preconceptions and misconceptions that are frequently held by pupils and strategies to reorganise their understanding. Hence, pedagogical content knowledge represents the special amalgam of content that is uniquely the province of teachers, their own special form of professional understanding (Shulman 1987, p. 8). Emphasis on this aspect of a teacher's knowledge led Shulman to a more encouraging reformulation of the saying referred above: "*Those who can, do. Those who understand, teach*" (Shulman 1986, p. 14). 'Those who understand' clearly need comprehensive knowledge of the subject, perhaps even more than what is the case for 'those who do', in order to develop their pedagogical content knowledge for teaching the subject. Pedagogical content knowledge includes identification and understanding of the really important ideas and skills in the subject, and teaching based on this understanding conveys to students what is essential about the subject and what is peripheral (Shulman 1987, p. 9).

In light of the development in research literature the last 15 years, Shulman's attempt to reinforce the 'missing paradigm' can be seen as rather successful. His notion of pedagogical content knowledge has been widely used, to such an extent that it is commonly referred to as simply "PCK" (see e.g. Gess-Newsome & Lederman 1999). This framework of the knowledge base of teaching is useful in the sense that it captures essential aspects of teachers' knowledge, skills and reflections related to *what* they are teaching. The framework has, however, its limitations. The subject matter content knowledge appears to be a given in

Shulman's framework, as a predefined body of knowledge. This applies even if knowledge of subject matter is understood as a deeper understanding of the subject's structures (Schwab 1964) rather than memorising a collection of facts. The framework does not take into account that there may be different interpretations of what the subject is essentially about and what constitutes its substantive and syntactic structures. Divergence in interpretations are likely to be particularly present within a school subject that lacks traditions and is 'under construction', as is the case with technology as a newcomer in Norwegian schools. As Gilbert (1992) put it:

For technology education, (...), the discipline has not been clearly identified, the sources of Shulman's (1987) knowledge base are not fully established, and there is inadequate documentation of case studies of pedagogical reasoning and action.

(p. 569)

With regards to how *teachers* interpret the nature of a subject, the potential of the concepts teachers' beliefs and professional frames for filling this gap will be examined in the following section.

Teachers' beliefs and professional frames

Awareness of the insufficiency of conceptions of teachers' *knowledge* in describing essential aspects of teachers' cognition in their work has induced '*teacher beliefs*' as a target for educational research. The notion has been given various interpretations and embraces a wide range of approaches to research. These include research on how teachers perceive the content and objectives of educational reforms (Haney *et al.* 1996), their understanding of specific curricular topics, such as the nature of science (Gallagher 1991) and STS issues (Zoller & Donn 1991) and examples of how beliefs influence teachers' planning, decision-making and classroom actions (Cronin-Jones 1991, Kagan & Tippins 1991). More theoretical founded work and discussions are undertaken in cognitive psychology on relations between knowledge and beliefs (Abelson 1979, Nespor 1987, Pajares 1992), and on consistency versus inconsistency between teachers' beliefs and their actions (see Fang 1996).

Though a concept of belief *systems* has been introduced (Abelson 1979), the literature on teachers' beliefs does not to any considerable degree address the holistic nature of teachers' thinking and cognition nor the dynamics of how teachers interact with new ideas and the cultural environment. These aspects are, however, attended to in how Barnes (1992) has formulated the concept of

'teachers' professional frames' based on his research in the teaching of languages in schools as well as the work of Schön, Elbaz and others. 'Frames' refers to the underlying assumptions that shape teachers actions. They represent clustered sets of expectations or preconceptions, through which the teachers' knowledge of the world is organised and that provide repertoires for their behaviour in it. According to Barnes, constructive collaboration requires that the participants have shared or mutual 'compatible' frames. This means that advice may be inappropriate if it can only be interpreted in terms of frames different from those held by the teacher, or if they represent responses to different concerns and priorities than those inherent in their own professional frames.

Barnes suggests five domains that contain repertoires of teachers' professional frames:

- Preconceptions, often implicit, about the nature of what they are teaching, and – for secondary specialists – about the subject they teach and how to interpret it.
- Preconceptions about learning and how it takes place, though modified by a view of what can be achieved in the classroom.
- Preconceptions about students (in general, and about the particular group being taught) that place limits upon what is thought to be useful or possible.
- Beliefs about priorities and constraints inherent in the professional and institutional context.
- The nature of his or her overall commitment to teaching – 'vocational', 'professional', 'career-continuance'.

Teachers' professional frames in these domains are described – unlike knowledge – as value-laden and dynamic. They have an individual history of development through education and personal experience, but are further developed through interaction with colleagues, pupils and the overall school culture and – as should be added – aspects of culture and society more generally.

The concept of teachers' professional frames opens up for *sociological* perspectives on teachers' work. In his classic work in the sociology of education, Lortie (1975) describes how teachers, though their work is essentially individual, draw on many years of 'apprenticeship of observation' as pupils and students. The latent educational culture acquired through observation is activated in their later training and work as teachers, and represents a key factor for shaping teachers' conceptions of what teaching means. Teachers may thus represent a conservative

force in education. In terms of Barnes' concept of teachers' professional frames, this means that construction of teachers' frames commences in the childhood of the teacher, and that they are maintained through collaboration with colleagues who have experienced the same sort of apprenticeship and with whom they possess mutual compatible frames. The correspondence between the frames of teachers working together may be strengthened through the increased emphasis on teacher co-operation in schools pointed to earlier in this chapter.

Sociologists have also investigated how individual schools develop their own characteristic school culture, and how teachers are socialised into this specific culture in their work (e.g. Rosenholtz 1989). It is, however, also upheld that it is the various *departments* in schools rather than the school as a total that are important for the teachers' work culture. Siskin (1994) shows that cultural differences between departments may be more distinct than differences between schools, and that an important function of department members' exertion in their work is to protect subject interests within the school as a whole. Thus affiliation with departments, or with a subject's sub-culture (Jones 1999), may contribute significantly to the shaping of a teacher's professional frames. The status of 'departments' in schools does, however, vary substantially between countries with different educational systems and culture. A brief discussion of the impact of these differences in the realisation of curricular ideas in schools will be included in the final discussion of findings of this study.

The concept of teachers' professional frames appears functional for analysing the introduction of technology as a new subject of teaching in Norwegian schools. The concept accounts for teachers as *representatives* of a shared culture, but also allows for a view of teachers as *individual participants* who create meanings and opportunities from ideas presented to them and who actively interact with their cultural and institutional surroundings. Both these perspectives are pertinent in comprehending how the teachers participating in the TiS project interact with ideas conveyed by this project, and how they thus create technology as a new subject of teaching in their schools.

PART II

CONTEXTUAL FRAMEWORK

CHAPTER 5

TECHNOLOGY IN THE CURRICULUM FOR COMPULSORY EDUCATION IN NORWAY

Familiarity with our technological heritage – the easing of life and the improvement of welfare it has furnished, but also the dangers technological innovations have introduced – is an essential element of a general education.

(L97 Core Curriculum, KUF 1993, p. 33²)

In contrast to the situation in some of our neighbouring countries, technology is not a distinct subject in Norwegian schools. This does not, however, mean that technology is a neglected field in the curriculum for compulsory education. On the contrary, technology is highly attended to in the national curriculum document, as the above quotation from the Core Curriculum illustrates. The curriculum for compulsory education represents the statutory framework for the work of the teachers who act as cases in the empirical study reported in this thesis. It hence constitutes an important part of the contextual framework for the study. In this chapter, some characteristics of this curriculum will be presented, and the opportunities it provides for technology teaching will be explored.

The present curriculum for compulsory education in Norway (KUF 1996) was implemented by a major school reform in 1997, and is customarily referred to as 'L97'. This chapter first briefly explains the structure of L97 as a whole. Then I will audit how technology is conceptualised in various parts of the curriculum, and how technology is represented in the intended learning outcomes specified for each subject. The question underlying the analysis is: *What place is there for technology*

² The page numbers provided in this chapter refer to the English version of the curriculum. The quotations in the Norwegian original can be located by subtracting 6 from the page number provided.

teaching within the framework of L97? A broad view on ‘what counts as technology education’ is deliberately maintained throughout this audit. However, in consistency with the presentation of gateways to technology education given in Chapter 3, how the curriculum deals with the use of ICT in various subjects will not be considered in this audit.

The first part of the audit analyses the general parts of the curriculum in light of the question posed above. The subsequent parts examine to what extent, and in what ways, the diverse aspects of technology addressed in the general part are maintained in the specifications of relevant school subjects. Finally, the potential for thematic approaches to technology teaching across the subjects or within school-specific elective units proposed by L97 is examined.

The structure of the curriculum

The curriculum L97 consists of three parts, with ascending level of specification. This structure is illustrated in Figure 1. The first part, referred to as the ‘*Core Curriculum*’³, was implemented already in 1993 (KUF 1993). The Core Curriculum, written in rather philosophical and idealistic terms, provides the educational rationale for compulsory education (grades 1 - 10), upper secondary education (grades 11 - 13) and adult education. The subsequent parts of the curriculum refer to compulsory education (grades 1 - 10) only, as illustrated in Figure 1. The second part, denoted *Principles and Guidelines for Compulsory Education*, bridges the Core Curriculum with the specifications for the school subjects. In this part, the fundamental values in the Core Curriculum are made operational and more specific. It also provides a foundation of principles that directs all teaching in compulsory education, including principles regarding teaching methods and assessment, approaches to thematic teaching across the curriculum and allocation of school hours. The third part of the curriculum presents, for each school subject, a framework for the subject with general aims and finally – in much more distinct terms – the subject-related objectives and specifications of the main elements pupils should work with in the subject (syllabuses). This final part also suggests learning activities through which the goals of the curriculum can be achieved.

³ The notion ‘Core Curriculum’ may cause some confusion. It is here used in accordance with the English translation of L97 (KUF 1993, 1996). In contradiction to how the notion is understood in an English educational context, the ‘Core Curriculum’ of L97 does not give any directions for teaching specific subjects, but acts as a guiding philosophy for education in general.

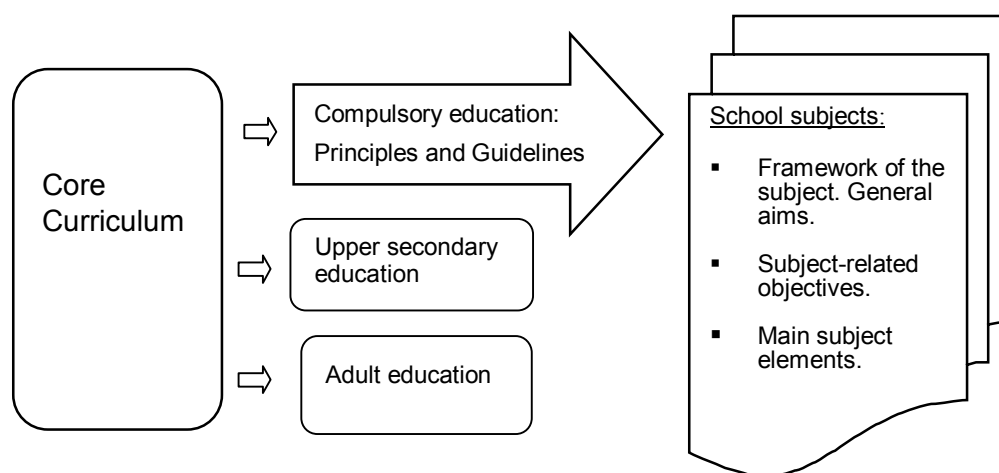


FIGURE 1. Structure of the curriculum L97.

Technology within the general parts of the curriculum

The Core Curriculum of L97 contains the overall aims which education in the three stages – compulsory school, upper secondary school and adult education – should work towards. These aims are described by drawing seven portrayals of a human being; the Spiritual human being, the Creative human being, the Working human being, the Liberally-educated human being, the Social human being, the Environmentally-aware human being and the Integrated human being. L97 states that general education should, for every pupil, promote the development of human qualities associated with all these portrayals. The Principles and Guidelines for compulsory education are also structured around these seven portrayals of a human being, and give directions for educating pupils in knowledge domains assigned to each of them.

Several of the portrayals of a human being convey, in various ways, aspects of technology as a field of human endeavour. References to technology can especially be found within the *Creative human being*, the *Working human being* and the *Environmentally-aware human being*. Therefore, the following will present how technology figures within these three portrayals in the Core Curriculum, and how these issues are further specified in the Principles and Guidelines.

The Creative human being

The curriculum describes the *Creative human being* by the ability to

find new solutions to practical problems by untried moves and unused methods, by identifying new relationships through thinking and experimenting, by developing new standards for evaluation and collaboration, or by originating novel forms of artistic expression (p. 27)

The manifestation of the talents of the creative human is described as to be found in

new and improved machines, tools and routines, in the results of work and research, in improved criteria for appraisal and judgement, in buildings, paintings, music, dance and poetry (p. 27)

From the above, it is clear that the Core Curriculum gives great emphasis to technological activity as part of human creativity. This emphasis is confirmed by the curriculum's identification of three creative traditions in human life and history that all pupils should be acquainted with and take part in. Besides the traditions of intellectual inquiry and artistic expression, the tradition of innovation is highlighted. This tradition is linked to practical work and learning through experience. The Core Curriculum describes technological development as essential to the tradition of innovation, and describes how this development has improved living conditions in small steps carried out by many contributors:

Many of the things that contribute to human welfare are the result not of great feats of genius, but rather of a long series of minor improvements, in all sorts of implements, tools and routines – from typewriters to sewing machines, from clocks to stoves, from building methods to working techniques. (p. 28)

The importance of promoting awareness of this part of our cultural heritage through education is also addressed:

Education must convey how living standards have continually been improved by trial and error, groping and gauging in generations of everyday practical endeavours. (...) Knowledge about this part of our cultural heritage and history provides us with both trust in tradition and readiness for change. (p. 28)

Thus teaching about technology as part of our cultural heritage should not only be directed backwards in history, but also forwards, and transmit a view of technology as a dynamic and creative process. Inviting pupils to participate in this process and shape the future is stated as an important responsibility of the school.

It is noteworthy that the Core Curriculum mainly describes the Creative human being in terms of technological endeavours. Creativity appears to be more linked to technology than to the arts in this part of the curriculum. In the Principles and Guidelines, however, this emphasis has been altered. To provide for the Creative human being the curriculum here mainly points to the *aesthetic* dimension of the subjects. It states that pupils should have the opportunity to experience the treasures stored in the various art forms and that the mediation of culture should be given a prominent place (p. 72). The examples given are pupils' participation in activities such as school choirs, concerts and drama groups. Hence, the curriculum's emphasis now appears to be on the *third* (cultural, in the sense of aesthetic) of the three traditions of creativity described in the Core Curriculum, and not on the tradition of innovation.

The Working human being

Within the portrayal of the *Working human being* in the Core Curriculum, technology is described in terms of realising human desires in a broad sense:

Technology is nothing more than the means humans have devised for achieving their goals, easing their work and co-operating better.

(p. 32)

Technology is described as *civilising*, by making it possible for us to live with less drudgery and disease, and by releasing time from chores and the struggle for subsistence to leisure and culture. Further, the curriculum describes technology as *inspiring*, as it constitutes a creative expression of the interplay between head and hand to meet needs and yearnings. L97 also places technology as a manifestation of *compassion*, as it may arise from a desire to nourish or heal, to prolong life or ease living, to care for children or elevate the quality of life.

The curriculum's description of the Working human being also embraces the impact of technology on human relations in society, exemplified by how new technology has altered the division of labour and the structure of power, class differences and social conflict (p. 33). The products of the Working human being in terms of "the repercussions of technological development", are described as having made life "less dependent on nature and more dependent on society" (p. 33).

When means to build the Working human being are described in the Principles and Guidelines of the curriculum, the strong emphasis on technology has faded, as was also the case with the Creative human being. This part of the curriculum associates the Working human being with pedagogical means such as practical activities, experience-based learning and the importance of making connections between

theory and practice. The Principles and Guidelines draws a picture of ‘the active pupil’ in the process of learning, and of teaching that should assist pupils in developing a broad competence and build a foundation for all-round development. What can be denoted as ‘learning to work’, is interpreted both as learning good working habits and as learning about working life and its organisations. On the whole, the Principles and Guidelines intend to prepare for active participation in work life in a general sense, by promoting such characteristics as willingness to make an effort, taking responsibility, being open to the opinion of others and the ability to renew ones own knowledge.

The Environmentally-aware human being

Norwegian culture entails long traditions of both outdoor life and concern for the environment, and these are also reflected in traditions of education. In L97 this focus can be identified in the portrayal of the *Environmentally-aware human being* in the Core Curriculum. While the Creative human being and the Working human being mainly are associated with positive outcomes of technology, the double-edged nature of technological development is now addressed:

Our living environment has become decreasingly dependent on nature and increasingly influenced by the man-made world. Our well-being depends on our ability to develop new ideas, to use advanced technology, to create new products and to solve traditional problems with more imagination and reason.

(...)

Our choices have consequences across geographic borders and across generations: lifestyle influences health; our nation’s consumption produces pollution in other countries; and our society’s waste becomes the plight of future generations.

(The Environmentally-aware human being, p. 51)

The Core Curriculum acknowledges the positive effects of technological development, viewing it as the way humans solve problems and create new possibilities. But it also points to the fact that the same development also causes problems and hazards, as technology extends the area of encroachment in both human life and in nature. Examples of problems and hazards mentioned in this concern are the use of DDT, acid rain and pollution more generally, deforestation, the greenhouse effect (*sic*) and nuclear explosions.

In the context of environmental awareness, L97 links technology strongly to science and science teaching, and highlights the importance of knowledge and understanding of science for being able to solve problems in an ethical manner. In opposition to the portrayal of the *Creative* human being, where science and

technology are placed in separate traditions of human endeavour, the distinction between science and technology is blurred in the description of the Environmentally-aware human being. The phenomena and endeavours in question are here alternately referred to as ‘science and research’, ‘new technology’, ‘applications of scientific insight’, ‘scientific breakthroughs’, ‘knowledge and new technology’, ‘applied science and technology’, ‘the applications of science’, ‘modern technology’ or simply ‘technology’ (pp. 51 - 52). No clear distinction seems to be made between these notions in the text. This makes it reasonable that they all refer to what is earlier discussed as the ‘seamless web’ of science and technology, or – as Cajal (2001) put it – “a common body of scientific and technological ideas and skills” (p. 725). In this notion, ‘outcomes’ and ‘consequences’ may as well be added.

The importance of the environmental aspects of technology as part of pupils’ general education is maintained in the Principles and Guidelines of L97. It states that “emphasis must be given to understanding the interconnections in nature, the interaction between man and nature, and our ethical responsibility for the management of nature” (p.74). Further, pupils are to acquire knowledge of and insight into technological development and the challenges, limitations and hazards of technology, and be confronted with the ethical choices which individuals and society often have to make when technology causes boundaries to be moved. The Principles and Guidelines also address the importance of education in fostering pupils as knowledgeable and informed consumers, and states that pupils should learn to be critical and make deliberate choices as consumers, as users of the media, and in the uses to which they put their spare time.

Principles for teaching

From the foregoing, it can be concluded that the general parts of L97 give prominence to technology as a component of pupils’ general education. The curriculum provides a broad picture of technology, and put forward inclusion of various technological aspects within most subjects, as well as interdisciplinary approaches.

The principles formulated for teaching in the Principles and Guidelines also promote technology teaching, yet in a different meaning of the notion. The principles for teaching put forward technology teaching in the sense of practical work with materials that entails technical problem solving. In prescriptions of methods, learning materials and assessment, the curriculum emphasises that pupils should be “active, enterprising and independent, and that they should acquire new knowledge by doing, exploring and experimenting” (p. 81). It states that pupils’ *play* is an important source for learning, and that play should be used as an approach to organised activities in order to promote motivation as well as a source

for the teacher to obtain knowledge about the individual pupils' interests and understanding. Further, *practical work* is emphasised as a means of letting pupils see connections between practice and theory, and it is stated that school should provide pupils with experiences in the planning, organising and solving of practical tasks (pp. 82 - 83). Pupils should also learn to work *independently* and be given the chance to explore areas of knowledge that interest them, for example by means of *project work*.

Technology teaching can easily be associated with the principles referred above, and can thus find a place within several subjects or as cross-curricular approaches. The potential for technology teaching as what the curriculum refers to as project work will be further explored later in this chapter.

Technology in the specifications for subjects

As indicated in Figure 1 (p. 58), the specifications for each subject in the curriculum for compulsory education consist of an introductory part, which gives a framework of the subject and its general aims in school, followed by statements of subject-related objectives and specifications of main subject elements. The specifications for school subjects represent highly detailed prescriptions of content and teaching methods in each subject. As described in Chapter 4, a 'reform of the reform' entailed a shift in the legal status of these prescriptions, and opened up for reallocations and exchange of subject elements as long as the aims for the subjects and education in general are maintained. Nonetheless, the specifications of subject elements still constitute an important incentive for the teaching of the subject. In the following, we will see how the aims set for subjects as well as the more detailed specifications for Science, Social Studies and Art and Crafts attend to aspects of technology, and thus how technology teaching can be undertaken within the framework of these subjects in compulsory education in Norway.

Technology in the Science⁴ curriculum

In the process of developing the curriculum for Science in L97, the Ministry of Church, Education and Research gave the responsibility for attending to technology in the curriculum to the working group for the Science curriculum. Accordingly, the working group's initial description of the subject included technology, referred to as a *discipline* alongside biology, physics, chemistry, astronomy, geology and

⁴ The name of the Norwegian school subject is 'natur- og miljøfag', which is translated to 'Science and the Environment' in the English version of the curriculum. A more direct translation would be 'Nature and Environmental Studies'. In this thesis the notion 'Science' is used for the subject – of convenience reasons.

meteorology (see Koritzinsky 2000). One of the main areas of content was meant to cover topics in technology. However, through revisions of the curriculum document and due to the fact that additional hours were not allocated to the subject, this explicit emphasis on technology was diminished in the final curriculum document and the number of main areas in the subject was reduced to four. However, as we will see in the following, technology is still highly visible in the Science curriculum and provides opportunities for approaching technology teaching through this subject.

The way the introduction to the curriculum for Science presents the subject has a clear democratic perspective, and also links science to technological development. Knowledge of science and technology is emphasised as important for the individual in order to master, understand and influence modern society. The curriculum aims at preparing the pupils to become active and informed citizens and enabling them to contribute to sustainable development and participate in decision-making concerning our common future (p. 220). Consequently, learning objectives are not only stated as the mastering of scientific content knowledge and skills, but also in terms of attitudes and awareness. This conveys a rationale for teaching the subject that mostly supports the social argument for both science and technology education reviewed in Chapter 3. The perspective the curriculum presents on science teaching is consistent with positions held by many science educators world-wide on what should be the main objectives of science education for scientific literacy (e.g. Hurd 1998, Millar & Osborne 1998, DeBoer 2000, Kolstø 2001, Ødegaard 2001).

The five general aims set for the subject do, however, give more prominence to other aspects of the subject. The *first* aim states that girls and boys should enjoy their experience of nature and that the subject should give them opportunities to develop imagination, creativity and an interest in exploring their surroundings. The *second* aim relates pupils' knowledge of various substances and of their properties and uses to environmental awareness. It states that pupils should gain insight into technology, various physical phenomena and the physical world picture and that they should be able to apply this knowledge in their daily lives and in their participation in society. Environmental awareness is also addressed in the *third* aim, which states that pupils should acquire insight into natural inter-relationships and the interplay between man and nature in order to enable them to contribute to sustainable development, look after their own bodies and health and to show care and respect for others. The *fourth* aim addresses the nature of science, and states that pupils should know about and practise scientific thinking and methods as well as see that science develops. Included in this aim is that pupils should learn about some important scientists and inventors, and become acquainted with the impact of science and technology on the development of society. The *fifth* and final aim

places the subject in an utilitarian perspective, and states that pupils should acquire experience in the use of tools, experimental apparatus and electronic equipment in a broad range of activities and forms of co-operation. The usefulness of knowledge from the subject in everyday life is highlighted in the statement that pupils should be able to put their knowledge of the subject to practical use, and develop the ability to use and evaluate information, technical aids, consumer goods and new products.

Though the democratic perspectives and the social argument reflected in the introductory part of the Science curriculum can be recognised in these aims, the emphasis appears to have shifted. The general aims for the subject put forward science teaching in a mainly utilitarian perspective with focus on applications of knowledge in everyday life, and with close connections to technology. The last point above, stating that pupils should be able to put their knowledge to *practical use* and the way this is related to *consumer goods* and *new products* shows some commonality with the ideas conveyed by the subject Design & Technology presented in Chapter 3.

How are these perspectives on science teaching maintained in the specifications of subject elements? For each grade, the main subject elements are given within four main areas: The human body and health; Natural diversity; Substances, property and use and The physical world picture. The subject matter within these headings represents to some extent an academic curriculum design (Zuga 1989), or a 'traditional' science curriculum, aiming at acquainting pupils with concepts and principles within the broad field of natural sciences. The content matter is, however, to a high degree linked to everyday utility and technological applications. The purpose of everyday utility in the household is clearly evident within electricity as a topic in grade 9, where pupils are to

- learn the safety rules for the domestic use of electrical appliances and gain experience with electrical wiring.

(Grade 9, The physical world picture)

Further, technological *applications* of science knowledge are included in many of the specified subject elements. For example, pupils in grade 4 are to

- learn about uses in technology of the centre of gravity, levers and friction.

(Grade 4, The physical world picture)

In grade 8, the curriculum states in corresponding ways that pupils are to

- determine the density of substances and study the technological uses of differences in density.

(Grade 8, The physical world picture)

When exploring physical properties of light in grade 10, pupils are to

- (...) experiment with how the eyes function and with the reflection and refraction of light, and give examples of their technological uses.

(Grade 10, The physical world picture)

These examples can be seen as representing the approach Fensham & Gardner (1994) have denoted 'science before technology' that was presented in Chapter 3. In the specifications above, the scientific concepts such as gravity, density, reflection and refraction are clearly specified, while it is left to the teachers (or textbook writers) to identify and exemplify their uses in technological contexts. This indicates that it is the scientific concepts and principles as such that represent the real agenda of the curriculum, while applications in technology and other fields appear merely as 'contexts' for learning these general concepts and principles. Even if the intention may be reasonable in demonstrating the relevance of science knowledge, these approaches may convey a picture of technology as straightforward *applications* of scientific knowledge, as other sources of knowledge involved in technology are not considered in the examples given above.

As a whole, however, the specifications in the science curriculum in L97 do not present technology solely as applications of and learning contexts for scientific concepts and principles. Technology is also addressed in its own right when it comes to cultural and societal aspects. How technology influences human living conditions, especially in a historical perspective, is an issue that is addressed in several main subject elements. For example, pupils are to

- plan and develop simple models for the conversion of the energy in running water into mechanical work, and learn how man has exploited this technologically in the past and exploits it in the present,

and

- consider simple principles for the transportation and purification of drinking water and waste water, in the past and present.

(Grade 7, Substances, properties and use)

Even if their point of departure still may represent the scientific principles, these examples give more emphasis to technology as means humans have developed for utilising natural resources throughout history. These aspects of technology, representing 'our technological heritage', are also found to be placed in more specific cultural contexts. The heritage of the Sami people is in particular

addressed, and pupils are to learn how Sami people utilise natural resources, past and present (Grade 9, Natural diversity) and study examples of traditional folk medicine in the Sami culture (Grade 8, The human body and health).

The societal importance of issues representing the interface of science and technology is addressed by stating that pupils are to

- learn how technological advances, for instance the x-ray and the discovery of penicillin and other antibiotics, have changed the epidemiological picture.

(Grade 8, The human body and health)

Interestingly, the curriculum here assigns x-ray and the discovery of antibiotics to the advances of *technology* rather than to those of *science*.

Controversies related to technological use of natural resources are, in a few instances, found as learning targets for pupils. Such controversies are exemplified by conflicts of interest that may arise over the use of fresh water in the local community (Grade 7, Substances, properties and use) and ethical questions related to genetic engineering (Grade 10, The human body and health).

In sum, the Science curriculum acknowledges various aspects of both science and technology; technical, societal, cultural and ethical. It provides for 'technology teaching' understood as applications of science knowledge in practical contexts with focus on its relevance in everyday life as well as an exploration of the historical, cultural and societal dimensions of technology as a human endeavour.

Technology in the Social Studies curriculum

The important cultural and societal aspects of technology make it sensible to look for possibilities for technology teaching within the framework of Social Studies. The introduction to the curriculum of this subject does, however, only make one reference to technology, stating the importance of understanding the interaction between people and nature:

The interaction between economy, ecology and technology presents major challenges to society today. Social Studies must accordingly develop pupils' insight into, and interest in the interaction between people and nature, and heighten their awareness of their living conditions and standards of living.

(p. 187)

This point is also present in one of the six stated general aims of the subject:

for pupils to develop and acquire knowledge about past and present life and human activity, and be able to relate living conditions to natural and man-made factors and to understand and explain changes in living conditions

(p. 190)

In the specifications of the curriculum for Social Studies, objectives and main subject elements are arranged and presented in terms of the disciplines History, Geography and Social Science. Within both History and Geography, humans' development of technology is represented in many of the subject elements stated in the curriculum for Social Studies. In the lower grades pupils are to

- learn about major rivers, and how man has used them at various times for transport and communications and as sources of energy, and about the building of bridges and locks

(Grade 3, People and society before us)

and

- become acquainted with how people learned to cultivate the soil, keep livestock and use ploughs, saddles, water wheels and windmills

(Grade 4, People and society before us)

The transformatory power of technology in history is addressed by stating that pupils should

- acquaint themselves with the changes in the distribution of power, in the business sector and in everyday life, brought about by the Industrial Revolution, in relation to, among other things to class structure, emigration and health

(Grade 8, History - major developments from about 1750 to the present day)

The role of industry in contemporary society, and how natural resources are transformed into consumer goods, is also addressed in several grades, usually with reference to environmental issues related to industry. For example, pupils in grade 6 are to

- become familiar with how production and consumption lead to soil, water and air pollution and with the efforts being made to counteract pollution

(Grade 6, Geography - the world around us)

Overall, the aim related to technology in human culture and history is well represented throughout the specifications of Social Studies, even if technology as part of society and human history is not emphasised to the same degree in the introduction to the subject's curriculum. Environmental issues are in focus in several main subject elements. However, controversies and conflicts of interests regarding the use of natural resources and development and use of technology are not addressed as important topics in the Social Studies curriculum. These issues are, in fact, represented to a higher degree in the curriculum for Science.

'Technology' in the Art and Crafts curriculum

The subject Art and Crafts ('Kunst og håndverk') went through a change of 'image' when the former curriculum M87 (KUD 1987) was replaced with the present L97. From being a merely practical subject embracing 'sløyd' (traditional woodwork), textile work and artistic drawing, the subject is now given a stronger intellectual profile. It is to include knowledge of architecture and acquaintance with great professional practitioners of art, as well as awareness of the local, national and global cultural heritage. This change has also involved the introduction of textbooks in the subject. Nevertheless, the focus in the Art and Crafts curriculum is still on "practical creative work with form and colour in a variety of materials" (p. 204). The specifications in the Art and Crafts curriculum are structured around two main areas; the two-dimensional form (Pictorial images and visual art) and the three-dimensional form (Sculpture, design and crafts). Within these, the main subject elements are presented along three distinct strands: Art and design history, Form, colour and composition, and Materials, tools and techniques.

Whether the Art and Crafts curriculum comprises *technology* teaching is partly a question of definition. As discussed earlier in this thesis, the English notion 'technology' carries connotations towards what would be referred to as 'teknikk' rather than 'teknologi' in Norwegian language. Hence woodwork, textile work and other sorts of craft that could be considered as 'technology' in an English lingual context, will not fit that easy in a Norwegian understanding of the word 'teknologi'.

In concurrence with the above, the word ‘technology’ (‘teknologi’) does not occur anywhere in the curriculum for Art and Crafts. *Technical* matters, however, are addressed within the curriculum strand ‘Materials, tools and techniques’. Here pupils will acquaint themselves with the use of tools, materials and techniques, and also learn how to name, sort and maintain them with reference to their own work (see Grade 10, Sculpture, design and craft; Three-dimensional form).

A few similarities with the ideas of Design & Technology as a subject in England and Wales can be found in the specifications of Art and Crafts. These similarities occur in places where the curriculum states that pupils should obtain experience with the design of useful artefacts. For example, pupils in grade 6 should

- experience the relations between form, colour and function and practise planning, sketching and making simple useful objects, for instance out of clay, wood, and metal

(Grade 6, Sculpture, design and craft; Three-dimensional form)

The concept of design is more frequently mentioned in the specifications of the subject in terms of acquainting pupils with traditional and contemporary art and design carried out by professionals. Pupils should learn to recognise and acknowledge a variety of artistic styles, and several named designers and artists are mentioned in this regard. Hence, pupils are mainly considered as ‘*observers*’ of design. In some instances, however, the curriculum states that pupils should gather inspiration from traditional and contemporary design in their own artistic expressions and practical work.

Interdisciplinarity, project work and optional subjects in L97

In addition to the possibilities for technology teaching within the subjects considered so far, L97 also holds a significant potential for technology teaching across the subjects and as optional subjects. This section will examine this potential in terms of interdisciplinary teaching, project work and optional subjects described in L97.

L97 highlights interdisciplinary approaches and thematic structuring of content while teaching the various subjects in the curriculum. It states that local work at individual schools or co-operating schools must involve co-ordination of related main subject elements from different subjects and also *thematic structuring of contents*. This means that main subject elements from one or several subjects are brought together in meaningful units (themes), taking into account the pupils’ experience, interests, and cognitive development as well as connections with the local environment and topicality. The curriculum implemented in 1997 included

the requirement that project work and thematic structuring of contents should constitute 60%, 30% and 20% of teaching time on the primary, intermediate and lower secondary level respectively. Through the revision in 1999, however, these percentages changed their status from being mandatory to functioning as a guide (see Koritzinsky 2000).

L97 gives examples of topics that may benefit from a thematic structuring across subjects. These include as diverse topics as international understanding, knowledge of the media, homosexuality and consumer knowledge. Clearly, the many-sided nature of technology easily lends itself to a thematic approach across the existing subjects.

L97 emphasises that pupil should be active, enterprising and independent in their school work, and *project work* is accordingly put forward as an important teaching method. L97 describes project work as

a form of work in which pupils, in order to tackle a problem or set of problems or a specific assignment, define and carry out a purposeful piece of work from the original idea to the finished product, result or solution

(p. 85)

This formulation may easily be associated with the process approach originally introduced in Design & Technology (DES/WO 1990) described in Chapter 3. Pupils were intended to follow a 'design process' from 'Identifying needs and opportunities', through 'Generating a design', 'Planning and Making' and finally 'Evaluating'. L97 states that, in conducting project work, the planning, implementation and assessment should be carried out in close co-operation between pupils and teachers, and that the role of the teacher is to be the one of a guide and mentor (p. 85). In the final year of lower secondary school (grade 10), pupils must carry out a project assignment which involves a written assessment.

Project work as described above is meant as a method of working with the curricular content of various subjects, not as a curricular topic in itself. However, project work is also placed as a specific elective subject called '*Practical project work*' ('praktisk prosjektarbeid'). This subject is defined as one among several choices within '*Compulsory additional subjects*' at the lower secondary level (grade 8 - 10). Other electives are mainly second foreign languages, such as German, French and Finnish. A diversity of activities can go into the subject 'Practical project work', and pupils themselves should participate in defining the content according to their interests. Thus, the elective subject 'Practical project work' provides opportunities for practical work with technology for those pupils choosing this subject.

Finally, opportunities for technology teaching can be found within the curriculum's specification of a subject area called '*School's and pupils' options*' ('*Skolens og Elevens Valg*', SEV). The intention of this subject area is to give each school the possibility to focus on local main areas and to give pupils opportunities to choose topics and activities they are particularly interested in (p. 350). Schools are also encouraged to develop their individual profile, bearing in mind the aims of the Core Curriculum and the Principles and Guidelines for the compulsory school. This corresponds to a (mostly) non-academic version of what has been elsewhere proposed an 'extension curriculum' (Donnelly & Jenkins 2001).

L97 provides a variety of examples of areas and activities for both school's options and pupils' options. These examples range from cultural initiatives, entrepreneurship and co-operation with local industry to sports and initiatives in which pupils can acquire motor vehicle or boating skills (pp. 351-353). Hence, both schools and pupils have the opportunity to define technology – in any sense – as an appropriate content of this subject area.

Concluding remarks

From the audit undertaken in this chapter, it can be concluded that the curriculum for compulsory education in Norway provides considerable opportunities for technology teaching. It presents a broad view of technology, embracing technical, creative, cultural, societal, democratic and ethical aspects of technology. A variety of approaches to technology teaching are consistent with the curriculum's requirements with regards to content as well as organisation.

The positive and optimistic image of technology that can be found in L97, especially in the Core Curriculum, differs significantly from what was the case in its forerunner. The previous curriculum from 1987 ('M87', KUD 1987) indicated a rather negative image of technology close to what was described in Chapter 2 as technological determinism in the sense that technology is 'running amok' and is out of control. The textbooks associated with M87 presented a view of technology as a cause of pollution, violence and other problems, and as a threatening both to our traditional values and culture, and more generally, to humankind (see KUF 1994b). L97, on the other hand, conveys an optimistic view of technology and the possibilities it provides for individuals and for society as a whole, as well as a view of technology as expression of human creativity. It has, however, been argued that the present curriculum does not present a balanced view of technology, but is now biased towards an over-optimistic faith in technological development rather than conveying the true 'Janus face' of technology (Koritzinsky 2000).

The curriculum facilitates a range of approaches to technology teaching with different content, objectives and organisation. Nevertheless it is a common opinion that technology is missing as an element in compulsory schools in Norway (e.g. Briså 1997). This may be due to several factors. Firstly, the curriculum's specifications of main subject elements do not address technology specifically to the same extent as is found in the Core Curriculum and the curriculum's Principles and Guidelines. Thus textbooks provided for each subject may not attend to technology to the degree the general parts of the curriculum suggest. This effect is elsewhere shown to apply to textbooks in Science (Knain 1999). Further – even if technology is given a significant place in the curriculum as a whole – few guidelines for organising and implementing technology as a distinct curricular element are available. Finally, the lack of educational traditions, teaching material and teacher training within technology in Norway may represent an obstacle for realising some of the intentions of our present curriculum.

CHAPTER 6

THE TiS PROJECT ON TECHNOLOGY TEACHING

It is rare today to be able to observe the emergence of a new subject in the school curriculum – the sources from which it springs, the conditions which sustain its development, the influences which determine its form and the goals it is expected to fulfil.

(Layton 1994, p. 11)

The empirical study that forms part of this thesis is undertaken within the framework of a curriculum project on technology called 'Teknologi i Skolen' ('Technology in the School', henceforth abbreviated TiS) run by the Norwegian Society of Engineers (NITO) in the period 1997 - 2002 (see NITO, undated). This chapter presents the background for the establishment of this project, the aims of the project and aspects of the implementation of the project.

The TiS project was initiated by NITO in 1996 with the aim of promoting technology as a field of teaching in Norwegian schools. The project has been managed by a project leader from NITO and a steering group consisting of experienced and dedicated teachers, representatives from professional organisations and science educators from a college and a university. The project has been non-governmental in the sense that it was initiated and run by NITO and the steering group, but it has been financially supported by The Ministry for Church, Education and Research. Other sources of financial support have been The Research Council of Norway (NAVF), industrial and technological corporations and NITO itself. In 2002, however, the responsibility for administrating and co-ordinating the project was transferred to the new national centre RENATE ('Nasjonalt senter for rekruttering til naturvitenskapelige og teknologiske fag') with financing from the state. The project period of the project is also extended, and the project now (2003) involves about 50 schools as well as colleges for teacher training (see RENATE, undated).

Background of the TiS project

One important feature of the educational environment of the TiS project is a widespread concern about declining recruitment to education in science, mathematics and technology among Norwegian students. This is the case for both students' choice of subjects in upper secondary schools and for enrolment to natural sciences and technological studies at colleges and universities. Sjøberg (2000) points to a paradox in this situation of lack of recruitment to technological careers: Norway is a highly technological society, our youngsters love to *use* products of modern technology, but they don't want to learn about it, choose education within technology or contribute to its further development.

Diverse attempts have been made to promote pupils' interest in, and motivation towards, technological education and careers. The TiS project run by NITO represents an important initiative of this kind. As a trade union of engineers, NITO clearly constitutes a stakeholder of professional technologists (Layton 1994), and a reasonable intention with the project may hence be to promote interest in technology and engineer education among pupils, with the purpose of enhancing recruitment. As part of this implicit agenda, they may see benefit in building a positive attitude towards technology and engineers among *all* pupils, and thereby in the general population.

As exhibited earlier in this thesis, the notion of 'technology education' is clearly ambiguous. On an occupational level, it may, in broad terms, be regarded as embracing two main educational strands. One strand represents the science- (and mathematics-) based technology studies at colleges and universities leading to degrees and professional work as engineers and civil engineers. Technology-related science studies in fields such as electronics, computer science, petroleum geology and biotechnology can also be regarded as belonging to this strand. The other main strand of technology education represents the vocational education offered in upper secondary school leading to practical occupations such as electricians, carpenters and motor mechanics. However, these occupations and the education leading to them would typically be denoted *technical* rather than *technological* in a Norwegian setting. Like the science-based technology studies in higher education, this technical strand also suffers from insufficient recruitment, though the explanations of this may possibly be unlike those leading to the low recruitment to the former mentioned strand of education and professional careers in technology. Hence, different approaches to changing the situation may be required. Since NITO is an organisation of engineers, it is to be expected that they would emphasise the first of the two strands pointed out above in their effort to promote recruitment to technological education and careers.

Aims of the TiS project

The aims associated with the TiS project are multifaceted. The project has obtained considerable inspiration and ideas from the subject Design & Technology, run as a compulsory school subject for all pupils in England and Wales. In early phases of the project, its goal was expressed as establishing Design & Technology ('Teknologi og Formgiving') as a new subject in Norwegian schools, and this has formed an important aspect of the promotion of the project. The specifications of aims for the project, however, include quite different aspects of technology teaching than those associated with Design & Technology. The following aims were set for the project:

- Provide pupils in compulsory school with knowledge of everyday technology
 - Promote better understanding of the relationship between technology and science
 - Place technology and development of technology in a historical and societal context
 - Develop practical and aesthetic skills by designing a product
 - Develop skills in the use of IT in the design process
 - Support mathematics and the sciences (as school subjects)
 - Contribute to the inclusion of technology as a part of liberal education
- (NITO, undated, my translation)

These aims carry interesting connotations worth mentioning. They link the technology project strongly to science, firstly by stressing the understanding of the relationship between science and technology as an aim, and secondly by the statement that the project should support Mathematics and Science as school subjects. The connection to science is fortified through the description of the subject area as one where knowledge from science and craft subjects are applied, and by the elements of the subject presented as:

- mechanisms, structures, stabile constructions
- gear, power transmission
- making products of plastic and metal
- electricity

(RENATE, undated)

The emphasis on science in the aims of the TiS project and in how the associated subject area is described could suggest a more science-related ‘gateway’ to the teaching of technology in the project than the one represented by Design & Technology, as this subject has been shown to have a very weak connection to Science in English schools (Barlex & Pitt 2000). However, the aims set for the *subject area* denoted Design & Technology (‘Teknologi og Formgiving’) in the description of TiS embrace more diverse aspects of technology as a subject of teaching. In addition to aims corresponding to those set for the project as such, the teaching in the subject area aims at:

- Training pupils’ ability to wonder and ask questions
- Helping girls and boys develop abilities of creating, as well as knowledge and skills about technology and design
- Helping pupils learn to solve problems systematically through combination of creative and analytic thinking
- Developing pupils’ practical and aesthetic abilities through designing a product. This involves also knowledge about processes in industry as well as in craft
- Helping pupils gain knowledge about different materials and use of materials, and about the materials’ physical possibilities and constraints
- Developing pupils knowledge about how individuals and society influence the technological development. The environmental consequences of technological growth will be emphasised, for the pupil to develop consciousness about how we can steer the technological development
- Enabling the pupil to evaluate processes, products and effects of their own and others’ designing – including technology from earlier times and from other cultures

(RENATE, undated, my translation)

This set of aims more strongly reflects what can be associated with Design & Technology, such as use of materials, problem solving and evaluation of products. The inspiration from Design & Technology is also highly evident in the description of working methods for the subject. This description includes:

The work entails that pupils are given the task of making a product according to given requirements. The challenge for the pupils is then to plan and make the product. The planning of the product may include investigations, development of ideas, sketching, evaluations and test models, before the final product is completed. The goal for the developmental work is to create a product with

sufficient quality. The entire process is to be documented through a report to be presented together with the product.

(ibid.)

Here, the emphasis is on pupils' planning and making of a product, and the process approach from Design & Technology can be recognised. No reference to the application of science or other kinds of knowledge is addressed in this description.

The above exhibits a potential tension in the identification of aims and content for the technology subject the TiS project attempts to introduce in Norwegian schools. While significant inspiration is gathered from Design & Technology as a subject in England and Wales, the ideas underpinning this subject are substantially mediated already in the description of the project. How the participating teachers respond to the tension indicated above and how ideas from Design & Technology are further mediated on the way from NITO to the classrooms are themes in the empirical study presented in this thesis.

Implementation of the TiS project

A total of 19 schools from different parts of Norway have been fully taking part in the TiS project during the project period from 1997 to 2002. The schools represent mainly the lower secondary level (grades 8 - 10), but also the upper grades of primary schools (grades 5 - 7, i. e. the 'intermediate' stage of Norwegian compulsory school).

Two teachers from each of the 19 schools have actively participated in the project (occasionally only one teacher), with a responsibility of transferring ideas and knowledge to his or her teacher colleagues at participating schools. A few of the teachers were especially active in contributing to the development of the project in its initial phases; others were recruited and selected on the basis of their interest and response to invitations sent to schools during the project period. Some of the teachers have attended the project simply because the school needed another teacher to attend in order to fulfil NITO's requirement of having two teachers from each participating school in the project. This requirement was set to make it easier for the individual teachers to realise the content of the project at their school, through not having to work alone.

The teachers participating in the TiS project have different backgrounds in terms of education and subjects of teaching. They have, however, mainly been recruited from those with a background in either Science or Art and Crafts. The schools were chosen from all over Norway, but deliberately in geographical clusters, in order to

facilitate co-operation between the participating schools and teachers. Overall, the somewhat random choice of schools and teachers means that there is a wide span of educational backgrounds, teaching experiences, fields of interests and motivation for participation in the group of teachers participating in the project.

The essential content of being part of the TiS project has been the teachers' participation in a two weeks course at the College of Ripon and York, St. John in York, UK. This course was organised three times, in 1997, 1998 and 1999, with new groups of teachers attending each year. The course took place during teachers' summer holiday, and hence required some level of commitment from the teachers to participate. On the other hand; their travel to England, the two weeks stay and the course at the college were fully funded by the project, and this may have acted as a motivational factor in itself for teachers.

During these two weeks teachers experienced a largely practical course, working with materials and tools among which some were new to them. Each day small projects were carried out in fields like electronics, constructions and mechanisms, plastic moulding and computer-aided designing. For example, they designed and made buggies run by electrical motors, a board game printed on a string bag with game pieces moulding from plastic, and a metal detector with an electronic circuit and a coil. During the course the teachers were introduced to the ideas inherent in Design & Technology and provided with information on how the subject is carried out in schools. This included a school visit. Teachers were also introduced to machines and equipment used in the subject, and to drawing techniques and software on computer-aided designing.

Responsibility for realising the aims and content of the project after the course has resided with the individual schools and teachers. This has led to a variety of approaches to the content of technology teaching and ways of organising it within the school's general schedule. Aspects of this variety are exhibited in Appendix 1, and will be further discussed in Chapter 8.

Participation in the project also meant that schools received some material resources provided by NITO. A few books on technology and technology teaching have been offered, and also a number of LegoDacta sets for construction tasks. The resources provided also included an amount of money for free use within technology teaching at each school. Some schools have also managed to obtain equipment and material through companies' sponsorship.

During the project period, NITO organised seminars once or twice a year that also assisted and inspired the teachers in their realisation of the project in their schools.

These seminars consisted of practical and theoretical sessions run by technologists or educators, and also exchange of ideas and experiences among the participants. The teachers wrote short annual reports to the project leader about activities linked to the project at their school, and some surveys were carried out among both teachers and pupils in order to evaluate the project (e.g. Angell, undated).

The TiS project has been a very popular one. It has aroused interest and enthusiasm in Norwegian schools in general, also among teachers and others not directly involved in the project. Coverage in newspapers, television and educational magazines has contributed to attention towards the project and technology as a field of teaching in compulsory schools. Hence, the project must be seen as having succeeded in putting technology on the educational agenda in Norway.

The place and identity of technology as a curricular area in Norwegian schools is, however, still indefinite. The TiS project represents an important source of experience for the further development of technology teaching as well as for the understanding of the transfer of educational ideas. By examining how the teachers participating in the TiS project act as 'curriculum creators' in realising technology teaching associated with the project, the research reported in this thesis may offer a contribution to these issues.

PART III

THE EMPIRICAL STUDY

CHAPTER 7

THE EMPIRICAL STUDY: RESEARCH DESIGN AND METHODS

The way we study teachers reflects the value we put on them.

(Goodson 2000, p. 14)

The empirical study reported in this thesis comprises an exploration of how teachers participating in the TiS project described in Chapter 6 perceive and realise technology as a subject of teaching in their schools. It also includes an analysis of influences on the realisation of ideas from Design & Technology in Norwegian schools. The present chapter describes the design of the study and the research methods employed, including an explanation of how empirical data and their interpretations are presented in the subsequent chapters.

Design of the study

The study is explorative in nature and has been carried out with a *flexible* design (see Robson 2002). This means that the research questions, theoretical framework, research tactics and interpretations of results have developed in an iterative process throughout the study. In the thesis, this feature of the study is reflected in that Chapter 8 presents results and interpretations that serve the purpose of *motivating* the research questions as much as answering them.

The study is undertaken as a cross-case study involving 14 individual teachers participating in the TiS project. They represent cases of teachers involved in this particular project, but can also be seen as cases of teachers engaging with new educational ideas more generally. The 14 teachers are selected from 9 different schools, meaning that some teachers work at the same school. Appendix 1 gives a

short presentation of the schools and teachers in the study. The schools are named alphabetically A, B ... J. School C vanishes in the study due to extenuating circumstances. The teachers are given fictitious names starting with the same letter as the school. In the text, the reader is thus reminded that for example Eric and Elna work at the same school (school E) by noticing that their initials are identical.

The cases have been selected with the purpose of providing as wide a span as possible across cases with regards to certain characteristics, reflecting what is referred to as *maximum variation sampling* (Glaser and Strauss 1967). Characteristics taken into account are individual factors such as teachers' age, gender and educational background and school characteristics such as size, location and level (primary or lower secondary school). The sample also includes teachers having been involved with the TiS project for some time as well as newcomers in the field of technology teaching. This was deemed relevant as variation in the sample along this dimension provides for taking both the teacher's development and the project's development into account in the analysis of data. Finally, the selection of cases attempted to compose a variation in teachers' approaches to technology teaching in the sample, based on early impressions from informal contact.

It is important to note that this variation in the sample is not sought with any purpose of reflecting the profile of some population of teachers in order to make statistical inference. Indeed, Yin (1994) has warned against using the notion 'sample' in case study research exactly because it carries connotations towards inferential statistics. Rather than attempting statistical generalisation, the present study is concerned with *analytical generalisation* (see e.g. Yin 1994, Kvale 1996), where findings in the case study may contribute to the development of theory in a broad sense of the notion. Thus phenomena observed and categories developed on the basis of the case studies may apply to a larger sphere than the one being studied, yet without any anticipation of their relative prevalence.

By means of the variation in teacher characteristics indicated above the present study seeks to identify as many aspects of the phenomenon under study, that is how teachers engage with new ideas on technology teaching, as possible. Further, the variation provides opportunities for replication of findings across cases with different characteristics, which in turn contributes to external validity of the findings beyond the immediate study (Miles & Huberman 1994, Yin 1994, Merriam 1998).

Empirical data from the study are analysed on two levels. Within-case analysis has attended to the individual teacher and how he or she perceives technology as a

subject of teaching and realises technology teaching in the classroom. Cross-case analysis has involved identifying similarities and differences between cases, development of categories that transcend individual cases as well as examination of common features of the phenomena these categories describe. In the presentation of results in this thesis, quasi-quantitative measures such as ‘all’, ‘many’ and ‘few’ (teachers) are used in order to indicate the degree of such transcendence of phenomena across cases. They should not be mistaken as indications of attempts to make inference to any exterior population in a quantitative sense.

Collecting data

The main sources of empirical data have been *interviews* with the teachers who constitute cases in the study and *observation* of their technology teaching in schools. The amount of fieldwork conducted at each school has been subject to substantial variation, ranging from one single visit with an interview to weekly observations of lessons stretching over a period of several months. Appendix 2 gives an overview of fieldwork conducted at each school.

In addition to these two main sources of data, informal contact with the teachers and other actors in the field in various settings has been an important part of the fieldwork. In the beginning phase of the study, I participated in the two week course arranged by NITO at the College of Ripon and York, St. John, as a participant alongside the teachers (July 1999). This provided an insight into the project and the input the teachers received that was essential to the progress of the study. Participation in the course also facilitated access to the field as it represented opportunities to make contact with teachers for further fieldwork. Informal contact with teachers was maintained throughout the study through e-mail contact, conversations during school visits and through participation in some of the seminars on technology teaching held by NITO and others. Access to written documentation related to the TiS project, such as the teachers’ reports, their written teaching material and surveys undertaken for evaluation of the project (Angell, undated) also provided useful background information for further data collection. Finally, informal visits in English schools have enriched my own comprehension of Design & Technology as a subject and this way contributed to the analysis of possible influences on the transfer of ideas from this subject to Norwegian schools.

Interviews

Interviews with teachers have been an important source of data in the study. Interview data comprise 16 tape-recorded interviews. Some teachers were interviewed at two different stages of the process of realising technology as a subject of

teaching in their schools. Most interviews were conducted with only one teacher, yet some were undertaken with two teachers from the same school present at a time (see Appendix 2 for details). The interviews were conducted at a location found appropriate by the teacher, usually an empty classroom, a meeting room at the school or in a (more or less) calm corner of the staff room.

Interviews lasted from 45 to 90 minutes and were tape-recorded. They were *semi-structured* in the sense that they developed from a list of issues to be explored, where neither the exact wording of questions nor the order of questions were determined ahead of time (Merriam 1998). The list of issues used in interviews with all teachers included open-ended questions on the type of activities undertaken in technology teaching, what the teacher sees as aims for technology teaching, how technology teaching relates to other subjects in the curriculum and the teacher's view on Design & Technology as a subject in England and Wales as well as the official aims set for the TiS project. Pre-defined questions also comprised more individual adapted ones intending to explore specific feature of the teaching observed as well as questions arising from the evolving analysis of data.

The interview was typically opened by asking the teacher to give a broad description of how technology teaching associated with the TiS project has been realised at their school. The teacher's response to this question often provided opportunities to explore other topics of interest, and some topics were hence naturally covered as the conversation proceeded without consultation of the list. Since the teachers being interviewed were highly interested in the topic of the interview they were eager to talk about the issues being addressed as well as related issues, and the interview thus sometimes developed into an informal unstructured conversation steered by the informant as much as by the interviewer. Before closing the interview, the list of topics was consulted in order to ensure the coverage of all topics and, if necessary, addressing remaining questions.

The atmosphere of the interview was usually relaxed. When appointing or starting the interview, the teachers were ensured that its intention was not to evaluate their technology teaching or their understanding of the issue along any dimension of quality, but rather to build an understanding of their specific ways of approaching technology teaching associated with the TiS project. Several teachers expressed that they enjoyed talking about the topic to someone showing interest in it.

In the beginning phase of the study, I was anxious to avoid exerting a researcher bias to the interviews for example by asking leading questions, which are usually assigned under the label "Questions to avoid" or equivalent in basic books on research methods (e.g. Merriam 1998, Robson 2002). Throughout the study,

however, I realised that questions that were (unintended) leading in the sense that they anticipated a certain view of the topic being addressed in fact hold a potential of *clarifying* the teacher's view. This position is earlier expressed by Kvale (1996, 1997), who claims that leading questions do not always reduce the reliability of the interview, but can rather *enhance* reliability. This point can be illustrated through the below interview sequence from the present study (Norwegian original to the right and my English translation to the left):

BB

What characterises a pupil who succeeds with such a project? Or what is it that characterises the product?

BB

Hva er det som kjennetegner en elev som lykkes med et sånt prosjekt? Eller hva er det som kjennetegner produktet?

Elna

I don't know whether I would say characterises a product, because you can end up with a rather unsuccessful product but have learnt quite bit from it.

Elna

Jeg vet ikke om jeg vi si kjennetegner et produkt, for du kan ha et ganske mislykka produkt men ha lært ganske mye av det.

The question(s) raised by the interviewer (BB) intended to elicit the teacher's (Elna) perception of technology teaching by making her tell what she sees as *quality* in the products pupils design and make in technology sessions. In her answer, Elna rejects the question and its underlying anticipation – that the quality of the pupils' products is significant – and states that what pupils *learn* from creating the product is a more significant scale for success. Thus an important piece of data arose from a question anticipating a view different from the one held by the teacher. Analogous examples of this effect of leading questions in the interviews can be identified in the presentation of interview data throughout the chapters to follow. The clarifying effect indicated is, however, not necessarily a generic feature of leading questions and hence recommendable for all kinds of interview studies. It might have occurred in the present study due to both the fact that the teachers interviewed are confident in what they are doing with regards to technology teaching, and to the nature of the field relations established where the view of 'subject as expert' (Cooper 1993) has been paramount.

The teachers were asked for permission to use and publish material from the interview. This lies, of course, inherent in the rationale of accepting an interview at the outset. The request was, however, repeated at the end of the interview in order to give the teacher a chance to withdraw parts of it in case he or she arrived at second thoughts about what had been said during the interview. All the interviews were, however, fully accepted for use.

The first few interviews were routinely sent to the teachers for ‘member check’ (Robson 2002) after transcription. Except some expressions of the usual astonishment caused by the reading of ones own talking in print, the teachers had few comments on the transcripts. The later interview transcripts were not sent to the teachers, except to those requesting them. This was due to a realisation of that ‘member check’ makes more sense when it comes to how the material is interpreted and *used* than for the transcripts as such. This issue will be considered later in this chapter.

Observations

Classroom observations served two different purposes in the study. Firstly, they acted as sources of data for how the teachers realise technology teaching related to the TiS project. Secondly, they provided a background that helped focusing the interviews with teachers on relevant and interesting themes. Hence observations preceded the interview in many cases.

The observations focused on the teachers’ direct actions in the classroom, such as how they introduced a topic or a task and the interventions they made during pupils’ work. This also included what teachers chose *not* to do in terms of instructions and interventions. In addition, observations indirectly provided information on the teacher’s preparation of the lessons by noticing what material the teacher brought to the classroom.

As the sessions on technology teaching usually involved a significant component of pupils independent work individually or in small groups, it was reasonable to employ *participant observation* in the classroom. This means that the observer seeks to become some kind of member of the observed group, which implies the establishment of some role within the group (Robson 2002). The role I established as a participant observer, especially at schools where observations went on for some time, was the one of an ‘assistant teacher’. In performing this role, I was conscious to follow the real teacher’s agenda for the sessions by asking advice, interacting with only small groups of pupils at a time and not bringing in new aspects to the teaching and the pupils’ activities. Conversations with pupils during their work enriched the data material. Simultaneously, I kept an eye on the teacher and how he or she structured the lessons and interacted with the pupils.

The practical nature of the technology teaching made tape recording of the sessions impractical. However, two introductory sessions were tape recorded (see Appendix 2) and included in the systematic analysis of data.

Data analysis

Data analysis has been an ongoing iterative process throughout the entire study. Reflections during data collection have involved analysis in the sense that they have generated preliminary interpretations and induced new inquiries. The final phase of the process has involved analysis through writing, rewriting and discussions of the interpretations with others.

The following presentation of how data analysis was conducted concerns, however, merely the main phase of data management and substantive data analysis. This entails the phase connecting the data collection with the conceptualisation of results and findings as they are presented in this thesis.

Transcribing and managing data

All interviews were fully transcribed by myself. In addition, two observed sessions of technology teaching were tape recorded and partly transcribed. The transcripts constitute a total of approximately 280 pages⁵.

Although transcribing interviews surely represents a “tedious and time-consuming project” (Merriam 1998, p. 88), this part of the empirical study generated a close relationship with the data important for further analysis. It provided opportunities to reflect on all details in the interviews and hence to make preliminary interpretations and analytic steps that were deeply rooted in the data material itself.

The transcribed data material was managed by use of the software ATLAS/ti (see <http://www.atlasti.de/>). ATLAS provides opportunities for handling large amounts of qualitative data, for assigning codes to sequences of data and for reorganising and comparing data across the units in which they are gathered. In the present study, each transcript was assigned as one ‘primary document’ in a joint ‘hermeneutic unit’ (see Muhr 1997), while notes from observations and written teaching material gathered from the teachers were kept as hand-written notes and paper copies respectively during analysis.

Data display and coding

All transcripts were coded by means of the ATLAS software in several steps. In the initial phase of analysis, ‘coding’ was used for organising the data material in broad themes for further analysis. Codes were assigned to sequences of the transcripts according to the topics being addressed in the sequences. For example, the code ‘*Activities*’ was used where teachers described what they were doing in

⁵ Times New Roman 12 p, standard margins, single line spacing.

technology teaching, 'Aims' designated sequences that elicited teachers' aims for technology teaching, 'Relation to science' was used as a code when a relationship between technology teaching and science was the topic and so on. These broad codes contained no reference to the *content* of the sequences such as *what* the teacher described as aims or *how* technology teaching was related to science.

The benefit of the thematic coding described above is that it facilitates a data display (Miles & Huberman 1994) where sequences on similar topics across the primary documents in the hermeneutic unit can be displayed together by use of the output function in ATLAS. Outputs of sequences from all primary documents for specific codes then formed the basis for further analysis including comparisons between cases.

Analysis within and across cases

The analysis of empirical data has been undertaken within as well as across cases. Within-case analysis involves treating each case as a comprehensive case in itself and where as many aspects of contextual variables as possible are taken into account (Merriam 1998). Thus within-case analysis in the present study has attempted to elicit the individual teacher's perception of technology teaching and to understand his or her realisation of technology as a subject of teaching in light of the teacher's overall conceptions of technology and teaching and factors specific to the individual school. Cross-case analysis has involved comparisons between cases and conceptualisations of various aspects of the theme that appear to transcend the individual case.

From the coding of broad themes described above, the analysis continued by interpreting the *content* of the sequences coded within each category of themes. Attempts were made to classify sequences according to categories derived from literature on technology and technology education, whereof some were presented in Chapters 2 and 3 of this thesis. However, it was found that these were not fully appropriate for interpreting the data material, and I therefore changed the strategy towards developing categories from the data material itself. The lack of correspondence between categories from the pre-defined conceptual framework and the data material represents in itself a finding of the study that will be further discussed in the chapters to follow.

Through repeated reading of the transcripts, more specific categories within the broad themes emerged and were assigned as codes to sequences of the primary documents. These were often intimately connected to the case from which it emerged and are hence products of the within-case analysis. Cross-case analysis involved a constant comparison (Glaser & Strauss 1967) between tentative

categories, data sequences from which the categories had arisen and related sequences of all the other primary documents. This way, the categories were further developed, refined and assigned to new sequences of data.

The categories developed as described above are only partly presented as ‘results’ of the study in this thesis. Seale (2000) warns against a “narrow approach to analysis” (p. 163) in his review of possibilities and disadvantages related to the use of computers in analysis of qualitative data. The ‘code-and-retrieve’ approach facilitated by many the computer software packages may cause an overemphasis on the development of *categories* (denoted *codes* in ATLAS with explicit reference to Grounded Theory) and on assigning segments of data material to those categories. This may cause that the larger stories the data material can tell are missed out in the analysis and in the presentation of results. As an attempt to avoid this danger in the present study, detailed coding of data material and analysis in terms of categories have been restricted to the conceptualisation of aims presented in Chapter 9. The other chapters present results and interpretations that transcend the categories used in analysis, but where their development has been an important tool for managing the data material.

The significance of multiple sources of evidence

It is often claimed that a case study requires multiple methods and multiple sources of evidence. The anticipations underpinning this claim are various and some controversial (see Silverman 2000).

Yin (1994) assigns the most important advantage of multiple sources of evidence to its potential for developing “*converging lines of inquiry*” (p. 92), implying that findings and conclusions from case studies are more convincing and accurate if based on several different sources of information. This anticipation relates to the concept of *methodological triangulation* (Denzin 1978), which means that findings should be supported by evidence gathered by a combination of several different methods. It is, however, argued that the prominence assigned to methodological triangulation relies on mistaken ideas (supported by the notion’s reference to trigonometry) of that a feature of a ‘true’ reality can be positioned by “getting a ‘fix’ on it from two or more other places” (Robson 2002, p. 371). Different methods may operate in different theoretical paradigms, which makes their combination problematic. Along similar lines, Silverman (2000) has warned against adopting multiple methods in the mistaken hope that they will ‘reveal the whole picture’. He asserts that this ‘whole picture’ is an illusion, and that data from different sources cannot simply be aggregated in order to arrive at an overall ‘truth’.

However, as acknowledged by the authors cited above, the use of multiple methods may benefit a study in other ways. Firstly, it allows the study to address different but complementary research questions. Secondly, it provides for reducing “inappropriate certainty” (Robson 2002, p. 370), which means that data gathered by additional methods may point the researcher to alternative interpretations than those immediately suggested by data acquired by use of a single method.

The study presented in this thesis combines interviews with classroom observation mainly on the basis of the latter two points. Research questions addressed in the study (see Chapter 1) concern teachers’ *perceptions* of as well as *realisation* of technology as a subject of teaching. Hence *interviews* and *observation* respectively are seen as appropriate methods for exploring these two related issues. In some cases interviews have, due to the impracticality of observing all technology teaching the teacher undertakes, to some extent *substituted* classroom observation, with the methodological problems this of course implies. Further, the combination of interviews and classroom observation has in some cases resulted in what at first instance has appeared as a *mismatch* between data gathered by means of the two methods. Some of these seeming mismatches are presented and discussed in the thesis. Rather than validating each other by triangulation, data gathered by means of two different methods have in these cases initiated further analysis and provided for new interpretations of both types of data.

Presenting results

The presentation of findings of a study does not simply imply an exhibition of facts discovered through the investigation undertaken in the presented research. The presentation in itself represents an important component of the iterative process of interpreting data gathered in the research. The manner in which findings are communicated to and mediated with the reader is thus essential with regards to the validity and trustworthiness of the study. This chapter on research design and methods hence includes an account of how data and results of the empirical study are presented in the subsequent chapters. The following sections present the rationale underpinning the specific approach employed for data presentation in this thesis, principles for presenting quotations, illustrations of how quotations are modified for presentation and the considerations guiding these modifications. The final section describes how and why results have been presented to the informants (the teachers) ahead of publication.

Presenting results through stories

The presentation of results from a cross-case study – as well the process of data analysis – involves a risk for delving too deeply into particular aspects of individual cases on the one hand and a risk for making cross-case analysis detached from the context in which data material is situated on the other. The former may lead to a lack of analytical and theoretical perspectives while the latter may miss out on the richness of the individual case as a whole and undermine the importance of contextual factors.

In reporting the present study, a balance between focus on how the individual teacher approaches technology teaching in the concrete context he or she operates and cross-case analysis in more abstract terms is sought. In the following chapters, I have attempted to establish this balance by presenting data material and interpretations partly by means of seven ‘stories’ throughout the thesis. These stories have commonalities with several types of tales in ethnographic writing (see Van Maanen 1988). They are *realist tales* in the sense that they attempt to give voice to the teachers while the observer remains in the background. Though this is partly the intention, the stories are, nonetheless and inevitably, told by means of the observer’s interpretation. Further, the stories carry aspects of *confessional tales* in that they convey a picture of how the researcher’s interpretations have developed and changed throughout the study. Finally, though relying heavily on documented data material, the stories share certain aspects with *impressionist* tales by how they attempt to communicate experiences from the field as encountered by the observer.

Each story is based on interviews and observations related to one specific case. However, the story does not represent a full case study and is not intended to convey a complete picture of the individual teacher and his or her perception and realisation of technology as a subject of teaching. Rather, it seeks to illustrate *specific* aspects of how the individual teacher approaches technology teaching in ways that attend to the teacher’s broader view and the school framework the teacher works within. The story is thus fully embedded in the single case rather than in theoretical categories, and therefore includes aspects of the context that are deemed relevant for the specific aspects of technology teaching it is intended to illustrate.

The stories represent an important foundation for the further presentation of analysis. The analysis presented between the stories entails establishment of analytical categories based on the case represented in the story, as well as cross-case analysis where perspectives arising from other teachers are compared and contrasted to those revealed in the story.

Principles for presenting quotations

In order to ensure trustworthiness of the study, the presentation of results includes a range of quotations from interviews with teachers as well as some quotations from the transcriptions of tape-recorded lessons. This section presents the principles employed for the presentation of these quotations.

The teachers' fictitious first names are assigned to all quotations. The interviewer is labelled "BB", corresponding to the initials of the researcher. This convention is preferred from the more impersonal "I" for Interviewer or equivalent, signalling the conviction that it actually is significant who undertakes the interview. The inconsistency between full first names used for teachers (e.g. Elna) and initials for first name and surname for the interviewer (BB) is due to the fact that the former are fictitious while the latter is authentic.

Quotations are presented both in Norwegian original and in English translation in the manner shown in the example given earlier in this chapter. This is done with the purpose of maintaining contact with the original data material, and giving readers competent in Norwegian the possibility to examine the reliability of translations and interpretations. Each quotation is attached with a code that identifies it in the data files. This code specifies the primary document from which it is gathered (usually an interview), and the line numbers where the quotation occurs in the primary document. For example, [P3: 540 - 552] means that the quotation is from the primary document named P3, and that it can be found at lines 540 through 552 in this document. By consulting Appendix 2, the reader can identify when and where the interview or teaching sequence where the quotation occurs has been undertaken.

The following overview explains the conventions used for presenting quotations illustrated through examples from the thesis.

Example:	Explanation:
But it is such a... if it is to have its main weight on craft, or if it should be on the sciences, I am not sure about that.	The three dots signify a pause, and that the sentence is not completed.
I thought that if I am to attend a course, it needs to be something related to practical work (...) But 'technology' in itself, that sounded very 'gloomy' to me.	Three dots in parenthesis (...) signify that a short sequence, typically a few words, is omitted.

<p>But of course, I guess one can discuss with the pupils and so also, the issues about... technology, what is technology... (...) But in school, at least I think very much in the sense of, in fact I have two approaches, that I try to have, to the teaching of Science.</p>	<p>(...) with line breaks means that a longer sequence, typically several sentences, is omitted.</p>
<p>Elna (...) they became curious, they walked around watching the products of others, how they had done it.</p>	<p>(...) used in the beginning of a quotation signals that it represents a direct furtherance of earlier statements not quoted.</p>
<p>BB Where is the border between 'sløyd', or Art and Crafts and - Irene - Well, when our pupils made those chairs, then I thought that was Technology and Design.</p>	<p>The dashes signify an interruption. In the example BB is interrupted by Irene who starts answering the question before it is completed. A dash is also used when the quoted person appears to interrupt her- or himself and starts expressing a new line of thought without pausing.</p>
<p>[added words] [silence] [reading the list]</p>	<p>Words obviously missing in the quotation are added in brackets. Brackets are also used in order to explain abbreviations or specific concepts used, and to communicate occurrences of silence or non-verbal actions.</p>
<p>And to the extent technology is addressed in the curriculum, it speaks <u>about</u> technology. One speaks <u>about</u>, and it is still a theoretical topic, and one does not give education <u>in</u> technology.</p>	<p>Words that are clearly emphasised in speaking are <u>underlined</u> in quotations where the emphasis is significant for the meaning of the utterance quoted.</p>
<p>But if our new Minister of Education figured out that “yes, technology is to be a specified subject in Norwegian schools”, what do you think such a subject should contain?</p>	<p>Quotation marks (“ ”) are used when somebody else is quoted in the utterance (though the quoting may be fictitious, as in the example given). The quoting is detected in the interview by a notable change of tone in the voice and from the overall meaning of the utterance.</p>
<p>When you challenge them on “<i>well, what do you think, what do you think about just sitting there?</i>” - No, that’s top, right. - “<i>But does it make anything happen?</i>” No... it is boring.</p>	<p><i>Italics</i> is used for fictitious quotations for clarity reasons in one interview sequence where the teacher imitates a conversation with pupils (shown as example).</p>

The verbal context from which the quotation stems is of course relevant for how it should be interpreted. Consequently, the question the teacher responds to is often included in the quotation. However, the quotations of interest are not always direct responses to questions posed by the interviewer but may occur as part of a longer individual or joint argument. In such cases the question that was originally posed is omitted in the presentation, as it might in fact no longer have direct relevance for what is quoted. Instead, the theme being discussed when the utterance came up is then clarified before quoting the teacher.

Modifications of data material for presentation

Transcription of interview material in itself carries interpretations and modification of the material. Further modifications of the transcripts are made in the presentation of quotations. This is done for two reasons, of which both relate to the substantial difference between oral language and written text and the fact that a transcription represents an artificial construction of communication reworked from oral to written form (Kvale 1997). Firstly, modifications are made in order to enhance the *readability* of the text and this way make the presented quotation more clearly convey the intended message in the original quotation. This of course involves an interpretation of what the intended message is. Secondly, and related to the former, modifications are made on the basis of *ethical considerations*. An individual's spoken language is very different from a written text, and often includes incomplete sentences and inaccurate use of words and grammar. Thus transcribed interviews carry a potential of stigmatising the interviewee as immature and unintelligent (Kvale 1997). Modifications in the interview material presented in this thesis are thus made with an attempt to attain a sound balance between readability and ethics on the one hand and authenticity on the other.

I will use an example from the data material to illustrate how and to what extent quotations are modified and also how translations are modified with the purpose of making quotations readable in English. The quotation [P2: 663 - 685] was transcribed as follows ('direct' translation to the left):

BB
But if he [the new minister] figured out that "yes, technology shall be a specified subject in Norwegian school", what should such a subject contain, do you think?

Benny
... it needs to have... then it must be taken out from the subjects that it - I nearly said - lies within now, it must be something about processes in... both regarding food, what is baking powder for example, [laughter] it is

BB
Men hvis han [nye ministeren] fant på at "jo, teknologi skal være et eget fag i norsk skole", hva skulle et sånt fag inneholde, syns du?

Benny
... det må jo ha... da må det jo trekkes ut i fra de fagene som det - holdt på å si - ligger inne i nå, det må jo være noe om prosesser i... både når det gjelder mat, hva er bakepulver for eksempel, [latter] det er noe moro som du

something funny which you can make explode, make bombs from... some will say, some will say that it is something that in fact makes a flat pancake become a high cake? What happens in a way? You may make small experiments with, that becomes a bit Science in a way, physics. It is about basic principles in what is around us, so... what it should be, it can be many things, it can be both model building and it can be ... to make biscuits or whatever, but you can in addition make the biscuit... and get the task to pack it and sell it and... so you can, it is a different way of thinking, you think around... maybe, that it becomes an end product from it.

kan få til å smelle, lage bomber av... vil jo noen si, noen vil jo si at det er noe som faktisk får en flat lefse til å bli en høy kake. Hva skjer i det, liksom, hva er det som skjer med bakepulveret? Det kan du lage små eksperimenter med, det blir jo litt sånn Natur- og Miljøfag liksom, fysikk. Det går jo på grunnleggende prinsipper i det som er rundt oss, så... hva det skal være, det kan jo være så mangt, det kan jo være både modellbygging og det kan være ... det å lage kjeks eller hva som helst, men du kan jo i tillegg lage kjeksen... også få i oppgave å emballere den og selge den og... så du kan, det er en annen måte å tenke på, du tenker rundt... kanskje, at det blir et sluttprodukt av det.

In the thesis, this quotation is presented this way:

BB

But if our new Minister of Education figured out that "yes, technology is to be a specified subject in Norwegian schools", what do you think such a subject should contain?

BB

Men hvis den nye utdanningsministeren fant på at "jo, teknologi skal være et eget fag i norsk skole", hva skulle et sånt fag inneholde, synes du?

Benny

Then it must be taken out from other subjects which it - in a sense lies within now. It must be something about processes in... both regarding food, what is baking powder for example? What happens to the baking powder when a flat pancake becomes a high cake? (...) It is about basic principles in our surroundings. It can be many things; it can be model building as well as making biscuits or whatever, but in addition to making the biscuits you may get the task of packaging them and selling them. It is a different way of thinking, you think around... maybe, that it results in a final product.

Benny

Da må det jo trekkes ut i fra de fagene som det - holdt på å si - ligger inne i nå. Det må jo være noe om prosesser i... både når det gjelder mat, hva er bakepulver for eksempel? Hva er det som skjer med bakepulveret når en flat lefse blir til en høy kake? (...) Det går jo på grunnleggende prinsipper i det som er rundt oss. Det kan jo være så mangt; det kan jo være både modellbygging og det kan være å lage kjeks eller hva som helst, men du kan jo i tillegg til å lage kjeksen også få i oppgave å emballere den og selge den. Det er en annen måte å tenke på, du tenker rundt... kanskje, at det blir et sluttprodukt av det.

The modifications made in the above quotation include drawing fractures together into full sentences. However, some incomplete sentences are retained in order to communicate the uncertainty related to the hypothetical nature of the topic. The sequence about the possibility of making 'bombs' from baking powder is treated as a digression and omitted from the quotation. It is judged not to contribute to Benny's overall argument in the quotation, a judgement that of course may be questioned. Elements of the omitted sequence are, however, rewritten as the two questions "what is baking powder for example?" and "what happens to the baking powder

when a flat pancake becomes a high cake?”, which are believed to capture what Benny is communicating in an appropriate manner.

Presenting results to informants

The results from the study have been presented to the teachers in the sense that copies of Chapters 8 - 12 have been sent to them before the thesis is submitted and published. In addition to the possibility it provided for verifying factual information, this move was mainly done as a matter of respect for the teachers and their contribution to the present work. As the decision of sending the presentation to the teachers was made early and communicated to the teachers, it also acted as a way of disciplining myself in the process of analysis and writing. By this I mean that it contributed to the resistance of potential temptations to over-interpret elements of data material or to present them in inappropriate contexts.

In general, informants may disagree with interpretations made from the data material as well as with the focus adopted when selecting material to present. However, their reactions to the interpretations and selections made cannot principally be a means for *validating* the interpretations, as they would rather represent *new data* (see Silverman 2000 for a review of the discussion of ‘respondent validation’). It was hence decided in advance that the chapters would not be changed as a consequence of reactions from the involved teachers. Exceptions to this rule would of course be made in case the teachers pointed to factual errors, obvious misunderstandings or sequences in the thesis that were ambiguous and could unintended be interpreted in disfavour of the teacher. The letter to the teachers enclosed with the chapters explained that the interpretations were made on my own behalf only and that they would not necessarily be changed as a result of their responses. However, the teachers were given the opportunity to write a note explaining their disagreement that would be printed in the thesis in case they disagreed strongly. They were given a deadline two weeks ahead for such a response. None of the teachers expressed any wish for enclosing any note explaining disagreement; some rather responded with asserting that they found the reading interesting and enjoyable.

CHAPTER 8

THE PROJECT IN SCHOOLS. ITS REALISATION AND MEANING

As the audit undertaken in Chapter 5 has shown, the current curriculum for compulsory education in Norway allows technology teaching with a variety of approaches with regards to organisation as well as content and connections to existing subjects in the curriculum. Further, the TiS project itself gives few directions for how technology teaching is to be carried out in schools. This provides the participating schools and teachers with extensive freedom in giving shape to technology as a new subject.

This chapter first describes some organisational aspects of how technology teaching associated with the TiS project is realised in the schools included in the present study. Then the role of the TiS project as such is discussed, and the concept of an ‘activity account’ will be introduced. The meaning of the project as an ‘activity account’ for teachers is then challenged and discussed on the basis of empirical data presented as the first two stories in this thesis.

Organisational aspects of realisation

Technology teaching associated with the TiS project is found to be realised in a wide range of ways in the participating schools. Some of this variation is related to organisational aspects, that is, in what ways technology teaching is organised, who teaches it, how it is placed on the school’s timetable and how it is related to subjects in the curriculum. An overview of how technology teaching is organised at the individual schools is given in Appendix 1, together with information on the background of the teachers who represent cases in this study. This overview shows significant differences between the schools. Some places, technology is taught as an independent unit identified as ‘Technology’, ‘Technology and Design’ or corresponding labels on the pupil’s timetable. Other schools have incorporated technology teaching into the everyday school activities as cross-curricular teaching projects. We also find technology specified as a significant part of existing subjects such as Art and Crafts, or incorporated into the teaching of Science. Some schools run combinations of these models. Other organisational differences between the schools is whether technology is elective or compulsory for the pupils, and if it is run all year or in concentrated periods.

At some of the schools, technology teaching is basically the responsibility – and also the interest – of the individual teachers who have attended NITO’s courses, and technology teaching associated with the project is realised occasionally within these teachers’ ordinary teaching, or it is also offered to pupils as elective units initiated and managed by them. At other schools, participation in the TiS project has had a broader impact on the whole school and other teachers’ practice. In all cases, the influence of the individual teacher on giving shape and content to technology teaching is found to be fundamental.

The meaning of the TiS project for teachers

The TiS project attempts to introduce elements of Design & Technology in Norwegian schools. Though any explicit curriculum has not been specified, the teachers have become acquainted with this subject and its embedded ideas through the course in York, yearly seminars and communication with the project managers and with each other. What is the meaning of the TiS project for teachers, and what role does it play for their realisation of technology teaching in schools?

The TiS project as an activity account?

The variation in organisational aspects of how the schools place technology in the curriculum, together with the differences in the teachers’ background and also the age range of the pupils they are teaching, suggest that technology as a subject or topic is approached in very different ways at the schools. Some differences found in the study will be interpreted and discussed throughout this thesis. However, technology teaching observed at the various schools in this study shows striking similarities in certain key aspects. In many cases, the teaching of technology is structured around specific activities that the teachers themselves have experienced at the course they attended in York and at the seminars arranged by NITO for the teachers participating in the projects. The core of the technology teaching observed appears to be the building of artefacts mainly defined by the teachers, though the activities are often placed in broader contexts than the building in itself. Characteristic activities associated with the TiS project can be identified as: making buggies run by balloons or electrical motors, building models of bridges and towers from tubes made from sheets of paper, moulding objects from plastics (vacuum moulding and line bending), making a ‘siege machine’ (a mechanism that can project a small ball or other object) from materials such as cardboard and wood, and making artefacts containing simple electronic circuits (typically a ‘flashing badge’ or an electronic map). More advanced electronics are represented by the building of an ‘electrical wire game’, which involves a circuit with transistors and a buzzer. Additionally, as NITO has provided the schools with sets of LegoDacta’s

construction kits, construction tasks with Lego are also a part of teaching associated with the TiS project.

Besides its reference to Design & Technology as a subject in England and Wales, the project does not emphasise a conceptualising of the subject that these activities represent. Nor does it communicate any connection between the activities that can be associated with the concept of the substantive and syntactical structure of a discipline as developed by Schwab (1964). The activities listed above may hence be seen as *constituting* the project and the subject it attempts to introduce in Norwegian schools. It should here be kept in mind that conceptual and structural problems in defining technology as a subject is not exclusive to the TiS project. As was shown in Chapter 3, the identification of content, structure and boundaries of technology as a school subject is disputed and subject to conceptual problems as well as implementation problems world-wide.

Nonetheless, it appears that the essence of the project is that it provides teachers with a collection of enjoyable activities for their pupils to engage with rather than providing a foundation for a new subject in Norwegian schools. Such an interpretation of the project may be warranted by the fact that identical activities are run for pupils of a very wide age range and that the same activities are chosen regardless of what organisational and curricular context the technology teaching is placed within.

This reading of the project may represent a ‘devaluation’ of the TiS project. Seen from the teachers’ perspective, however, the need for new teaching activities to use in the classroom is pressing, and hence emphasised by many of the teachers in the interviews undertaken in this study. The course they attended in York and the yearly seminars arranged by NITO have provided input in the direction of their stated needs, and this may explain the high popularity of the TiS project and courses related to the concept of Design & Technology. For example, when asked about his needs for professional development, David points to the practical technology courses he has experienced as exemplary with regards to what he needs in order to develop his competence as a teacher:

BB

What do you need if you would wish to increase your competence further, in order to develop yourself in your work? What kind of input do you feel you have a need for?

David

I need, I think, the kind of course one often experiences related to technology, those practical courses where you can work practically, I think, with ideas. Because all

BB

Hva trenger du hvis du skulle ønske å øke kompetansen din enda mer for å kunne utvikle deg i jobben? Altså hva slags type input føler du at du har behov for da?

David

Jeg trenger, tror jeg faktisk den type kurs som en ofte opplever i forbindelse med teknologi, sånne praktiske kurs der du kan dra og jobbe praktisk, tror jeg, med ideer. For

such courses make it easier to make use of things, and then you adjust it a bit.

BB

So that you get projects and activities you may use -

David

- Yes, I really believe you need a number of ideas, you need a bank of ideas in a way. What we [the school] can work with, is really to make a good organisation that creates room for doing different things. So it is things like that, to have the opportunity, have time and room to attend courses where one builds windmills, and where one builds rockets. (...) But I do think to have the ideas is quite important.

alle sånne kurs gjør det enklere å ta i bruk ting, og så justerer du litt på det da.

BB

Sånn at du får prosjekter og opplegg du kan bruke -

David

- Ja, jeg tror faktisk du trenger en del ideer, du trenger en idebank på en måte. Det vi [skolen] kan jobbe med, er egentlig å lage god organisering som gir rom for å gjøre forskjellige ting. Så det er jo sånne ting, å ha mulighet, ha tid og rom til å delta på kurs der en lager vindmøller, og der en lager raketter. (...) Men jeg tror å ha ideene er ganske viktig.

[P14: 1127 - 1147]

David introduces banking as a metaphor for the type of courses and input teachers need to develop their work, like those provided by the TiS project on technology teaching. Though it may be to see the project from a rather narrow perspective, the TiS project may hence be described as giving teachers access to an ‘*activity account*’. Through practical courses where teachers are allowed to ‘act as pupils’ and try out new activities and material for themselves, they have the opportunity to broaden their repertoire in their own teaching – or to ‘refill their activity account’.

The relevance of an ‘account’ as a metaphor is strengthened by teachers actually talking about ‘using up’ activities. Below, Eric is asked about the thinking behind the technology projects they are running in the project week at School E (see Appendix 1). Besides identifying what can be ‘alright’ for the pupils to do, he expresses a concern for not ‘using up’ technology projects that could otherwise be undertaken in ordinary lessons in the classes:

Eric

[We have] considered what could be alright for the pupils. That’s one thing, the other is that we must not use up good projects on... that they otherwise can do in the classes. So these are things that we will not directly repeat in the classes, then it has to be other projects. So we are constantly in need of developing new projects.

Eric

[Vi har jo] tenkt på det som kan være alright for elevene. Det er det ene, det andre er at vi må ikke bruke opp gode prosjekter på... som de ellers kan kjøre i klassene. Så dette er ting vi ikke direkte vil gjenta i klassene, da må det være andre prosjekter. Så vi har konstant behov for å utvikle nye prosjekter.

[P 6: 18 - 23]

The need Eric expresses for new projects in technology teaching is prevailing in interviews with all the teachers. They call for concrete ideas for teaching activities, but also information and experiences on physical materials they may utilise in activities with pupils; materials that are cheap, easily available and easy to use for

the kids. This represents what Shulman (1986) has denoted '*curricular content knowledge*'. Some relate the need for curricular content knowledge to their lack of prior interest in and experiences with practical technology:

Irene

I have never been interested in such things. Never taken apart an alarm clock or anything. So I am not really a typical, such technology, no, no, no. But what we did in York was great fun, and... But I am a bit afraid of, in a way, to get started, I am confident with what I have done myself, but to invent things on my own and start to experiment and create new projects and so, I am a bit reserved towards that. Then it is more like I need input, I need to learn more, somebody needs to tell me how to do it, somebody must give me a recipe or something.

Irene

Jeg har aldri vært interessert i sånne ting jeg. Aldri skrudd fra hverandre en vekkerklokke eller noe. Så jeg er egentlig ikke typisk sånn, sånn teknologi, nei, nei, nei. Men det var innmari gøy å lage de her tingene vi gjorde i York, og... Men jeg er jo litt redd for, liksom, å gå i gang med, altså det jeg har laget er jeg trygg på, men å finne opp ting selv og begynne å eksperimentere og lage nye oppgaver og sånn, der er jeg jo litt tilbakeholden. Der er jeg jo mer sånn at jeg har lyst på input, jeg må lære mer, noen må fortelle meg hva jeg skal gjøre, noen må ha en oppskrift eller sånn.

[P16: 278 - 287]

Irene expresses that her lack of experiences makes her insecure in experimenting and following her own ideas in technology teaching. She needs somebody giving her instructions in order to go on with new projects. However, her self-image with regards to practical technology appears to change due to her involvement the TiS project:

Irene

We try in all possible ways to spread it, and I talk about it wherever I go. So I am now identified as "that technology woman", when they approach me the talk is about technology, and "how fun" and all that. And I would never have believed it, before I went to York, that I should be such a physics and mathematics and technology and... I would never believe it. So it has been really enjoyable.

Irene

Vi prøver jo på alle mulige måter å få spredt det, og jeg snakker om det hvor enn jeg er. Så jeg blir jo identifisert som "ho der teknologidama", når de kommer til meg så er det snakk om teknologi, og "så gøy" og alt det der. Og det hadde jeg jo aldri trodd, før jeg dro til York, at jeg skulle være noe sånn der fysikk og matematikk og teknologi og... Det hadde jeg aldri tenkt. Så det har vært veldig gøy.

[P16: 917 - 923]

From being somewhat alienated from practical technology, Irene tells that she is now identified as "that technology woman" and that she is associated with competence in this field. It is evident that she enjoys this change of self-image. She explains what she needs in order to develop herself further as a technology teacher this way:

BB

What do you feel you need, you said you had learnt a lot on the course we attended in York -

BB

Hva føler du at du trenger, du sa du hadde lært mye på det kurset vi var i York -

Irene

- Yes, well, I would perhaps have, (...) I

Irene

- Ja, altså jeg ville jo kanskje ha, (...) jeg

would like to learn more about cogwheels and be able to make for example a mechanical toy. Just because I haven't made a mechanical toy, I don't dare to bring it in and present it to my pupils.

kunne tenkt meg å lært litt om sånne der tannhjul og kunne laget for eksempel en mekanisk leke. Bare for at ikke jeg har laget en mekanisk leke, så tør ikke jeg å ta den inn og presentere den for elevene mine.

[P16: 819 - 828]

Irene expresses a wish for learning how to make a mechanical toy. However, it appears that she does not only need a recipe on how to do it or explanations of how it works; she needs the *practical experience* before she feels able to present the task to pupils.

The teachers' call for ideas, experiences and resources as those pointed to above might be assigned to the fact that the 'subject' is new; it lacks traditions in schools and teachers may not have the competence required to teach the subject. However, the present study has revealed that the teachers' want for concrete activities also apply to more established subjects as well as to teachers who are highly competent in relevant technological areas. The former can be illustrated by how Hanna tells about her expectations to, and experiences from, a course in science for primary schools she is attending at a nearby college:

Hanna

I go to the college now in order to learn physics, among other things, the course is about science on the primary level. What I hoped, was that it was some experiments and so, suitable for using with small kids, because I feel I have too few ideas for simple things to do that I can cope with very quickly and that kids understand and can succeed with. That's what I hoped for, but it became a bit 'up in the clouds', it is very interesting what we get, but still I feel it is not as useful as I had hoped.

Hanna

Jeg går jo på høgskolen nå for å lære fysikk, blant annet, det er jo naturfag på småskoletrinnet. Det jeg håpet på, var at det var en del sånne forsøk og mye sånne, som passet til bruk med små unger, for det føler jeg at jeg har for lite ideer til å komme på helt enkle ting som både jeg får til veldig fort og som unger skjønner og får til. Så det hadde jeg håpet på, men det ble litt oppi skyene, det er veldig interessant det vi har altså, men jeg føler ikke at det er så matnyttig som det jeg hadde håpet på da.

[P9: 967 - 975]

Hanna describes the science course as interesting, but not as useful as she hoped for. In her view, what are missing in the course to make it useful are ideas on simple science experiments that the kids could accomplish.

One of the teachers in lower secondary school provides us with an example of the latter point made above, that the need for an activity account is not restricted to teachers who lack experience and competence with practical technology. Jim is a lower secondary teacher with a multifaceted background in fields such as woodwork, applied physics, electronics and also professional design. He expresses a similar need for resources and ideas as the teachers cited above:

BB

You said you need input and backing and so from the project or from somewhere else, what do you wish, what is it that you need in a way?

Jim

I need some useful..., you may call it textbook or some sort of source for activities and orientation related to it. It could have been connected to subject elements in the curriculum.

BB

You would like to have a book?

Jim

A book, or a booklet or folder that in a way could have been a discovery, some hints, some advice, contact persons.

BB

Du sa at dere trenger påfyll og oppbacking og sånn fra prosjektet eller fra et eller annet sted, hva er det du ønsker deg, hva er det du trenger, på en måte?

Jim

Jeg trenger på en måte brukbare..., kall det pensumbok eller en slags kilde for både oppgaver og orientering rundt det. Du kunne godt ha knyttet det til aktuelle fagting i fagplanen.

BB

Du ville hatt en bok?

Jim

En bok, eller hefte eller perm eller på en måte som kunne vært en oppdagelse, noen tips, noen råd, kontaktpersoner.

[P17: 1034 - 1052]

Jim's expression of what he needs for development as a technology teacher is strikingly similar to Hanna's call for a textbook with ideas, in spite of the differences in their background. Though Jim owns a high competence in the areas covered on the course the teachers attended in York as part of the TiS project, he found this course very useful:

Jim

It was a great place to come, to come to York. (...) They did things in cunning and easy ways that in fact makes it possible to put it into the school context.

Jim

Det var jo en kjempeplass å komme, å komme til York da. (...) De gjorde ting på snedige og forenklet vis som gjorde at det var faktisk mulig å sette det inn i en skolehverdag.

BB

Yes, you saw things you could use with your pupils?

BB

Ja, du så ting som du kunne bruke med elevene dine?

Jim

Yes, all the way, that I knew - you can just look at, the teachers who were there, that we were completely electrical, you know, didn't have time for coffee, we didn't have time for relaxing! I can't remember smoking so little ever before...

Jim

Ja, hele veien, som jeg visste - det kan du jo bare se på, vi lærere som var der borte, at vi ble jo helt elektrisk, vet du, hadde ikke tid til kaffe, vi hadde ikke tid til å slappe av! Jeg tror ikke jeg har røkt så lite så lenge jeg kan huske...

[P17: 114 - 125]

Through the course, Jim discovered how the things he mostly knew before could be done in "cunning and simple ways", thus making it available as teaching activities. His enthusiasm for taking part in this course is described by how he missed coffee

breaks, didn't experience any need for relaxing and not even for smoking which he usually does.

The above interpretation of the TiS project as playing the role of simply providing an activity account for teachers may be seen as representing a mechanistic view of the work of a teacher. It may include an understanding of teaching as equivalent with 'executing' a predefined curriculum in the classroom, and thus undermine the professionalism of teachers. The teachers' massive call for curricular knowledge in terms of new ideas and activities may indicate that the teachers themselves hold such a view of their own work.

The mechanistic view of teachers' work indicated above, does, however, place the TiS project, the ways it is realised by the teachers and the work of teachers more generally in a much too narrow perspective. Even if the TiS project may fulfil teachers' need for new activities, the teachers' role in realising the TiS project in schools can not be understood as simply executing a 'collection of activities'. The purpose, content and focus of the teaching are not given by the teaching activities in themselves, but by the teachers. In the classroom observations undertaken in this study, the determining role of the teacher in creating technology teaching based on the activities associated with the TiS project has been highly evident. In the following, this will be exemplified by the presentation and discussion of the first two 'stories' based on case studies in this study. The stories exhibit how two different teachers, Ann and Benny, teach technology based on an activity of making a buggy run by an inflated balloon. They will reveal how the 'same' activity is utilised by the teachers in realising technology teaching very dissimilar in nature. The differences between the two teachers' use of the activity will then be interpreted and discussed. In order to broaden the picture of these two teachers' technology teaching, the stories also include an account of how they run one of their other teaching projects with their pupils. This also makes the stories serve the additional purpose of contributing to the empirical basis for further analysis at a later stage of this thesis.

FIRST STORY. ANN'S BUGGY PROJECT

Ann teaches 'Technology and Design' as an elective unit for pupils in grades 5 - 7 within the weekly 'Cultural Session' at School A (see Appendix 1). One of the teaching projects she undertakes with her pupils in this unit is the building of a buggy that can run by means of a balloon. The buggy is made by gluing square lists together, forming a rectangular frame. Wheels are attached to tiny dowels, functioning as shafts that run through holes in pieces of cardboard attached to the frame. The balloon is mounted through a small piece of plastic tube attached to the buggy, and the buggy can drive across the floor when the balloon is inflated and then released. In the final sessions on the buggy project, the pupils are free to decorate their buggy according to their personal preferences. Pupils work individually in all sessions, but are encouraged to co-operate and to help each other.

Except for the final decoration of the buggy, the project is strongly defined by the teacher. The teaching communicates low degrees of freedom regarding the working principle for the buggy, the use of materials, tools and techniques and how to organise the work. This does not, however, mean that Ann is not open to the pupils' own ideas. She expresses a positive attitude to their initiatives, but the technology sessions is apparently not based on a purpose of having pupils working out their own ideas on how to build the buggy.

Ann places strong emphasis on the technical quality of pupils' products, and she teaches them, in an apprenticeship manner, how to use tools properly and techniques for achieving good technical quality. Examples are how to cut square lists in equal lengths, how to make them form a frame with exactly right angles and how to make holes for the dowels at identical distances from the frame.

The teaching of these techniques is usually carried out as sequences of instructions and demonstrations directed towards the whole group of pupils at suitable stages in the lesson. In these sequences, Ann also introduces and discusses mathematical concepts and principles such as being at right angles or parallel, and the relationships between those. Scientific concepts such as friction, energy and air resistance are also highlighted. This 'script' of the lessons makes Ann attempt to have all her pupils work at the same stage of the process of making their product at the same time. Ann's lessons strongly communicate the importance of technical details and the value of careful adjustment of each part of the construction. The pupils seem to adopt her concern, and show great care when cutting or gluing pieces of their work.

Ann's demand for product quality creates a great deal of work for her in preparing the lessons, as the following example illustrates. In her first group of pupils, Ann made wheels for the buggies out of chipboard. When starting the next group, I noticed that the wheels provided were different. When asked about the reason for this change, Ann tells 'the story about the wheels':

BB

... And you have changed the wheels?

Ann

Yes, the wheels. That was a story [laughing]. Because we can not afford much at this school, and this autumn there was almost no money left, so I managed to argue for buying what I needed for the electronics, and tried to argue that this was almost all that I needed for the whole Cultural Session before the summer. Then I realised, when we were to make those buggies, that we needed wood material for that. So I asked here at the school, and I found a caretaker who had such a drill that could drill out wheels. Where you get a hole in the middle and you can drill around it. You get a wheel. So I got along drilling the wheels out of thin chipboard. The problem is that it drills so it forms an 'angle' on the wheels, they became thin on the inner side, and...

BB

They tilt?

Ann

Yes, they tilt, and they were rough, so I asked the pupils to sand them down, and some of them attacked the task whole-heartedly, they almost used a hacksaw! [laughing] - and they filed them in order to make them perfectly smooth, but of course they were not, since they filed that persistently! So the problem was that the wheels were not round and then the buggies didn't go very well either. So when we had a test race, with the completed buggies, it appeared that

BB

... Og så byttet du om på hjulene?

Ann

Hjulene ja. Det var jo en historie [latter]. For vi har ikke så god råd på skolen her, og i høst så var det nesten tomt for penger, så jeg fikk kranbla meg til å kjøpe inn det jeg trengte til elektronikken da, og prøvde å argumentere for at det var stort sett det jeg trengte for hele kulturøkta fram til sommeren da. Så oppdaget jeg da vi skulle lage de her bilene at vi trengte jo trematerialer til det og. Så jeg forhørte meg her på huset så var det noen av vaktmesterne som hadde et sånt bor som kan bore ut hjul i hvert fall. Hvor du får et hull i midten og så får du bora rundt. Du får et hjul. Så jeg til og skulle bore ut de her i sånne litt tynne sponplater. Problemet er at den borer så det blir 'vinkel' på hjulene, så de blir tynne innerst og så...

BB

De skråner?

Ann

De skråner ja, og så ble det jo flisete og sånn så jeg ba elevene pusse hjulene, og det var noen som gikk løs på den der pussinga med liv og lyst, de drev med baufile omtrent! [latter] - og skulle drive å pusse ned de her så de skulle bli helt jevne, men det ble de selvfølgelig ikke da, når de driver og pusser så iherdig! Så problemet ble at hjulene ikke ble runde og da gikk ikke bilene særlig godt heller. Så når vi skulle ha sånn prøvekjøring da, med de ferdige bilene, så viste det seg

the one who had filed the wheels least in fact, her car went best because there was a thin edge on her wheels. But then I got a tip, because I kept complaining at home and everywhere about those wheels that were so unsuccessful. [laughing]. Then my mother came across someone who works at the Science Centre downtown, and in some connection mentioned that they had many wheels in store, stemming from a lorry project, and a lot left. So I got the telephone number down there, and called him, and asked if I might buy some wheels. It was indicated that I could get them somewhat cheap, but in the end it wasn't as cheap as I thought, but then I figured out: no, I'll buy these wheels and get rid of the problem. So now they are at least round, and they roll nicely! They are a bit thick though, so I wonder if it will affect much that they are somewhat heavier, but I think the fact that they are round and smooth and nice will make them roll better this time! It is a bit frustrating for the kids when they have put such effort in it and spent several weeks on a buggy, and it is not working because the wheels are... flat in a way, like if the buggy have had a puncture. So at least they understood the importance of having round wheels, and so did I.

BB

It's not so easy to achieve that when you file, even if you know.

Ann

No, it isn't. I know there are other tools that may make the wheels better than what I have achieved here, but... Yes. That was the story about the wheels.

at hun som hadde pusset minst på hjulene, faktisk, den bilen gikk best for det var så tynn kant på hjulene da. Men så fikk jeg tips da, for jeg drev og klaget hjemme og overalt om de her hjulene som var så mislykka da [latter]. Så var det mora mi som hadde truffet en som jobbet nede på Vitensenteret, som da hadde i en eller annen sammenheng kommet inn på at de hadde så mye hjul liggende, fra et sånt lastebilprosjekt, og masse til overs da. Så jeg fikk telefonnummeret ned dit da, og ringte til han da, og lurte på om jeg kunne få kjøpt noen hjul da. Det var snakk om at jeg skulle få det litt billig men da det kom til stykket var det ikke fullt så billig som jeg hadde tenkt, men da fant jeg ut: nei, nå kjøper jeg de hjulene så slipper jeg det problemet. Så nå er de i hvert fall runde, og triller fint! De er litt tjukke da, så jeg er spent på om det påvirker mye at de er litt tyngre da, men jeg tror det at de er så runde og glatte og fine gjør at det triller bedre denne gangen! Det er litt frustrerende for ungene når de har lagt såpass mye arbeid i det og brukt flere uker på en bil, og så går den ikke fordi hjulene er... de er flate på en måte, akkurat som bilen har punktert. Så de skjønnte i hvert fall at det er viktig å ha runde hjul, og det gjorde i og for seg jeg også.

BB

Det er ikke så lett å få det til når du pusser, selv om du vet det.

Ann

Nei, det er ikke det. Jeg vet det fins en del andre sånne redskaper hvor du kanskje får finere hjul enn det jeg fikk til her da, men... Ja. Det var historien om hjulene.

[P1: 341 - 401]

'The story about the wheels' neatly displays Ann's concern for the quality of her pupils' products. By utilising her spare time and family,

and also bursting the budget for her technology unit, she has managed to get hold of high quality wheels and hence improve the quality of the pupils' buggies. Nevertheless, in Ann's view some concern is still required, as the new wheels are thicker and heavier and may hence not be perfect either!

The second main project Ann is running with her pupils in her technology unit is the making of a 'flashing postcard' – a decorated piece of cardboard with an electrical circuit on the backside. Ann suggests cartoon comics as a theme for the postcard, but the pupils are free to decorate it according to their own preferences. The electric circuit consists of two light emitting diodes (LEDs), a battery and copper tape (for 'wiring'). One of the LEDs is of a flashing type, making both diodes flash when attached to the battery. For the pupils to make the circuit, Ann gives each of them a template that clearly shows the arrangement of the battery, the LEDs and the pieces of copper tape. The pupils make two tiny holes for the LEDs at suitable places in the postcard, making them act as eyes of an animal, lanterns on a boat or light up other spots according to the design of their individual postcard.

The postcard project is run in the same apprenticeship manner as the buggy project. She shows the pupils how to transfer drawings from cartoon magazines onto their cardboard by using wax paper. For the soldering part of the project, she instructs them in how to use a soldering iron properly and assists each pupil in soldering their own circuit. Ann's teaching of this project also contains a significant part of concepts and principles from physics – taking the low age of the pupils into account. When introducing the project, Ann gives an introductory session on electricity, in which she addresses the concepts current and voltage, and the principles of moving charges and a closed circuit. Since the pupils have ready-made templates showing the appropriate position of each component in the circuit, the pupils would have been able to build the circuit without an accurate understanding of the concepts and principles addressed by Ann in the session. When Ann is asked why they were still included in her teaching, an interesting misunderstanding arises:

BB
And you had a session first, where
you taught the function of the circuit.

Ann
Yes.

BB
Why did you do that? (...)

BB
Og så hadde du en sånn økt først,
hvor du gikk gjennom hvordan
kretsen virket.

Ann
Ja.

BB
Hvorfor gjorde du det? (...)

Ann
(...) well... it is important that the pupil learn theory and practice in a way simultaneously, and when they are to... well... one could have wired first and talked about it afterwards, or one could talk about it first and wired afterwards, but I thought it was reasonable to talk about it first, so that they got some understanding of what is actually going on, and why, and the kind of things we should be aware of when we are to wire and solder and such things.

Ann
(...) jo... det er jo viktig at elevene får med seg teori og praksis på en måte samtidig, og når de skal... altså... man kunne jo ha kobla først og snakket om det etterpå, eller man kan snakke om det først og koble etterpå, men jeg tenkte det var greit å snakke om det først, sånn at de får litt forståelse av hva som egentlig skjer, og hvorfor, og hvilke ting vi må passe på når vi skal koble og lodde og såne ting.

[P1: 250 - 269]

Ann understands the question as being about why she taught the conceptual knowledge *before* the practical work and not *after*. This may indicate that to skip this part of the session, which she denotes 'theory', is an idea that did not at all occur to her.

Ann's emphasis on concepts and principles from physics in her technology teaching may be seen as somewhat surprising, taking her background into account. Her specialisation from teacher education is in Music and Art and Crafts, and she has no education in science except from her compulsory school as a child. Ann also admits an almost alienated relation to physics:

Ann
(...) physics has been some kind of a non-subject to me. I know kind of very little of what it is all about in a way, as I feel it, because I have never been very much interested in physics! I never did any courses on it in upper secondary school or anything. So when I talk about buggies and light and so, then it is only related to the things I am doing and not to the background which is physics.
(...)

I do not consider it as teaching physics as a subject. I am rather thinking that I have some specific things I wish to do, and then I have to cope with what it is all about and...

Ann
(...) fysikk har vært et sånn ikke-fag for meg det da. Jeg vet liksom veldig lite om hva det dreier seg om på en måte, føler jeg da, for jeg har aldri interessert meg veldig mye for fysikk! Jeg har aldri tatt noen fag i forhold til det på videregående eller noe som helst. Så når jeg snakker om biler og lys og sånt, så er det liksom bare utfra de tingene jeg holder på med og ikke utfra den bakgrunnen som er fysikk da.
(...)

Jeg tenker ikke det som at jeg underviser i fysikk som fag da. Jeg tenker mer at jeg har noen konkrete ting jeg har lyst til å gjøre, så må jeg sette meg inn i hva det dreier seg om og...

BB
To reach that goal?

BB
For å nå det målet?

Ann
Yes. So, if it is physics or if is something else, that doesn't really bother me much!

Ann
Ja. Så om det er fysikk eller om det er noe helt annet, det ofrer jeg ganske lite tanker!

[P11: 390 - 402]

Ann conveys a pragmatic attitude to the physics that she includes in her technology teaching. She addresses the knowledge she sees as necessary in the projects she is doing with the pupils on a 'need to know' basis, without regards to the subject matter knowledge as a learning objective in itself. The systematic teaching of conceptual knowledge constitutes a natural and integral part of Ann's technology teaching, even if the area of knowledge is outside her main field of interest and competence and hence requires extra preparation for her.

SECOND STORY. BENNY'S BUGGY PROJECT

In his teaching of 'technology' as a distinct part of the subject Art and Crafts in grade 7 at School B, Benny runs a project that in principle is similar to Ann's buggy project described in the foregoing story. The teaching he creates based on this activity is, however, very different from Ann's teaching.

For the lessons, Benny has provided balloons, ready-cut wooden wheels and dowels that can function as axles for the buggy. Beyond this, he does not give pupils any initial instructions on which materials to use or how to build the buggy. The possibilities are, however, limited by the resources to be found in the classroom used for Art and Crafts lessons and the adjoining woodwork room. Here, pupils have free access to cardboard and coloured paper, wood and textile materials, paint, glue guns and other tools normally found in a school's woodwork room. When Benny introduces the project to the pupils, he does not specify to what extent the buggy should be nicely decorated or whether the point is to make it run efficiently.

During the sessions, pupils mainly work independently with their project in groups. Benny very rarely gives any instructions to the whole class. Rather, he moves between the groups of pupils watching them work, assisting them by providing materials and tools when required and asking them questions about their ideas and how they

plan to proceed. He encourages pupils to try out their own ideas rather than answering questions or proposing solutions.

The pupils approach the project in various ways. Some put much effort into making the buggy run efficiently. For example, some pupils try to improve the buggy's efficiency by attaching more than one balloon to it, or by attaching rubber bands to the wheels to improve their grip on the floor. Others are not concerned about whether their buggy can run at all, but pay more attention to the decoration of it – either in 'fancy' ways with colours and glossy paper or attempting to make it look like a real car. Benny describes the variation in the pupils' buggies this way:

Benny
(...) Some made it somewhat big, wide, long, and it became quite heavy and they could hardly make it move. And some... So there has been a range of different variants, and they have reflected a bit on the cause of this afterwards. And of course those that were most... richest ornamented and decorated were the heaviest, and most difficult to make go forward. But they have put... some have put much effort into the design part, and subtleties in how it looks, and have lost something when it comes to the buggy's drive. Some have managed to find a combination, and some have simply run very fast, but it has been a scrappy version. To put it mildly, cardboard with balloon and nothing else. So... but it depends on what they thought was the intention. Some want it to ...*fttt!* go speedy, and some want it to look nice.

Benny
(...) Noen bygde jo litt stort, bredt, langt, og det ble jo ganske tungt og kom ikke av flekken. Og noen... Så det har vært en del forskjellige varianter, og de har jo reflektert litt over i etterkant hva som er årsaken til at det ble sånn. Og det er jo selvsagt sånn at de som har vært mest... rikest ornamentert og dekorert har vært tyngst, og mest vanskelig å få til å gå framover da. Men de har jo lagt... noen har lagt veldig mye i formgivingsbiten, og utseendemessige finesser, og har jo tapt på framdrift, da. Noen har jo klart å finne en kombinasjon, og noen har bare rett og slett gått knallfort men det har jo vært en skrapa variant, da. Mildt sagt, papp-plate med ballong og ikke noe mer. Så det... men det er jo alt etter hva de syns har vært hensikten da. Noen ønsker at det gjerne skal... *fttt!* gå unna, og noen ønsker at det skal se litt sånn lekkert ut.

[P1: 353 - 365]

Benny's description conveys that he wants the pupils to have freedom – not only in how to perform the task – but also in defining the *intention* of the task. Benny's recognition of the agenda of the task as the pupil's agenda is confirmed when he is asked what characterises a pupil who succeeds in technology:

Benny
Well... 'succeeds', that must be one who feels that he or she accomplishes

Benny
Ja... 'lykkes' må jo være en som føler selv at en mestrer noenting. Det er jo

something. That is quite important, that they have the feeling of accomplishment.

(...)

As long as the task is as loosely defined as it is, all of them will feel that they accomplish.

litt viktig, at de selv skal føle mestring.

(...)

Så lenge oppgavene blir definert såpass løst, så vil jo alle sammen føle at de mestrer.

[P2: 454 - 467]

Hence, whether pupils succeed in gaining knowledge, skills or experiences through the technology project does not appear to be the most important aspect of Benny's teaching; it is of greater importance that the pupils gain a *feeling* of success. The freedom he gives the pupils in working with their technology projects facilitates the goal of letting every pupil attain the feeling of success.

The second main project Benny runs in his technology sessions is called 'Defend yourself'. The task is given simply as "build a model of a fortress that can keep you safe from enemies and where you can survive a fortnight". As with the buggy project, pupils are free to choose available building material and tools in completing their project. The resulting products in the three gender-segregated groups (see Appendix 1) turn out to be strongly gendered, showing striking similarities with what has earlier been reported by Murphy (1994, 1996). The boys' fortresses have an aggressive character, with focus on attacking the enemies with weapons, or mechanisms for killing them as soon as they come close to their fortress. Most of the boys' fortresses have a more or less empty inside, but with an intensely decorated outside – one with models of dead and bleeding people (presumably enemies) hanging from the walls. The girls' fortresses have a stronger focus on the 'survive a fortnight' part of the task. Once the walls (certainly impregnable) are put up, they are concerned about what are the needs of a group of people during two weeks in isolation. They have included food supply, sanitary and cooking facilities, furniture and clothes as well as ladders to get out of the fortress in case they are attacked – despite the impregnable walls.

The strongly gendered products surprise Benny a bit, but it does not appear to him as a problem. He describes the results and his reflections upon them this way:

Benny

It becomes two completely different approaches to solving the task. The girls become much focused on having comfort... they have utilised the fact that we have been in the room used

Benny

Det blir jo to vidt forskjellige tilnærminger da, til oppgaveløsning. Jentene blir veldig fokusert rundt at de skal ha komfort... de har utnyttet det at vi har vært på det som er

for textile work and made use of textiles in full measure, to make curtains and bedding and equipment and wallpaper and really emphasised comfort. More focused on comfort than defence maybe, but anyway... the essential thing, what do we need to keep the enemy away... there they have a clear focus on having a tidy and nice environment and possibilities for personal hygiene, and a lot of food. So that is what they have thought. The boys, they think more traditional... defence, emphasise more external defence without paying attention to that they actually are to live and eat and attend to personal needs as well. They represent two different ways of thinking. And the girls cultivate one, and the boys cultivate the other. So in a mixed group we would maybe have obtained a combined result, but I also think that - it is just a hypothesis, I think the girls would have adjusted themselves to the boys to a larger degree. I think the girls enjoy very much engaging with the task exactly the way that they want.

tekstilformingsrommet og tatt tekstiler i bruk i fullt monn, til å lage seg gardiner og sengetrekk og utstyr og tapeter og virkelig komfort i høysetet. Mer fokusert på komforten enn på forsvaret kanskje, men likevel... altså grunntanken, hva trenger vi for å holde fienden unna... der har de jo en klar fokus på at de skal ha det rent og pent og muligheter for god personlig hygiene, og masse mat. Så det er det de har tenkt. Guttene, de tenker mer tradisjonelt... forsvar, legger vekt på mer ytre forsvar uten å ha så mye tanker for at de faktisk skal bo og spise og ivareta sine personlige behov midt oppi. Og det blir to forskjellige måter å tenke på. Og jentene rendyrker den ene, og guttene rendyrker den andre. Så i en blandet gruppe så kanskje vi kunne fått et kombiresultat, men samtidig så tror jeg at ... - det er jo en hypotese da, men jeg tror at jentene hadde tilpasset seg guttene i større grad. Jeg tror jentene koser seg med at de får utfolde seg med oppgaven akkurat som de selv har lyst til.

[P2: 120 - 138]

Benny acknowledges the different approaches to the project. It also appears that he sees it as important that pupils enjoy working with it and that they develop a sense of ownership to their projects. Even if the products might have been more 'mixed' – taking both feminine and masculine aspects into account – in a group with boys and girls together, Benny emphasises the importance of letting pupils of both genders engage with the project the way they find most enjoyable.

In general, the way Benny runs the technology sessions carries a strong flavour of play and that the intention is to have fun. In the interview, Benny confirms this impression:

Benny
You should wonder a bit, but you should enjoy it and discover that it is in fact fun. And it... fun, practical and wonder. Those are three catchwords that I think are important, and

Benny
Du skal undre deg litt, men du skal ha det 'lænt' og du skal oppdage at det faktisk er artig da. Og det... moro, praktisk og litt undring. Det er tre sånne stikkord som jeg synes er

then the tasks have been somewhat loosely defined, so the kids are allowed in a way to make them their own projects. And try to find a solution to a rather broad task.

viktig, og da har det blitt til at oppgavene har blitt ganske løst definert, så ungene har fått lov til å på en måte gjøre det til sine egne prosjekter. Og prøve å finne en løsning på en forholdsvis vid problemstilling.

[P2: 393 - 398]

Benny's technology teaching – as it is observed in this study – can aptly be characterised by the three catchwords he launches above, that is, “fun, practical and wonder”.

This focus on ‘having fun’ and pupils’ excitement does not mean that a conception of *knowledge* is absent in Benny's view of technology teaching and its aims. He describes a knowledge component of his teaching in two dissimilar respects. Firstly, he emphasises how pupils *learn* through working freely with technology projects, for example the buggy project:

Benny

(...) It is made from very simple materials, but still they discover on their way that what runs quickly and what does not run at all is marginal. They have to think about what... that wheels need to roll freely... must be a... something called friction and grip. Some have tried to experiment somewhat with it. With various surfaces and... making the grip fasten between the ground and the wheels. That having three times as much compressed air does not make the buggy run three times further, or three times quicker, has somebody figured out after... According to the theory, they tried with two and even three balloons and found that a buggy with only one [balloon] in fact runs further as well as faster.

Benny

(...) Den bygges jo med veldig enkle midler, men likevel så oppdager de jo underveis at det er marginalt hva som går fort framover og hva som ikke går framover i det hele tatt. De må jo tenke gjennom hva som... at hjul må kunne rulle fritt... må være en... noe som heter friksjon og veigrep. Noen har jo prøvd å eksperimentere litt med det. Men ulike overflater og... som får veigrepet til å feste seg mellom underlag og hjul. At om du har tre ganger så mye komprimert luft, så går ikke farkosten tre ganger så langt, eller tre ganger så fort er det noen som har funnet ut etter... sånn i teorien, så prøvde de seg med både to og tre ballonger og fant ut at en bil som har bare en [ballong] faktisk gikk både lengre og fortere.

[P2: 330 - 34]

The quotation contains a range of knowledge Benny relates to the buggy project. This knowledge is, however, not ‘transmitted’ from the teacher to the pupils. Instead, he sees it as a product of the pupil interacting and experimenting with the physical environment and the technological task.

Benny also emphasises the value of technology teaching for pupils who do not normally succeed with the school's academic subjects, and this exhibits another conception of the knowledge component of his technology teaching:

Benny

(...) It is, as I see it, a possibility for the kids to engage with practical work. And what I see from the kids who maybe otherwise struggle a bit with the traditional school subjects, there is a clear difference that they can use... technical skills, and that they in fact have knowledge that they are otherwise not given the chance to express during the school day.

Benny

(...) Det er jo, som jeg ser det, en mulighet for at ungene skal kunne utfolde seg med litt praktisk arbeid. Og det jeg ser av de ungene som ellers kanskje sliter litt med de tradisjonelle skolefagene, så er det jo en klar forskjell med at de får brukt... tekniske ferdigheter altså, og faktisk har en kunnskap som de ellers ikke får mye utløp for i skolehverdagen.

[P2: 44 - 49]

In this quotation, Benny talks about practical skills and knowledge, but not as something pupils should *learn* through technology teaching. Rather, the skills and knowledge appear to be attributes of the pupils themselves. The pupil already *has* the knowledge, which the school should value and allow the pupil to demonstrate.

Same activity – different content

The two preceding stories have exhibited how Ann and Benny run the 'same' teaching activity offered to them from the 'activity account' provided by the TiS project. The stories have shown that the two teachers create very dissimilar teaching based on the relatively well-defined activity of making a buggy run by means of a balloon. The structuring of the lessons differs significantly. Ann's teaching is structured by teacher instruction with pupils working individually, while Benny's teaching is structured by pupils' independent work with each other in groups. It is, however, important that the structural differences are not only a matter of personal 'style', representing different ways of teaching the same content. Rather, the curricular content as such, imparted by the 'same' teaching activity in Ann's and Benny's sessions is very dissimilar.

Ann's buggy project has a content of conceptual knowledge and technical skills. It involves concepts and principles from mathematics and physics, technical procedural knowledge and skills in the use of tools. The technical skills are taught in an apprenticeship manner, resulting in high technical quality of pupils' products, a feature of technology teaching that appears to be of crucial importance to Ann.

Benny's buggy project has its focus on pupils' play with materials and their own ideas. He places strong emphasis on pupils' freedom in designing and making their buggies, and the criteria of success are left to the pupils' decision. The intention of Benny's technology teaching appears to be the development of pupils' creativity, curiosity and self-esteem, and this intention flavours his technology session to such a degree that it may be regarded as representing the 'content' of his teaching.

The stories and their interpretations given in this chapter indicate that teachers may utilise the same teaching activity to teach technology in very different ways. The substantial differences in content and emphasis suggest that the two teachers perceive the educational *purpose* of technology teaching differently, and that there are different *aims* governing their actions. Rather than 'executing' teaching activities representing the curriculum of Design & Technology or NITO's agenda for the TiS project discussed in Chapter 6, the teachers should thus be understood as actively *creating* a curriculum where activities from the available 'activity account' are utilised for realising their own aims for their teaching. These aims appear to form a unifying structure of the technology subject they create.

CHAPTER 9

TEACHERS' AIMS FOR TECHNOLOGY TEACHING

The perspectives brought up in the previous chapter give rise to questions on what constitutes the teachers' curriculum for the technology teaching they create on the basis of the TiS project. What does technology teaching mean to them in terms of educational purposes? What do they want pupils to gain from technology teaching; what are the *aims* that govern their actions as teachers of technology as a new educational subject?

This chapter explores how teachers participating in the TiS project perceive the aims of technology as an educational subject and how their realisation of technology teaching can be understood in light of these aims. In the analysis and presentation of data, the classification of arguments for technology as a component of general education presented in Chapter 3 is used as a starting point. The presentation departs from how teachers perceive the implicit agenda of the TiS project as the one of enhancing recruitment to further education and careers in technology, and how they see implications of this agenda for their teaching of technology. This reflects the economic argument for technology education. The other arguments reviewed in Chapter 3, that is, the political, social, cultural, educational arguments as well as an argument of practical utility are also reflected in how the teachers express their rationale for technology teaching. It will, however, be shown that the teachers' agenda and perspectives often go beyond the categories provided by this framework. Consequently, the presentation conceptualises teachers' aims for technology teaching within a framework of categories mainly derived from interpretations of empirical data from the study itself.

The initial use of the framework of arguments is based on the anticipation that it is reasonable to expect a connection between the *arguments* expressed by the teachers when discussing technology as a subject of teaching and the *aims* they possess for their technology teaching. At this point, the use of these concepts needs some clarification. The meaning of an '*argument*' will be taken as any possible answer to a question 'why is technology teaching important?', while '*aims*' will give answers to 'what do we want to achieve in technology teaching?'. Further, '*learning objectives*' will be used as a third concept to denote the more specific learning outcome, as intended by the teacher, in terms of knowledge and skills. Obviously, these three concepts are highly interrelated, and their respective meaning can not always be distinguished from each other when used in concrete situations. In the

interviews, rigorous definitions and stringent use of the concepts have hence not been considered applicable. The reader will, for example, notice that answers to questions about aims may be answered in terms of arguments or objectives, and also that the interviewer's questions are not always unambiguous in how these concepts are used. Accordingly, the concepts of aims, arguments and learning objectives will be used in a rather flexible way throughout the following presentation, with roughly the meaning indicated above. Together they constitute the rationale on which the teachers base their creation of a technology curriculum.

Departing from the economic argument: Pointing pupils to technology

The economic argument addresses technology education as important for economic purposes. It embraces the need for a community to recruit technological expertise in order to enhance the nation's economy, as well as the individual pupil's need for a basis of knowledge on which further education and a future career in technology can be built. This also involves making pupils aware of career possibilities in this field. In the presentation of the TiS project earlier in this thesis, it was proposed that the societal aspect of the economic argument and the need for recruitment is likely to represent an important motivation for NITO when initiating the TiS project.

How do the teachers participating in the project comprehend this underlying agenda? What implications do they see for their own teaching of technology? The following sections present interpretations of teachers' aims for technology teaching that can be related to the economic argument.

Exposing the joy of technology

Many of the teachers point to recruitment as the main purpose of the TiS project and hence the technology teaching they create from it. This purpose is often associated with enhancing pupils' *motivation* for technology as an area of further education and careers. They focus on the need for stimulating pupils' *interest* in technology, more than on what could be appropriate learning outcomes in terms of knowledge and skills as a basis for further education towards a technological career. In turn, this often leads to an imperative of making technology teaching appear as 'fun' for the pupils. For example, Benny states:

Benny
It should be a bit fun! And that is part of the intention with the TiS project, if the kids are to be recruited into science, mathematics and

Benny
Det skal være litt artig! Og det er jo noe av hensikten med det prosjektet Teknologi i Skolen at, hvis ungene skal rekrutteres til

technology, then they need to obtain a positive first impression of approaches in these subjects as enjoyable.

realfagene, så må de få et positivt førsteinntrykk av det at realfaglige vinklinger kan være moro da.

[P2: 724 - 727]

Benny here links 'having fun' directly to the purpose of recruitment; a first impression of the subjects as enjoyable may initiate a future choice of a technological career. This exhibits that his technology teaching described in the Second story and interpreted as aiming at developing the individual pupil's creativity, curiosity and self-esteem, may as well be seen as based on instrumental purposes related to the societal aspect of the economic argument. Through being exposed to the joy of technology, pupils may gain positive attitudes that in turn enhance recruitment to technological careers.

Jim makes a connection between the joy of technology and *play*:

Jim

You discover new aspects of yourself, you discover that there is in fact a child inside you, that you have a playful nature, to put it that way, which needs stimuli. And that's what I often try to consider in my teaching more generally in school, that if we can reach the playful individual in a human, then we can teach them anything! Or, to put it this way, they can themselves learn anything.

Jim

Du oppdager nye ting ved deg selv, du oppdager faktisk talt at der er et barn i deg, eller et lekende vesen, hvis du kan si det sånn, som trenger stimuli. Og det prøver jeg ofte å tenke på når jeg har undervisning generelt i skolen, at bare vi får tak i det lekende individet i et menneske, så kan vi lære dem hva som helst! Eller, for å si det sånn, de kan selv lære hva som helst.

[P17: 130 - 136]

Jim describes stimulation of the child's playing and curious nature as the key to their learning, and indicates that exposing pupils to the joy of technology may thus have a motivational effect. However, it appears that he also intends to give pupils access to the joy of technology for its own sake. Though Jim has a comprehensive background in many technological directions, he describes his experience of the course he attended as part of his participation in the TiS project as "a good world to enter", and that being introduced to this 'world' was something he missed in his own general education:

Jim

It was like a world, it was like a good world to enter, in a way entering a world that I have longed for since... I told many when I was there that I should have experienced this when I was 15-16 years old. This is something I have missed. Literally it was: This is what I miss in lower secondary school!

Jim

Det var som en verden, det var som en god verden å komme inn i, på en måte komme inn i en verden som jeg har lengtet etter siden... Jeg sa det til mange da jeg var der borte, dette skulle jeg ha opplevd når jeg var 15-16 år. Dette er noe jeg har savnet. Ordrett var: Dette savner jeg på ungdomsskolen!

[P17: 100 - 104]

It appears that the fascination for technology Jim has developed on his own, yet not been introduced to in his own education in any systematic ways, is something he wishes to let his pupils experience. In this way, he wishes to share his enthusiasm and the joy of technology with his pupils.

Opening doors to technological careers

Besides enhancing pupils' motivation towards technology by exposing that it might in fact be 'fun', teachers point to a need for exposing what technological work is *about*. As an aim for technology teaching, this implies that pupils should be given experiences that reflect what it means to work as a technologist and opportunities to discover their latent abilities in this direction. Teachers in this study emphasise that our school system, due to the absence of technology as a subject of teaching, so far has denied pupils experiences that may 'open doors' into technology as an area of work. For example, Irene states that today's kids do not show interest in crafts and vocational training and that technology teaching in early years may counteract this tendency:

Irene

(...) The kids do not show interest in craft subjects any more either (...) I think that when we take it into compulsory school like we do now, then it may stimulate [their] interest in other things than merely the theoretical subjects.

(...)

They can simply find that "Wow, I have abilities for this, this interests me", but as long as we don't have it in school at all, right, they don't know that they can, or want to, try it. Thus, perhaps we in a way open some doors for them quite early. "Oh yes, it is an electrician I want to be!" for example.

Irene

(...) Ungene viser jo ikke interesse for håndverksfag lenger heller. (...) Jeg tror det at når vi tar det inn i grunnskolen sånn som vi gjør nå, så vil det vekke interessen for andre ting enn bare teoretiske fag etter hvert.

(...)

De kan rett og slett finne ut at "Jøss, det her har jeg evner for, det her er jeg interessert i", men så lenge vi ikke har det i skolen i det hele tatt, ikke sant, så vet de ikke at de kan, eller har lyst til, å prøve. Så på en måte så åpner vi kanskje noen dører for dem ganske tidlig. "Å jammen, det er jo elektriker jeg har lyst til å bli!" for eksempel.

[P16: 208 - 223]

Irene points to the individual aspect of the economic argument in terms of providing pupils with *experiences* with occupations related to technology. These experiences may 'open doors' in the sense that the pupils may discover latent abilities and develop their interest that in turn may assist them in their choice of career.

As a representative for teachers in lower secondary school, Eric expresses a similar concern, and claims that pupils leaving lower secondary school normally would not be provided with such experiences. Following the metaphor introduced by Irene above, this means that the 'technological doors' are still not opened to pupils when

they leave lower secondary school. Making a comparison with academic subjects, Eric points to what he denotes “a great injustice built into our compulsory school”:

Eric

Pupils who choose an academic stream, they know the subjects, they know the working methods, they know the ways assessment is done. They know what they choose. Those who choose practical vocational training, on the contrary, especially the technological directions, have not had the chance to try out abilities and skills, and they don't know what they are choosing. Seen this way, there is a great injustice built into our compulsory school the way it appears today.

Eric

Elever som velger allmennfag videre, de kjenner både fagene, de kjenner arbeidsmåtene, de kjenner evalueringsformene. De vet hva de velger. De som velger yrkesfag, derimot, spesielt de teknologiske yrkesfagene, har ikke fått prøvd ut evner og ferdigheter, og vet ikke hva de velger. Slik sett så er det en stor urettferdighet bygget inn i vår grunnskole slik den nå fremstår.

[P6: 270 - 276]

Both Irene and Eric justify technology teaching in compulsory education based on its importance in enabling pupils to make informed career choices. Their main point does not appear to be what pupils *learn* through technology teaching that may give them a head start on their career. Rather, they are concerned about making pupils *aware* of the potential they possess for technological work and letting them experience what this kind of work is like.

Though most of the teachers in this study have grasped the message of enhancing recruitment, two rather different interpretations of what pupils should be recruited *to* are found among them. These two interpretations correspond to the two ‘strands’ of technology education referred to in Chapter 6. While Benny earlier talked about recruiting pupils to subjects such as science and mathematics, Irene and Eric have directed the aim towards the other strand, the one of technical vocational occupations. In the quotations above, Irene has pointed to the importance of stimulating pupils’ interest in “*other things*” than the theoretical subjects and Eric has stated that pupils not choosing an academic stream lack experiences with the alternatives. This runs contrary to Benny’s argument earlier presented – and also to the aims NITO has formulated for the TiS project – that technology teaching related to the TiS project should enhance interest in mathematics and science, subjects often classified as belonging to the theoretical and academic ones. Jim puts the two strands of technology education directly in opposition to each other, and claims that the strand of technical vocational education has been neglected in the general discourse and in initiatives like the TiS project:

Jim

(...) We may educate as many engineers as we want, but unless there are people there to actually do the work the engineer plans, then... To overstate it a bit. We have

Jim

(...) For du kan jo utdanne så mange ingeniører du på en måte vil, hvis der er ingen som på en måte kan utføre den jobben som ingeniøren på en måte planlegger, så... For å

regularly contact with the machine line [in upper secondary school], which has a large recruitment problem, because it has a low status. To put it bluntly, it is so to say merely the least able, who have taken that line, that's what they say. Right, and now everybody is expected to become engineers, and their competencies are supposed improved so much. Then things are turned upside down in society, if you concentrate on only one area. And that is ridiculous, because one who repairs elevators or a motor mechanic have as good an income as a teacher, who also has a rather long education, like many other professions.

BB

Yes, craftsmen do make a good income.

Jim

Yes, but it is physical work, and physical work has in a way been degraded in status. And the attitude to it is rather bad. But the best competence you can have to live a good life, that is to work physically and not sit on your bottom until you grow fat.

sette det litt på spissen. Vi har jo jevnlig kontakt med blant annet maskin og mekanikerbiten [i videregående skole], som har et stort rekrutteringsproblem, fordi at det har lav status. Det er bare subbussen, for å si det stygt da, som på en måte har gått der., sier de selv. Ikke sant, og så skal alle begynne å rekrutteres til å bli ingeniører, og så de skal kompetanseheve dem så mye. Da går dessverre samfunnet litt av hengslene, hvis du på en måte setter alle kluter til på en plass. Og det er ganske vilt, fordi at en heismontør eller en bilmekaniker tjener jo like godt som en lærer gjør, som på en måte også har ganske lang utdannelse, som mange andre yrker har.

BB

Ja, håndverkere tjener jo veldig bra.

Jim

Ja, men det er et fysisk arbeid, og fysisk arbeid har på en måte blitt degradert i status. Og holdningen til det er ganske dårlig. Men den beste kompetansen du kan ha for å ha et godt liv, det er jo å jobbe fysisk og ikke sitte på ræva til du blir feit.

[P17: 746 - 766]

Jim points to the great need for people educated in practical vocational directions in society, and that this need may be stronger than the one for engineers. He sees the low popularity of these lines of education as a paradox, as practical technical occupations are well paid and provide for a good and healthy life. He assigns the problem to the low status of technical vocational education, and that this low status is due to the practical nature of the work. In the prolongation of Jim's argument, we may recognise the 'rehabilitation of the practical' as requested by Layton (1984) and the potential of technology teaching in this rehabilitation.

In sum, the teachers participating in the TiS project largely interpret the implications of the economic argument for technology teaching as 'opening doors to technological careers' by means of motivation, experiences and improved status. The meaning of 'technological careers', however, remains ambiguous among the teachers.

Proceeding beyond the arguments

Though the teachers in the first instance may draw on aspects of the economic argument in formulating aims for technology teaching as shown above, their main

aims appear to run in quite different directions. These aims reflect some aspects of the other arguments presented in Chapter 3 in various ways. In the below quotation for example, Ann points to skills that can be learnt through technology teaching, and that are important in work life. This may hence be seen as reflecting the economic argument in a broad sense. However, her argumentation soon embraces other perspectives:

Ann

That's the impression I have, that there is a great demand for abilities to be creative, and also critical of ones owns work, to be able to make something concrete out of abstract plans. To put it in another way, make things and so on. And I absolutely believe that technology is such a subject where you link theory and practice in a very special way, and the kids get experiences with working with things that are useful in everyday life, like electricity for example, related to those flashing postcards. That is something we are surrounded by every day, and that it is important that people know something about! It is also things... the progress of things... Technology is something that surrounds us in everyday life, and hence it is stupid to stand there not knowing anything about how things function. Then it is difficult to develop things further. (...) If kids are trained in this way of thinking, I believe it is much easier to start to... that Norway will manage to develop things further, instead of just stealing from others, buying from others...

Ann

Det inntrykket jeg har i hvert fall, er at det etterspørres jo mye, det å kunne være kreativ og være på en måte kritisk til eget arbeid, det å utfra på en måte litt abstrakte planer klare å gjøre noe konkret. For å si det sånn, lage noen ting og sånn. Og det tror jeg absolutt at teknologi er et sånt fag hvor du knytter teori og praksis på en veldig spesiell måte, og ungene får erfaringer med å jobbe med ting som er nyttig i hverdagen, sånn som elektrisitet for eksempel, i forhold til det her med de blinkende postkortene. Det er jo noenting som vi omgir oss med til daglig, som er viktig at folk kan noe om! Det, også ting... hvordan ting går framover... Teknologi er noe som vi omgir oss veldig med i hverdagen, og da er det jo dumt å stå der å ikke vite noenting om hvordan ting fungerer. Da er det vanskelig å kunne utvikle noenting videre. (...) Hvis ungene får trening i å tenke litt mer sånn her da, så tror jeg at det er mye lettere å begynne å ... at Norge klarer å utvikle ting videre, i steden for å bare stjele fra andre, kjøpe fra andre...

[P1: 967 - 987]

From the consideration of skills that are important in work life, Ann moves directly into what can be seen as reflecting the argument of practical utility. Using electricity as an example, she points to the usefulness of technological knowledge in everyday life. She then states that it is important that people know something about the technology that surrounds them – and hence gives a touch of the cultural argument. However, this statement develops back to an economic argument through a logic that can be interpreted as viewing the general public's common understanding of everyday technology as a 'reservoir' for professional recruitment and hence further economic development of the nation.

The above shows that the teachers' views may reflect the arguments for technology teaching reviewed in Chapter 3 in rather complex ways. More important, however, is that the framework of arguments fails to capture essential perspectives in how

the teachers consider the aims of technology teaching, and its appropriateness as an analytical tool might hence be questioned. This can be illustrated by how Frederic reflects on the aims of working with technology with pupils:

BB

Can you say something general on what you see as aims of working with technology with pupils?

Frederic

The main aim is to generate interest in technology and in the physics/chemistry subjects, physics, so that they choose further education within these subjects, physics, technology.

BB

To generate interest, primarily.

Frederic

Generate interest, yes. And then we ought to create teaching activities that are enjoyable and that support that aim. And it is in a way, the main aim for NITO is to get more students to study engineering.

BB

But of course, as a teacher one must - one thinks of many things at a time.

Frederic

Yes. And it is about bringing more work that is practical into daily school life.

BB

It is too theoretical?

Frederic

Yes. Much... I think so. Very many pupils like to do things, make things. That is also a part of the aim, to make some 'doing' activities, which are not just to read, listen and write. But to do something with the hands, to construct. And make the pupils see that they can create things, based on... yes, that they have the potential to create, that they are able to create things and also believe in that they are able to do it.

BB

Kan du si noe generelt om hvordan du ser som målsettinger med å jobbe med teknologi med elever?

Frederic

Hovedmålsettingen er å skape interesse for teknologi og for fysikk/kjemi-fagene, fysikk-faget, sånn at de velger utdanning innen realfag, fysikk, teknologi.

BB

Å skape interesse i første rekke.

Frederic

Skape interesse, ja. Og da må vi jo prøve å lage undervisningsopplegg som fenger og som bygger opp under det. Og det er jo på en måte, altså hovedmålsettingen til NITO er å skaffe flere studenter til ingeniørfagene da.

BB

Men det er klart, som lærer så må man - så tenker man på mange ting på en gang.

Frederic

Ja. Så går det også på å bringe mer praktisk arbeid inn i skolehverdagen.

BB

Det er for teoretisk?

Frederic

Ja. Mye... Jeg syns det. Så mange elever liker å gjøre ting, lage ting. Så det er jo også en del av målsetningen, å lage en del gjøre-oppgaver, som ikke bare er å lese og høre og skrive. Men gjøre noe med hendene, konstruere. Og få elevene også til å se at de kan skape ting, ut i fra... ja, at de er skapende, at de er i stand til å skape ting og også tro på at de er i stand til å gjøre det.

[P7: 194 - 228]

Frederic's first answer to the question of aims reflects the economic argument, as he refers to the implicit goal of the TiS project concerning recruitment (and worth noting, he highlights *physics* in this regard). The implication of this goal to

Frederic is to generate interest by offering the pupils teaching activities that they find enjoyable. Then, prompted by a hint on that teachers might see additional aims, his argumentation turns toward a different direction. He now addresses a concern for the *teaching context* as such, and the potential of technology in making it more varied – as technology offers activities that are different from reading, listening and writing. He also asserts that it is important in itself to let pupils create things, and indicates aims for technology teaching that operates on an affective level.

Frederic's viewpoints expressed above are examples of several concerns found in this study that do not easily fit into the framework of arguments presented in Chapter 3. One might suggest that some of them are covered by the category of *educational arguments* for technology education (Medway 1989, Gilbert 1992). However, the many aspects of teachers' concerns and aims that could be classified within this category leads to a risk for letting 'educational arguments' function as a residual category and thus leaving data under-analysed. To avoid this, aims expressed by teachers that could count as 'educational' have been conceptualised within more specific categories based on this study's data material and will be presented as such in the following.

'Making school more practical'

A large majority of the teachers in this study express a pressing need for making pupils' everyday work 'more practical', and hence welcome technology as a teaching topic on this basis. The call for 'making school more practical' is a familiar one in educational settings in general. As an agenda for educational change, it is, however, often vaguely expressed. In the following, we will see how the teachers in this study give more concrete expression to what 'making school more practical' might mean, and to how they see the potential of technology teaching in fulfilling aims covered by this notion. Results from the study show that 'making school more practical' expressed by the teachers is not a singular aim, but contains several concerns and perspectives that may have different implications for teaching. These will be conceptualised within three categories reflecting teachers' concerns for the *teaching context*, for pupils' *experiences* with the material world and finally for the inclusion of technology understood as *practical knowledge* in the curriculum.

Improving the teaching context: 'Practical' as opposed to textbooks

When teachers (and others) talk about school as 'too theoretical' or a need for making pupils' work 'more practical', these notions are often not used in an epistemic sense. Rather, they are related to the teaching context, and to the nature of *activities* pupils are undertaking in school. The teachers' call for 'making school more practical' hence refers to a need for variation in the teaching context, and for making it include activities that deviate from the 'delivery' of declarative knowledge that is commonly regarded as a characteristic feature of schooling. This corresponds to what Donnelly and Jenkins (1992) have earlier identified as a meaning of 'theoretical' referring to "a form of classroom organization as much as a body of knowledge" (p. 43). The link between the need teachers express in this regard and the TiS project is made explicit in Frederic's reflections cited in the previous section. He stated that some of the intention with technology projects is to make some "do-activities", to let pupils construct something with their hands, as opposed to 'reading, listening and writing'. (It should, however, be noted that Frederic does not denote this 'theory' in the quotation referred to; this notion is in fact introduced by the interviewer). Other teachers in this study also explicitly express their purpose with technology teaching as directly related to their concern for the teaching context, rather than to a conception of knowledge either inherent in technology as a subject or a way of covering the curriculum in other subjects:

Henry

(...) I do it because I believe it is interesting to the pupils and that it is stimulating for them to do something different from what they usually do. So that it is not only theoretical.

Henry

(...) Jeg tar det jo for at jeg syns det her blir interessant for elevene og at det er kjekt for dem å gjøre litt andre ting enn det de gjør til daglig og. Så det ikke blir bare teoretisk egentlig.

[P9: 633 - 635]

Rather than considering pupils' learning outcomes of technology teaching, Henry describes his motives for doing technology projects with his pupils by the need for 'making school more practical' with regards to the teaching context. He sees the benefit of technology teaching in that it allows pupils to engage with activities that depart from the usual classroom organisation.

A salient feature of the traditional classroom organisation is the use of textbooks. They represent a manifestation of the classroom organisation Frederic has summarised as 'reading, listening and writing', or what is frequently referred to as 'theory'. Hence, whether the knowledge addressed in books is to be classified as 'theoretical' or related to 'practical situations' does not affect the characteristic of school as 'theoretical' or not in the above sense. It is the books *as such* that make the subjects 'theoretical', not what is written in them. David formulates this in a remarkable way while talking about technology as a suitable approach to science teaching:

David

In my opinion, it lies close to science, because the physics is there. Then the question is how you weight it, if you choose to take what is written in books and so on, or if you adjust it to technology.

David

Jeg mener at det ligger veldig mye for naturfag, for fysikken ligger der. Så det spørres jo litt hva du vektet opp altså, om du velger å gå på det som står i bøker og sånn, eller om du tilpasser det til teknologi.

[P3: 1087-1090]

David places technology as a direct opposition to what is written in books, and sees these as two distinct and different approaches to science teaching.

The aim of making school more practical, understood as taking in activities different from working with textbooks, makes teachers ambivalent to the idea of establishing technology as a regular subject in Norwegian schools. This is based on the assumption that technology teaching then will become as 'theoretical' as the other subjects. Elna sees this as a danger, because a practical subject would require more resources and hence be more expensive:

Elna

But it is important that it does not become a new theoretical subject.

Elna

Men det er viktig at det ikke blir et nytt teoretisk fag, altså.

BB

Do you see any danger for at it would be so?

BB

Ser du noe fare for at det skulle kunne bli det?

Elna

Yes, it requires some resources, and if one is to make school cheap, then you cannot create a new, get a new practical subject.

Elna

Ja, det krever en del ressurser, og hvis en skal gjøre en billig skole så kan du jo ikke ta et nytt, få et nytt praktisk fag.

BB

That one could happen to sit and read about...

BB

At man kunne komme til å sitte å lese om...

Elna

Yes, about technology. It must not be like that. It must be a subject with a practical approach.

Elna

Ja, om teknologien altså. Og det må det ikke bli. Det må være et fag som er praktisk retta.

BB

Otherwise there is no point in it?

BB

Ellers forsvinner hele vitsen med det?

Elna

Yes, then there is no point in it. To read about the technology? No, it must certainly be... no. More practical. And it should be a premise, that it is to be a practical subject and not a new theoretical subject.

Elna

Ja, da er det ingen vits. Å lese om teknologien? Nei, det må jo være... nei. Mer praktisk. Og det bør ligge der altså, at det skal være et praktisk fag og ikke et teori-fag.

[P5: 621 - 651]

Gina expresses a similar anxiety as Elna. She addresses the need for letting pupils apply knowledge from various subjects in practical and meaningful contexts, and below she points to technology as a subject that can provide them with opportunities to work that way:

Gina

(...) Technology certainly is a subject that is interdisciplinary, where pupils can have the chance to work that way. Let's just hope that if the subject is established in schools, that it does not imply three new textbooks in the subject, right!

Gina

(...) Teknologifaget er jo et fag som er tverrfaglig, hvor elevene kan få jobbet på den måten. Bare håper jo at hvis det faget kommer inn i skolen, at det ikke blir tre nye lærebøker i det faget, ikke sant!

[P8: 758 - 760]

The introduction of textbooks would be directly counteractive to what Gina and other teachers see as the benefits of technology teaching, that is, to let pupils undertake activities that deviates from the common school activities of reading, listening and writing.

The need the teachers see for 'making school more practical' in the above meaning makes them welcome the resources made available to them through the TiS project. Technology teaching associated with the project fits perfectly with their experienced needs, as it provides them with ideas, activities and a pedagogical framework for letting pupils engage with material manipulative tasks that represent a deviation from the declarative way teaching of subject matter knowledge is traditionally carried out.

Building experiences

'Making school more practical' in teachers' perceptions of technology teaching also embraces an aim that can be denoted 'building experiences'. Some teachers point to a tendency that pupils lack experiences, or that their experiences cover a narrow field. For example, Gina suggests that young people gain less experience with "tinkering, operating and investigating" in their spare time than they used to earlier, as many of them spend their time in front of a television or a computer:

Gina

(...) even if technology wasn't a subject in school earlier, there were many who made things at home and tinkered and operated and investigated a bit, and obtained it in other ways. But maybe they don't do that anymore, the youngsters, they sit on their bottoms and watch TV and look into a PC screen and maybe do not tamper with very much. Therefore, we may need to include it in schools so

Gina

(...) for det om det ikke har vært et fag i skolen før, så er det kanskje mange som har holdt på å lage ting hjemme og skrudd litt og operert litt og undersøkt litt og fått det på andre måter. Men det gjør de kanskje ikke, ungdommene lenger, de sitter nå på rompa og ser på TV og ser inn i en PC og holder kanskje ikke på å fikle så veldig mye. Så man må kanskje ta det inn i skolen for at de skal få

that they can get some practical experiences with things. litt sånn praktiske erfaringer med ting altså.
[P8: 668 - 674]

To Gina, the experiences gained by “tinkering, operating and investigating” have a value in itself, and – as pupils appear to no longer gain those experiences on their own – it should be a responsibility of the educational system to provide them with such experiences. Hence, technology may be justified as a specific curricular area where pupils have the chance to gain experiences with the material world.

The aim of ‘building experiences’ can also be identified in a more instrumental view among the teachers. A familiar principle in education is to build teaching on what pupils know, or on their prior experiences. The *existence* of relevant experiences is, however, also a matter of concern. David points to pupils’ lack of experiences as a major problem in science teaching:

David

To me it is maybe about giving them practical experiences. And experiences are in fact important, if one is to think about subjects. If we consider science, for example, we face - and that is in fact the main problem - we face pupils with an extreme lack of experiences. (...)

There are incredibly many that do not have experiences at all, and I think it applies to young people in general. If you take a look at what the youth of today are doing, then you find an awful lot of ‘nothing’, it is awfully lot of consume, right? We try to give them knowledge, and we do some calculations and so on, and then we realise that the pupils have no idea of what we are doing. They do not really know, they manipulate some numbers and so, but they have no pegs to hang it on. (...) And in the case of science, not least, I believe that the theoretical content should be reduced in the lower secondary school in the future, and that the amount of practical work should be increased, that is, to give them as many experiences as possible and do things. Certainly some are able to give explanations, but it happens very easily, in this group of pupils, that we explain them into tedium and then they find the subject boring. And then they quit it.

David

For meg handler det kanskje om å gi dem sånne praktiske erfaringer. Og erfaringer syns jeg er viktig faktisk, hvis en skal snakke om naturfag for eksempel, så opplever vi - og det er egentlig det store problemet - vi opplever ekstremt erfaringsfattige elever.

(...)

Det er ekstremt mange som ikke har erfaringer i hele tatt, og det tror jeg gjelder i ungdomsgruppen i det hele tatt, hvis en begynner å se på hva er det ungdom i dag driver med, så er det fryktelig mye ingenting, det er fryktelig mye konsum, ikke sant? Vi prøver å gi dem kunnskap, ofte så driver vi å regner og gjør en del ting, og så merker vi at elevene har ikke begrep om hva de holder på med. Altså de vet ikke egentlig, de manipulerer med noen tall og sånn, men de har ikke noe sånn og henge det på. (...) Og innenfor naturfag, ikke minst, så tror jeg at innenfor det skole-systemet vi går mot, så skulle ungdomsskolen faktisk i noen grad tone ned teorien og tone opp det praktiske arbeidet, altså gi dem mest mulig erfaringer og gjøre ting altså. Det er klart at noen av dem kan forklare det, men det blir så fort til, i forhold til den gruppa her, at vi forklarer dem ut i kjedsomhet og så syns de faget er kjedelig. Og så slutter de med det.

[P3: 1123 - 1142]

David expresses the same concern as Gina with regards to pupils’ lack of experiences. He does, however, attach a more instrumental view to the aim of ‘building

experiences', by relating it to pupils' learning in other school subjects. He states that pupils' lack of experiences is a major problem in the teaching of content knowledge – especially in Science. Teaching may not make sense to the pupils, because the basis of experiences on which to build science knowledge and understanding is missing. Technology teaching aiming at building pupils' experiences with the material world may hence assist pupils in making meaning of science knowledge. We may here see a correspondence with what is known as 'getting a feel for the phenomena' in the discussion of what pupils may gain from practical work in science teaching (Woolnough & Allsop 1985). In the final part of the above sequence, David also links the aim to instrumental aspects related to recruitment. Building experiences may make the subject more meaningful to the pupils, and in this way serve as a motivational factor and prevent pupils from quitting the subject.

Introducing pupils to the technologist's knowledge

The above two aims within the category of 'Making school more practical' are not primarily based on considerations of learning objectives in terms of knowledge or skills. On the contrary, they reflect teachers' concern for the *teaching context* as such and how it can be improved and a view of *experiences* as pupils' outcome of teaching. However, teachers in this study are also found to hold conceptions of *knowledge* related to technology teaching, and formulate intended learning outcomes – conceptual and practical – for their teaching of technology related to the TiS project.

As Hodson (1996) has noted concerning the discovery learning movement, psychological justifications might easily be mixed up with epistemological ones. This can also be found in the data obtained in the present study, as the teachers frequently express the knowledge dimension in technology teaching in mainly pedagogical terms. Some of their expressions can be associated with a somewhat clichéd version of the notion 'learning by doing' (see Driver 1983). This involves a conviction that pupils 'learn better' by doing things by themselves, whereas the learning objectives, *what* the pupils this way should learn, is not made explicit. Exceptions are skills related to the use of tools and machines explicitly mentioned by many of the teachers.

Taking the complex and intricate nature of technology itself and its component of tacit knowledge into account, it is not surprising that a basis of knowledge assigned specifically to technology, what there is to be learnt that is essentially technological, often is vaguely expressed by the teachers in the present study. Nonetheless, one of the teachers, Eric, is found to directly and more thoroughly draw on a conception of technology as knowledge in creating aims and content of his technology teaching.

In the following story, we will see how he explicitly articulates a view of technology as knowledge, and how his view fits well with elements of the conceptual framework on technology presented in Chapter 2. The story also reveals how Eric's perception of a knowledge base of technology guides his creation of technology as a subject of teaching, and how his teaching, as well as his formulation of its purpose, conveys a picture of *'the pupil as technologist'*.

THIRD STORY. 'THE PUPIL AS TECHNOLOGIST'

Eric has been actively involved in the TiS project from its start. School E is, mainly due to Eric's influence, one of the most active schools in the field of developing technology as a subject of teaching in Norway. Before the TiS project was started, and before the curriculum L97 was implemented, he taught 'teknikk' as an elective subject for many years. He also teaches Science, which represents his educational background.

Eric expresses technology teaching and his broader work with the TiS project as based on two different rationales. One is the individual aspect of the economic argument described earlier, that is, the importance of 'opening doors' to technological careers by providing pupils with experiences of what a technical or technological career means. Secondly, he emphasises that technology should be regarded as a component of pupils' *general* education alongside the humanities, the sciences and aesthetic subjects:

Eric
 (...) we possess a narrow conception of general education in Norwegian compulsory school. And the concept is related only to the humanities, the sciences and the aesthetic subjects. Practical technological ... elements of practical-technological character are missing. And to the extent technology is addressed in the curriculum, it speaks about technology. One speaks about, and it is still a theoretical topic, and one does not give education in technology.

Eric
 (...) vi kjører et smalt allmenn-dannelsesbegrep i norsk grunnskole. Og et begrep knyttet kun opp mot humanistiske fag, naturfagene og estetiske fag. Praktisk teknologisk ... elementer av praktisk-teknologisk art, mangler. Og i den grad i det hele tatt læreplanen opererer med teknologi, så snakker man om teknologi. Man omtaler, og det er fremdeles et teoretisk fag, og man gir ikke opplæring i teknologi.

[P6: 189 - 195]

Eric makes a distinction between education *about* technology and education *in* technology. The distinction that can be recognised from Gilbert (1992), and Eric appears to give the concepts a corresponding

meaning. In Gilbert's framework, education *about* technology embraces the cultural and organisational aspects of technology (Pacey 1983) taught in a discursive manner while education *in* technology includes the technical aspect of technology. The latter matches what Eric denotes "elements of practical-technological character".

School E runs education *in* technology in several organisational settings. It is offered to pupils as 'Practical project work' alongside the second foreign languages (German and French) in all grades 8 - 10, because – as Eric states – "what is more practical than technology?" [P6: 265]. Though Eric sees it as important to offer pupils technology as a choice in their compulsory education, he denotes technology as 'Practical project work' a "*negative choice*" for many pupils. This means that the unit mainly attracts pupils on the basis that they do *not* want to study German or French, subjects usually studied by pupils intending to take an academic line in upper secondary school. Thus 'Practical project work' attracts pupils not intending to take the academic line, and whose motivation for school in general may be low. Eric states that this was not the case with his former subject 'teknikk', as it was placed differently in the curriculum and didn't have to 'compete' with subjects important for further education along the academic line.

In order to let all pupils, not only those who have made the 'negative choice' indicated above, take part in technology teaching, thematic teaching related to technological topics is run for all pupils. One such topic is the one of bridges taught in all grade 8 classes. This involves the activity of building bridge models from paper tubes. The pupils are to make drawings to plan their bridge. When the bridges are finished, they are loaded with bags of sugar in order to test their strength and stability, thus adding an element of competition to the activity. Several other components of the teaching link the bridge model activity to 'real' engineering. A professional engineer visits the school and talks to the pupils about the constructions of real bridges, and they go on a trip along a river to study bridges and their constructions. The pupils also watch and discuss the famous film showing the collapse of Tacoma Narrow Bridge. Eric links the collapse of this real bridge to the pupils' bridge models, not only in terms of technicalities such as stability of constructions, but also in the sense that engineering involves the possibility of *failure*:

Eric
It [Tacoma Narrow Bridge] fell down. And it is somewhat dramatic for the pupils to watch, so we have prepared them for that, that when we will test the bridges with our famous sugar

Eric
Den [Tacoma Narrow Bridge] ramla ned. Og det er litt dramatisk for elevene å se, så vi har lagt inn en beredskap på det, at når vi skal teste broene med vår berømte sukkertest -

test - we have some sugar bags that we have found appropriate to test them with - then it is, it is legitimate that some bridges collapse. Vi have included preparedness on this. Because it has happened also historically. With modern constructions.

vi har noen sukkerposer som vi har funnet egnet til å teste dem med - så er det, det er lov at noen broer knekker sammen. Vi har lagt inn beredskap på det. For det har skjedd også da historisk. Med moderne konstruksjoner.

[P6: 97 - 102]

Eric prepares the pupils for the possibility for that their bridge models will collapse when loading them with sugar bags as a test of strength and stability. This may be seen as introducing pupils to the 'real world of technological practice', where criteria for success lie outside the technologist's wants and desires. This introduction to the 'real world of technological practice' is also present in how Eric and his colleagues have planned a new bridge project in grade 8 next year. They have engaged an engineering company to evaluate the pupils' drawings with construction suggestions of bridges, and to choose the best one. Then all the groups of pupils are to build this winner bridge and find technical solutions in order to realise it.

A third way technology associated with the TiS project is taught at School E is through a week designated to project work within 'School's and pupil's options'. The pupils work on projects the entire week, where technology is one option among other areas. The pupils involved choose between two projects, and spend the whole week working on them. One is to design and make a holder for matchboxes from plastic and the other is the building of a 'siege machine' that can project small balls. In the initial part of the project week, the pupils are to plan the construction of the 'siege machine' or matchbox holder by means of drawings. Eric discusses the drawings with each pupil, and suggests materials, tools and arrangements they can make for example for joining parts of the artefact. When the pupils start working with the making of the product, Eric refers back to the drawings when supervising pupils and encourages them to change the drawing, not only the product, if they get new ideas during the making process. This way of working obviously requires more time than other teachers have used with their pupils on running the 'siege machine project'. When this is addressed by the interviewer with reference to other teachers who spend only a few hours on the 'same' project, Eric explains that drawing represents an important learning objective in his technology teaching:

BB

You certainly work much more thoroughly with it, than to do it in two hours of course, so what do you want

BB

Dere jobber jo mye mer grundig med det, enn å gjøre det på to timer selvfølgelig, så hva ønsker dere at elevene

the pupils to learn through that 'siege machine project', of specific or general kind?

Eric

Yes... from some formal things, that you should see, learn to draw! Learn to use drawing skills, make working drawings. I try to motivate them with that drawing is a way of thinking. At the same time this is a, contains also an indirect criticism of drawing as it is run in Art and Crafts, that is more into such decorative drawing.

skal lære gjennom det kastemaskinprosjektet, av spesielle eller generelle ting?

Eric

Ja... av litt formelle ting, at du skal se, lære å tegne! Lære å bruke tegneferdigheter, lage arbeidstegninger. Jeg prøver å motivere dem med at å tegne er en måte å tenke på. Samtidig er dette en, inneholder også indirekte en kritikk av tegning slik den foregår i formingsfaget, eller kunst og håndverk, som det heter nå, som går mer på sånn skjønn-tegning.

[P6: 407 - 419]

Eric describes drawing as "a way of thinking", that is, a *tool* in a technologist's work. Through his technology teaching, he tries to make drawing function as a tool for the pupils, and contrasts this function of drawing to the 'decorative drawing' taught in Art and Crafts.

Technology teaching to Eric also means teaching pupils to make use of the things more normally considered as 'tools', that is, machines and workshop equipment. He has influenced the school into prioritising the purchase of equipment for technology teaching above the level that is commonly obtained at a school as a matter of course. This includes equipment for vacuum moulding and line bending of plastic, glue guns and machines for drilling, rubbing and sawing. When teaching, he encourages pupils to make use of this equipment, and not only stick to simple solutions which they can handle with basic manual tools. Above, Eric criticized about how drawing is taught in Art and Crafts. A similar criticism is also present in how he talks about teaching pupils to use technical equipment:

Eric

We try to do what we can to make pupils use machines, the ones we are allowed to let them work with. The drill gun, and what's its name...drill jig which drills vertically, the surfacing machine, contour saw, glue gun - hot glue, they use more advanced techniques than what has perhaps characterised woodwork ['sløyd']. And indirectly this is a critique of woodwork as a subject, like it is still run after more than a hundred years in Norwegian schools. Still the same

Eric

Vi forsøker å gjøre hva vi greier med å få elever til å bruke maskiner, de vi har lov til å sette dem i gang med. Hånddrill, og hva heter den... sånn borjigg, som borer loddrett, slipe-maskin, kontursag, limpistol - varmlim, de bruker litt mer avanserte teknikker enn det som kanskje har preget sløyden. Og indirekte så er dette også en kritikk av sløyd-faget, slik den vel enda kjøres etter vel hundre år i norsk skole. Fremdeles samme materiale - tre, og fremdeles

<p>material - wood, and still simple hand tools and processes, saw, plane, file. And it is the same artefacts one make.</p>	<p>enkle håndverktøy og prosesser, sage, høvle, file. Og det er de samme tingene man lager.</p>	<p>[P6: 434 - 442]</p>
---	---	------------------------

To Eric, an important aim of technology teaching is that the pupils acquaint themselves with the use of machines that are more advanced than what is common in the traditional woodwork subject ('sløyd') in Norwegian schools, which Eric indicates is somewhat outdated.

Eric's conception, and practice, of education 'in' technology is clearly linked to a view of technology as a specific domain of knowledge. This is evident in the following interview sequence, which starts with how Eric contrasts technology to science as a school subject, where the goal is understanding of conceptual knowledge:

<p>Eric (...) The goal for us here in technology, to put it simple in contrast, is to make products, it is to apply knowledge. And it may be scientific knowledge, technology is based on science, plausibly also mathematics, but technology does also have a knowledge base of its own, an independent knowledge base.</p>	<p>Eric (...)Målet for oss i teknologi, kan da si enkelt i kontrast, det er å lage produkter, det er å anvende kunnskap. Og det kan være naturfaglig kunnskap, teknologi bygger på naturfag, gjerne også matte, men teknologi har også en egen kunnskapsbase, en selvstendig kunnskapsbase.</p>
<p>BB Is it possible to say something about what this consists of?</p>	<p>BB Går det an å si noe om hva den består av?</p>
<p>Eric ... yes, when we were to make a holder for matches... they must work out the thickness of the material, that is, the plastic has thickness, so when they folded this it became too tight for the matchbox, it couldn't slide down as it was supposed to.</p>	<p>Eric ... ja, da vi skulle lage sånn fyrstikkholder... de må beregne tykkelse på materialet, altså plasten har tykkelse, så når de bretter dette så ble det for trangt for fyrstikkesken, den gled ikke ned som den skulle.</p>
<p>BB It doesn't exist in mathematics.</p>	<p>BB Det eksisterer ikke i matematikken.</p>
<p>Eric No, and they must be able to put a bit in a drill machine, that is not a physics subject, all these practical skills, they need to know something</p>	<p>Eric Nei, og de må kunne sette i bor i en bormaskin, det er ikke noe fysikkemne, alle disse praktiske ferdighetene, de må kunne noe om</p>

about materials, materials' properties, flexibility, what kind of tools you can apply to plastic, you can apply to wood, you can apply to metal. What nuts and bolts are on the market, that make it easier to arrive at a product... To handle all the equipment, those small machines we have, that is also technological knowledge, that does not belong in [school] Science.

materialer, materialers egenskaper, formbarhet, holdt på å si, hva slags redskap kan du behandle plast med, kan du behandle tre med, kan du behandle metall med. Hva som finnes på markedet av dingser og bolter, som gjør det lettere å komme til et produkt... Å håndtere all redskapen, disse små maskinene vi har, det er også teknologisk kunnskap, som ikke hører til naturfaget.

[P6: 506 - 535]

Eric asserts that technology has an independent knowledge base. When challenged on identifying what constitutes this knowledge base, he responds by referring to an incidence in the project where pupils were designing and making a plastic holder for matchboxes. They measured the necessary dimensions of the holder very carefully, but came out wrong because the thickness of the plastic sheet influenced the final internal dimension of the product. The problem may be seen as an example of what Staudenmaier (1985) has denoted *problematic data* in his conceptual framework of technological knowledge (see Chapter 2). This category of knowledge represents problems – and solutions – that cannot be derived from theoretical knowledge; they only belong in practical contexts.

The quotation also contains other characteristics that can be recognised from Staudenmaier's conceptualisations of a technological knowledge base. *Scientific concepts* are included in how Eric acknowledges that scientific knowledge *may* be applied to the making of products. The properties of materials he addresses in the quotation may be seen as an example in this regard. He also mentions materials' flexibility, which – if interpreted as generalised conceptual knowledge – reflects Staudenmaier's conceptualisation of *engineering theory*. Finally, as we have seen earlier, *technical skills* are important in Eric's view of technological knowledge. This is, however, not restricted to proper use of machines and equipment. As evident in the above quotation, it also embraces knowledge of what *kind* of machines and equipment are appropriate for working with various materials, as well as familiarity with the types of screws and bolts and so on that are available.

As shown above, Eric possesses a clearly articulated perception of technology as a specific domain of knowledge. In accordance with this perception, his teaching of technology appears to aim at giving pupils access to aspects of the technologist's knowledge by letting them 'act as technologists'.

Familiarising pupils with technological surroundings

While the Third story has conveyed a picture of the pupil ‘as a technologist’, many teachers in this study express a rationale for technology teaching that places the pupil *outside* the enterprise of technology itself. They express aims for technology teaching that can be categorised as ‘*Familiarising pupils with technological surroundings*’. This category captures several perspectives whose main commonality is that they convey a picture of the pupil as a *member of a technological society*. Rather than teaching pupils how to work with and develop technology or to motivate them for further technological education and careers, the aims associated with this picture involve knowledge, skills, attitudes and experiences pupils should gain in order to be familiar and confident with technology in their material and cultural surroundings. Despite the fact that many pupils engage with modern technological artefacts as a matter of course – or perhaps *because* of this fact – teachers see a need for preventing pupils from being alienated from technological aspects of the society they grow up in. Though the notion of ‘literacy’ (Norwegian: ‘allmenndannelse’) is rarely used by the teachers in the present study, the aims embraced within ‘familiarity with technological surroundings’ can be seen as their interpretation of what ‘technological literacy’ means in concrete terms and what this educational goal implicates for teaching.

Extending the horizon of registration

One aspect of familiarising pupils with technological surroundings emphasised by several teachers is to enable pupils to register and recognise principles and structures in technological artefacts and systems around them. An example often pointed to in this regard is the principles used in bridges and other mechanical constructions where strength and stability are important:

BB
What do they learn?

Elna
Specifically with the bridge construction, they see how stable... that is, how things should be related to each other in order to make it stable. And that you, among other things, after that exercise, that they start to look at constructions. There were some who came and had been down to the old railway station, and looked at the roof there, and there were things like that, and they had watched bridges. “Yes, that’s right, we have used, there are those triangles” they say afterwards.

BB
Hva lærer de?

Elna
Akkurat det med bro-konstruksjonen, de ser hvor stabile... altså hvordan ting skal stå i forhold til hverandre for å få det stabilt. Og at du blant annet etter den oppgaven, at de begynner å se på konstruksjoner. Det var noen som kom og hadde vært nede på gamle Østbanen, og kikka i taket der, og der var jo sånt, og så hadde de kikket på broer. ”Ja, det stemmer jo, vi har brukt, det er sånne trekanter” sier de etterpå.

BB
They are everywhere.

BB
De er overalt.

Elna
So that in a way, through the practical work also, see that this can be found outside. In a way extend their horizon of registration.

Elna
Sånn at du på en måte, gjennom det praktiske arbeidet og, ser at dette her fins ute. På en måte utvide horisonten for å registrere ting.
[P5: 118 - 138]

Elna asserts that when having worked practically with constructions of bridge models, the pupils are more able to register and recognise the principles in ‘real’ constructions that they encounter. Besides the learning outcome of knowledge of the principles as such, it appears that to develop pupils’ ability to register the use of these principles, or what Elna refers to as “*extending their horizon of registration*”, acts as an intended outcome in itself. In the Sixth story that will be presented in a later chapter, we will see how Elna teaches a technology project that explicitly aims at extending pupils’ horizon of registration in the domain of electronics.

Elna indicates that the *practical* experiences are important for pupils in order to acquire the ability to register and recognise technological principles. The necessity of practical experiences to fulfil this aim is also explicitly formulated by Frederic:

Frederic
(...) When they have built constructions, towers and bridges and so out of paper tubes, and they see a bridge outside, then they look at it with completely different eyes that if they had read about it.

Frederic
(...) Når de har bygd konstruksjoner, tårn og bruer og sånn i papirrør, og ser en bro ute, så ser de med helt andre øyne enn om de skulle ha lest om det.

BB
They recognise...

BB
De gjenkjenner...

Frederic
They recognise what they have built themselves in a completely different way. And they look - they start to look! Compared to what they did before. When we are out on trips, they say: “Teacher, there is such a bridge that we built”, you get some of those comments that show that they really look with different eyes when they have done it.

Frederic
De gjenkjenner det de har bygd selv på en helt annen måte. Og de ser altså - de begynner å se! I forhold til det de gjorde før. Når vi drar på tur så [sier de:] ”Lærer, der er det sånn bro som vi bygde”, du får en del sånne kommentarer som viser at de virkelig ser med andre øyne når de har gjort det.
[P7: 255 - 267]

Frederic asserts that pupils look at their surroundings “with different eyes” when they have acquired experiences of using principles in their own technology projects than what would be the case if they had merely read about those principles.

Jim pursues a similar argument for technology teaching. In his conceptualisation of what ‘technological literacy’ means, he emphasises that people should have a

comprehension of technology as part of daily life, with special reference to everyday household products:

BB

How do you interpret 'technological literacy'?

BB

Hva legger du i 'teknologi som allmenn-dannelse'?

Jim

It is about people in general having an understanding of that technology is part of daily life, and that applies to adults also. They use technology every day, but they do not reflect on what they are doing. It is in the same way as toilet paper, you have got used to use it, you know what it is used for, but you don't know in a way... there are many such things you use every day that you do not reflect on any more, because it has become so common.

Jim

Det ligger i det at folk generelt har større forståelse for at teknologi er en del av hverdagen vår, så det mener en jo på voksne og. De bruker teknologien hver dag, men de har ingen refleksjon om hva de holder på med. Det blir på samme måte som med do-papir, du er blitt vant til å bruke det, du vet hva du bruker det til, men du vet på en måte ikke... altså, det er mange sånne ting du bruker i hverdagen som du ikke reflekterer over lenger, fordi at det er blitt så allment.

[P17: 862 - 871]

Rather than focusing on recognising technological principles, Jim directs technological *objects* in our daily surroundings, and that we do not reflect on them because they have become common and a matter of course.

Humanising technology

One aspect of the aim of familiarising pupils with technological surroundings is found to be the building of an awareness of technology as distinctive *human*. Several teachers express perspectives on technology teaching that can be interpreted as an aim of *humanising technology*. This involves improving pupils' awareness of technological products as human products, that they do not exist as a matter of course and that they are subject to a constant development influenced by society and individual human beings.

For example, Ann points to a need for making pupils aware of the existence of a technological development as such:

Ann

(...) to make them aware of what actually is, make them aware of what is technology and aware of how much new that is constantly manufactured, that it is not - like the fact that many kids have mobile phones now, it isn't many years it has been like that. Just things like that!

Ann

(...) det å bevisstgjøre dem på hva som egentlig er, bevisstgjøre dem på hva som er teknologi og bevisstgjøre dem på hvor mye nytt som hele tiden lages, at det er ikke - sånn som at mange unger har mobiltelefon nå, det er ikke mange år man har hatt det. Bare sånne ting!

[P11: 522 - 526]

Ann uses mobile phones as an example of a modern product today's kids seem to relate to as a matter of course, and expresses a need for making pupils aware of the fact that they have not always been around. Ann's pupils are quite young (10 - 12 years old), but the same idea arises from Gina, who teaches 15 -16 year olds. This comes up when Gina talks about the challenge of comprehending how products of modern technology work, as they are often very complex and appear in a 'black box' manner. For Gina, this makes the need for understanding the simple principles even more pressing:

Gina

You have to start somewhere if you are to understand how things work, and if you know the simple things then you may combine it and make something more complicated, and then you do not always have to worry about, when you know that it works you don't have to worry about why. But you have to start somewhere to understand that it really requires a bit to have things work! And even if one thinks 'black box', one should have an awareness of the fact that somebody actually has thought something before and put something into that box, simply that.

Gina

Du må jo begynne en plass hvis du skal forstå hvordan ting virker, og hvis du kan det enkle så kan du alltid sette sammen og lage noe mer komplisert, og da trenger du kanskje ikke bry deg om, når du vet at det virker så trenger du ikke bry deg om hvorfor. Men du må begynne en plass for å forstå at det skal litt til at ting virker som de gjør altså! Og selv om man tenker 'black box' så skal man ha en tanke om at det er faktisk noen som har tenkt noe før og puttet noen ting inni den boksen der, bare det.

[P8: 609 - 617]

The first part of her argument is not really straightforward to follow. However, Gina ends up with stating that teaching the basic working principles of what is inside a 'black box' may fulfil an aim of creating awareness of technological products represented by 'black boxes', as human products – someone has figured things out, created them and put them together in the box.

Some teachers address the aim of 'humanising technology' in their teaching by focusing on specific human beings that have been important for technological development. At school F, the human nature of technology is addressed in terms of emphasising the people behind technological innovations in various subjects and contexts. In the subject Norwegian, for instance, the pupils have been reading about inventors and scientists. Frida explains why they make this emphasis:

Frida

We think it is important to know something about it, there are some persons that have had large impact on the development, on the technological development. And that they become acquainted with the persons and the theories they worked with.

Frida

Vi synes det er viktig å vite litt om, det er jo noen personer som har betydd veldig mye for utviklingen, for den teknologiske utviklingen. Og at de kjenner til de personene og de teoriene de har jobbet med.

[P7: 512 - 514]

While Ann and Gina above address the importance of making pupils aware of the dynamic and human nature of technology as such, Frida emphasises that humanising

technology should also involve knowledge on the *specific* humans who have contributed to technological development. To Frida, this knowledge appears to be a significant part of the general cultural knowledge and awareness pupils should gain through their education, and she may hence be seen as advocating a cultural argument for technology teaching.

Engaging with technology: Building pupils' confidence

An affective component of 'familiarising pupils with technological surroundings' is found to be central in how some teachers formulate aims for technology teaching. This affective component has to do with pupils' confidence in engaging with technical objects on an everyday basis, and often arises from what at first appears to be utilitarian perspectives of technology teaching. For example, Ann clearly addresses utilitarian aspects when reflecting on what pupils should gain from technology teaching:

Ann

And also that they should not be so afraid of... things in the home, to change a light bulb for example. Well, it might not be exactly 'technology' to change a light bulb, but... That they are not... Our society is increasingly specialised, and one calls for help for the slightest thing, that they might not be so afraid to check things out on their own in a way. (...)

BB

That one is not dependent on the experts?

Ann

All the time, yes. Of course, you need to use the experts as well, but... yes. There are some who are so helpless that they don't... they need an expert to find out that they have forgotten to plug in the contact, or... well, it is perhaps to exaggerate, but it is somewhat like this, because they have pushed the wrong switch or simple things like that, it is a pity that one needs to use experts for such things...

Ann

Og også det at de kanskje ikke er så redd for å... ting i huset, det å skifte en lyspære for eksempel. Det er jo ikke akkurat 'teknologi' det å skifte en lyspære, men... At de ikke er... Det er jo sånn at samfunnet blir mer og mer spesialisert, og man tilkaller hjelp for den minste lille ting, at de kanskje ikke er så redd for å sjekke ut ting på egenhånd, på en måte. (...)

BB

At man ikke er avhengig av ekspertene?

Ann

Hele tiden, ja. Så klart du må jo bruke eksperter også, men... ja. Det er noen som er så hjelpeløse at de ikke... de må ha en ekspert for å finne ut at de har glemt å sette i en kontakt, eller... altså, det er jo litt overdrevet da, men det er jo litt sånn, for at de har trykket inn en feil bryter eller bare sånne enkle ting, litt synd at man må bruke eksperter for sånne ting...

[P11: 526 - 543]

Ann expresses the view that people should be more able to cope with everyday technology on their own, not having to call upon experts all the time. To Ann, this utilitarian aim of technology teaching involves building pupils' confidence in terms of *attitudes* more than knowledge and skills. She indicates that people may be *afraid* of engaging directly with technical issues in everyday life, and she wants her teaching to counteract what can be called 'technological apathy' and promote

pupils' self-esteem towards their ability to engage with their technological surroundings in everyday life.

With relevance to the above, Ann tells how her own attitudes towards everyday technology changed during her engagement with the TiS project. Her initial motivation for joining TiS was the aesthetic aspects of Design & Technology, and she had never been one who used to “fumble with technology and stuff” [P1: 873 - 876]. The course she attended within the TiS project became important to her as it – in her own words – “opened her eyes towards the technological part of the subject” [P11: 38 - 42]. Ann illustrates this by telling ‘the story about the egg clock’: One day in the kitchen she dropped, by accident, the clock used for timing boiled eggs onto the floor, and the clock broke. So what can one do with a broken egg clock? Ann explains:

Ann

... - and it fell onto the floor, and it didn't work, right. No, damn, I will take it apart; it never occurred to me that I could do such things. So I took it apart and I didn't exactly understand what to do with it, because I was a bit afraid that all the springs would rip off, but we could maybe find something that we could try to adjust a bit... so it changed somewhat, it still didn't really work, but... [laughing] - but it was just this idea that it is in fact possible to try yourself before you just throw things away (...)

BB

But now it occurred to you to take it apart?

Ann

It has never occurred to me before, but after I had been to York, it occurred to me that I could actually try that! [laughing] I think it's a pity that I have not discovered this before, to put it like this, I was 25 before I understood that I actually could try things like that. That was maybe to overdo it, but... but if I'd had such a subject at school, maybe I would... yes, got more things like that.

Ann

...- og den datt i gulvet, og virket ikke, sant. Nei søren heller, nå skal jeg skru den opp; det har aldri falt meg inn at jeg kunne gjøre sånne her ting. Så jeg skrudde opp og jeg skjønnte jo ikke egentlig hva jeg skulle gjøre med det, for jeg var litt redd for at alle fjærene skulle sprette ut da, men vi kunne liksom finne noe som vi kunne prøve å justere litt på da... så den forandret seg litt, den virker ikke helt enda, men... [latter] - men det var liksom bare den tanken at det faktisk går an å prøve selv før du bare kaster en del (...)

BB

Men nå falt det deg inn å skru den opp?

Ann

Det har aldri falt meg inn før, men etter at jeg har vært i York, så falt det meg inn at det kunne jeg jo faktisk prøve! [latter] Jeg syns det er synd at jeg ikke har oppdaget det før, for å si det sånn, jeg var 25 før jeg skjønnte at jeg faktisk kunne prøve litt sånne ting. Det var kanskje å ta i litt da, men... men hadde jeg hatt det som fag på skolen, så hadde jeg kanskje... ja, fått med meg litt mer sånne ting.

[P1: 1011 - 1033]

The principal aspect of ‘the story about the egg clock’ is not really the usefulness of being able to repair broken things, but rather the idea – or attitude – that it is possible to investigate technical things on your own. This story illustrates a change in Ann's own attitudes as a direct result of attending the TiS project. Through

participating in the course related to the projects, she developed a more active attitude towards the technical world around her, and her non-technological self-image was altered. Ann also indicates that since she feels that 'egg clock experiences' were absent in her own education and childhood, she wants to provide her pupils with such experiences. Ann recognises this to some degree as a *gendered* issue; the idea of taking things apart occurs more easily to boys than to girls:

Ann

I think the boys do more things like that... take apart radios or... build things in their spare time because it interests them, while the girls not really... It simply doesn't occur to them. They must in a way be put in a situation where you are forced to try, because you will maybe discover that it can actually be enjoyable.

Ann

Jeg tror guttene gjør mer sånn... skrur opp radioer eller... bygger ting på fritida fordi de er interessert i det, mens jenter ikke helt... Det faller dem ikke helt inn. De må på en måte bli satt i en situasjon hvor du er nødt til å prøve, for du kanskje oppdager at det er faktisk kan være artig det og.

[P1: 1041 - 1046]

Ann sees it as important to "force" girls into technological situations, in order for them to discover that they may actually enjoy it. Since it does not automatically occur to them, Ann sees the school as important in building girls' experiences with the technical world and hence equipping them with an active attitude towards it. This statement appears to resonate with her own change of attitude during her participation in the TiS project – a change signified by the above described 'egg clock experience'.

Elna gives a parallel argumentation as the one from Ann, where utilitarian aims for technology teaching converge towards affective ones. Elna emphasises pupils' curiosity, and in the quotation below she talks about how she experienced that this curiosity was invoked while her class was creating products where individual solutions to problems were emphasised:

Elna

(...) they became curious, they walked around looking at each others projects, how they had done it. And to obtain some of that curiosity, how is this thing made, in fact.

Elna

(...) de ble nysgjerrige, og gikk rundt og så på andres ting, hvordan de hadde gjort det. Og få litt den nysgjerrigheten, at hvordan er det her laget egentlig.

BB

So it has to do with attitudes?

BB

Så det har med holdninger å gjøre?

Elna

Yes, maybe the fact that things... ok, maybe we can do something with this.

Elna

Ja, litt det der at ting kanskje... ok, kanskje vi kan gjøre noe med det her.

BB

That we can do something?

BB

At vi kan gjøre noe?

Elna

Yes, repair for instance, later. If something is broken, instead of... can we do something here, with it? Not be so afraid of open it and have a look.

BB

Find out what's wrong and maybe get it to work again?

Elna

Yes. Take it apart, if something is broken, take it apart and have a look inside. If it is something that will be thrown away anyway, then you can take it apart. A bit of curiosity.

Elna

Ja, reparere for eksempel, senere. Her er noe gått i stykker, isteden for... kan vi gjøre noe her, med det? Ikke være så redd for å skru opp og kikke

BB

Finne ut hva som er galt og kanskje få det i stand?

Elna

Ja. Skru opp, hvis det er noe som er gått i stykker, så skru det opp for å se liksom inni. Hvis det er noe som likevel skal kastes, så kan du jo skru opp. Litt nysgjerrighet.

[P5: 269 - 300]

Elna introduces utilitarian aims of technology teaching in suggesting that one should make an effort to *repair* things that are broken and that will be thrown away. However, to actually make the thing *work* properly again, so that you *don't* have to throw it away, appears to be of somewhat minor importance to Elna as well as to Ann. Both indicate that the object *will* be thrown away anyway, but then you may use the opportunity to investigate how it works and how it is made before they find their way to the dustbin. The aim of technology teaching they are addressing is hence not only utilitarian in character; it also has to do with promoting pupils' active attitudes towards themselves as active agents in their technological surroundings.

Knowledge about industry and production

One component of pupils' technological surroundings is clearly the industrial production that takes place in contemporary society. Hence, knowledge about what goes on in these enterprises is a reasonable aspect of familiarising pupils with technological surroundings.

Accordingly, some of the teachers propose knowledge about industry, production and how things are manufactured in modern society as learning objectives related to technology teaching. These objectives do not appear to be in focus in the technology teaching *observed* in the present study. They are rather pointed to by teachers when they are asked about what content they would appreciate for technology teaching, though not necessarily having had the opportunity to realise at their school due to diverse constraints. Edith is one example:

Edith

(...) And to perhaps see how things function in work life, or in trades, with for example vacuum moulding or bending [of plastics],

Edith

(...) Og det med å kanskje se litt hvordan er det ting fungerer i arbeidslivet, eller i næringslivet da, med for eksempel det med vakum-

and to see that it is simple principles that are required. And it is also about that there is too much theory in lower secondary school. Clearly, far too much theory for many. And part of the goal also must be to get out of the classroom more and, if we had had a bit more than the single lesson in the middle of the day, we could have taken them out, visited companies. And that's what society requires now, that one is more acquainted with how today's society functions, how it comes about in work life, in a way. If we keep sitting here constricted by these four walls... I wish we managed to do a lot more.

forming eller knekking [av plast], at man ser at det er enkle prinsipper som skal til. Og så er det litt det med at det blir for mye teori på ungdomskolen. Helt klart, alt for mye teori for mange. Og litt av målet også måtte vært å komme ut av skolen mer og, hadde vi hatt litt mer enn den ene timen midt inni, så hadde vi reist ut med dem, kommet på bedriftsbesøk. Og det er det samfunnet nå krever, at man er mer inn i hvordan dagens samfunn fungerer altså, hvordan skjer det i arbeidslivet liksom. Blir man sittende her innenfor disse fire veggene... så det skulle jeg ønske vi fikk til mye mer.

[P4: 204 - 216]

Edith wishes to visit companies in order to provide for pupils to learn “how things function” in the work life. This objective appears to contain organisational aspects (“how today's society functions”) as well as knowledge of the technical principles of modern production, exemplified by production of plastic objects. However, the wish for taking pupils to out-of-school visits is much related to Edith's concern for variation in school life for the pupils, as she perceives school as “too theoretical”. Hence, taking pupils out of the school building to visit corporations may be motivated by the need for ‘making school more practical’ with regards to the teaching context as much as the importance they assign to teaching pupils about industry and production in itself.

However, as the above quotation exhibits, the organisation of the timetable may act as a constraint for realising the intention of visiting corporations, regardless of its principal purpose. Other constraints reported by the teachers in this regard, are problems in establishing and maintaining constructive contact with companies where pupils could gain direct information and experience, and in fact that they as teachers also possess too little knowledge on what goes on in industry and production.

Still, many of the teachers formulate how technology teaching can contribute to pupils' knowledge on how products they encounter in everyday life are manufactured. This general learning objective is often exemplified by products made from plastic materials, and attached to activities of creating artefacts from plastic by the use of line-bending and vacuum moulding, techniques the teachers became acquainted with through the TiS project. For example, Gina describes what she believes the pupil gained from her technology teaching this way:

Gina
(...) They worked with plastics, I doubt that any of them have ever made a plastic product

Gina
(...) De jobbet med plast, jeg tviler på at noen av dem har noen gang laget et plast-

before the way we did. But they perhaps do not realise that they have learnt how a plastic product is manufactured, they thought of it as simple enough, logical when they were there and saw it, but they have not thought about that they have experienced anything new, I don't think so!

produkt på den måten vi gjorde. Men de ser kanskje ikke at de har lært hvordan et plastprodukt framstilles, de syns det var greit nok, logisk når de var der og så det, men de har ikke tenkt over at de har opplevd noe nytt, jeg tror ikke det!

[P13: 446 - 450]

Though the techniques of producing artefacts from plastic may appear as simple enough to the pupils when they see it, Gina asserts that pupils gain knowledge on how plastic products are manufactured by making their own artefacts from plastic sheets. They have had a new experience and learnt something they were not previously aware there was to be learnt.

Henry relates knowledge on how things are manufactured to a conception of a process:

Henry

In my opinion, it is important that the kids get an understanding of how things they use are made. I think it is important just so, that they understand that this needs to be done something with and how it is done. I think it is a bit handy that they get knowledge like that.

Henry

Jeg mener at det er viktig at ungene får en forståelse av hvordan ting de bruker blir laget. Jeg syns det er viktig akkurat det, at de skjønner at dette må det gjøres noen ting med og hvordan det gjøres. Jeg syns det er litt greit at de får med seg sånn kunnskap.

BB

For example how plastic objects are moulded, in a way?

BB

For eksempel hvordan plast-ting er formet liksom?

Henry

Yes. Just like yoghurt cups, as they say, that there is a process there for doing it. That they understand that something is required to make it. (...) I think it is handy that it develops an understanding of the fact that things are made and how it is done. Of course, they do not need to know exactly how it is done, but that they have a clue. (...) A process is required.

Henry

Ja. Bare sånn, som yoghurt-begere, som de sier, at det er en prosess der for å gjøre det. At de skjønner at det må noe til for å lage det. (...) Jeg syns det er greit at det blir en forståelse for det at ting lages og hvordan det gjøres. Selvfølgelig trenger det ikke være helt på akkurat nøyaktig hvordan det gjøres, men at de har en viss peiling. (...) Det må en prosess til.

[P9: 892 - 907]

Henry's main point is not the specific knowledge of what an industrial process involves, but rather the *existence* of the process. Henry's concern is that pupils should not consider technological products as a matter of course, but be aware of the fact that "something needs to be done" and that "a process is required".

The aims Henry and Gina have expressed for technology teaching above may in fact be interpreted in alternative terms than addressing knowledge about industry and production as learning targets for pupils. Henry's focus on the somewhat vague 'something is needed' and Gina's emphasise on pupils learning of something they were not aware of was there to be learnt may as well point back to the aim of *humanising technology* that was conceptualised in an earlier section. Providing pupils with experiences and knowledge on how things are manufactured raises their awareness of technological artefacts as human products.

As we have seen, several teachers point to knowledge about industry and production as a reasonable objective for technology teaching. However, this objective does not appear to considerably influence their *classroom* teaching related to the TiS project. Explicit links to industry and production in contemporary society are seldom made in how teaching activities are presented and managed by the teachers. Their structuring of technology teaching, for example involving activities on plastic moulding, do not appear to be based on any intention of modelling a complete industrial process in realistic ways, though the activities pupils undertake may illustrate *some* aspects of those processes. It appears, on the other hand, that other aims are more influential on how their technology teaching is focused and in turn influence how they conceptualise the intention of teaching pupils about industry and production.

Critical consumerism: Sustaining environmental awareness

Many of the teachers point to the pupils' environmental awareness as an element of what technology teaching should aim towards. They often relate it to what can be denoted *critical consumerism*, that is, that the individual should be aware of environmental aspects of their consume. This aim has an information component of making pupils aware of environmental consequences related to consume, but also carries an imperative of acting in the technological surroundings in certain ways. By making pupils aware of the importance of products' quality and whether they are durable or not, they might acquire sound consumer habits that contribute to sustaining the environment:

BB

Are there other aims? (...) Why is it important to have technology on the timetable?

Gina

A reasonable reason is these things with environmental questions, what do we produce, how do we produce and why. 'Use and throw

BB

Flere ting som kan være målsettinger? (...) Hvorfor er det viktig å ha teknologi på timeplanen?

Gina

En nærliggende grunn er jo dette med miljøspørsmål, hva produserer vi, hvordan produserer vi det og hvorfor. 'Bruk og kast',

away', there is a lot of problems like that.

det er masse sånne problematikker.

[P8: 462 - 470]

Though critical consumerism and environmental questions seldom represent the teachers' main focus, the issues often come up in association to technology teaching. As Gina above, Ann mentions the 'use and throw away' mentality and how technology teaching may counteract this mentality:

Ann

And I think it is important, the awareness with regards to environmental aspects, with technology.

Ann

Så tror jeg det er viktig det med, altså bevisstheten i forhold til miljøaspektet da, med teknologi.

BB

How's that?

BB

Hvordan da?

Ann

Well, what is... I'm thinking of pollution and cleaning... 'use and throw away' mentality, what is durable and not durable, in a way. (...) And I also think of awareness related to commercials. Commercials are often very offensive, directed towards kids and teenagers and... That the kids become conscious about what they buy, whether it is good quality or whether it only looks good, the role design plays with regards to functionality, things like that.

Ann

Altså, hva som... jeg tenker på forurensing og rensing... bruk og kast mentalitet, hva som er holdbart og ikke holdbart på en måte. (...) Og også bevissthet i forhold til reklame, tenker jeg på. Reklame er jo veldig offensiv ofte, rettet mot unger og ungdom og... At ungene blir litt bevisst på hva de kjøper, om det er bra kvalitet eller om det bare ser fint ut, hva design har å si i forhold til funksjonalitet, sånne ting.

[P11: 547 - 562]

Ann sees it as important that pupils develop a critical attitude towards consume, commercials and the quality of products. These issues are, however, not addressed explicitly in her teaching of technology. They rather appear to form part of the silent rationale for her teaching:

Ann

It is on my mind, but I don't think it has become explicit, but I am thinking that it could be important to address it, such aspects. Some of it I believe "come to the surface" when we are teaching also. But that's part of the reason for that we have chosen to focus on plastic this spring, we have planned to visit the oil company Statoil, to have a look at oil, how it is recycled and used and so, and then include plastic as part of that. And it is to be related to pollution and how many things are in fact made out of plastic. Those things will be included, I believe.

Ann

Jeg tenker litt på det, men jeg tror ikke det har kommet så mye til uttrykk akkurat det, men jeg tenker på at det hadde vært viktig å tatt det opp, sånne aspekter og da. Noe tror jeg nok "detter ned", når vi underviser også. Men det er jo litt av grunnen til at vi har valgt å fokusere litt på plast, nå i vår, vi har planlagt å besøke Statoil, og se litt på olje, hvordan det gjenvinnes og brukes og sånn, og så trekke inn plast i den forbindelse da. Og da er det litt i forhold til forurensing og det med hvor mange ting som lages av plast egentlig. Litt de tingene kommer inn der tror jeg.

[P11: 571 - 578]

Ann exhibits that environmental aspects do, however, more explicitly form part of the background for her desire to let pupils work with plastic this year and links this to a visit to an oil company.

Hence, the teachers may add an environmental perspective to technology teaching that nonetheless has its main focus on pupils' production of artefacts. The teaching may, directly or indirectly, aim at making pupils conscious of all the products in their surroundings, our consumption of produced goods, their possible environmental harm, the power of commercials, and the importance of product quality and functionality in order to avoid unnecessary consumption of goods. In Ann's case, we may see a link to her emphasis on the quality of *pupils'* products that she exhibited in the First story of this thesis.

In Gina's teaching of technology, environmental aspects are addressed more directly in one of her teaching projects. She starts the project by discussing recycling with pupils, what kind of objects and materials may be recycled, and the kind of new products that may result from this. Pupils are then given the challenge of creating a new product from waste materials of their own choosing. The project does, however, turn out in a different direction than intended – as will be described in the Seventh story later in this thesis.

How things work: Understanding everyday technology

The teachers' views of what pupils could learn from technology teaching often include technical aspects of artefacts, tools and systems. Correspondingly, they express an aim for their teaching as increasing pupils understanding of everyday technology from a technical point of view, which also corresponds to one of the aims formulated in the project policy for the TiS project (see Chapter 6). Though it addresses the technical aspect of technology, the aim as the teachers express it appears to – if seen isolated – involve mainly conceptual knowledge as learning outcomes for pupils. It does not address specific skills in how to *make* products, make system *work* or make *use* of tools. Rather, it involves knowledge and understanding, often in terms of technical principles, that can answer a question of 'how things work'. Some teachers refer to understanding of 'how things work' as an immediate response to what technology teaching should aim at:

BB
 (...) What should be the aims if technology was a subject on a more regular basis? What should be its aims?

Gina
 It is about gaining an insight in how things we

BB
 (...) Hva skal målsettingene være hvis man skal ha teknologi som fag på mer sånn fast basis? Hva skulle være målsettingene med det?

Gina
 Det går nå på å få en innsikt i hvordan ting vi

use daily function, in other ways than... in the traditional subjects there is usually much more theory than... Or there is much theory that is not connected to what we do in everyday life. So I see a possibility that it can give the pupils more understanding of how things work, and how things generally are made.

bruker rundt oss daglig fungerer, på en annen måte enn... det blir jo mye mer teori til vanlig de tradisjonelle fagene enn... Eller det er mye teori som ikke er knyttet opp mot det vi gjør til daglig. Så jeg ser for meg at det kan gi elevene mer forståelse for hvordan ting virker, og hvordan ting er laget i det hele tatt.

[P8: 376 - 386]

The teachers' emphasis on technological objects familiar to pupils from their everyday surroundings, as exemplified by Gina above, is found to be reflected in much of the observed teaching related to the TiS project. For example, a teaching project frequently run by the teachers within the TiS project is the one of letting pupils study, discuss and explain mechanical working principles of everyday tools and artefacts. These tools and artefacts are often those involving simple mechanical mechanisms, such as a wine opener, a rotary beater or a wrench.

The teachers present several interrelated motives for why knowledge on 'how things work' should constitute a significant part of technology teaching in schools. These motives are often related to how modern technology and people's engagement with it differ from what was the case in earlier times. Today's kids are often familiar with the use of a range of advanced, often electronically based, tools and products. Consequently, teachers see a need for drawing pupils' attention to more simple and traditional tools and objects, and make them aware of their working principles:

Frederic

When one thinks of technology, it is quickly associated with IT and computers and complicated things, but that we rather look more at ordinary objects we use daily, and why do they appear as they do and what use do we make of them.

Frederic

Når man tenker teknologi, så blir det fort IT og datamaskiner og kompliserte ting, men at vi egentlig ser på mer hverdagslige gjenstander som vi bruker, og hvorfor ser de sånn ut som de gjør og hvilken nytte vi har av dem.

[P10: 261 - 264]

While kids growing up in earlier times were acquainted with simple tools from their daily life, teachers experience that today's pupils in fact are not familiar with the working principles and use of simple tools – they may even be unfamiliar with the *existence* of these tools, as pointed out by Irene:

Irene

(...) like in the old days, perhaps the kids knew more about how things functioned, but now everything is taken for granted in a way. The kids actually don't know how things function, that you in a way rediscover them and look at the rotary beater and those cog-

Irene

(...) sånn som i gamle dager, så kanskje ungene visste mer hvordan ting fungerte, men nå tar man alt for gitt på en måte. Ungene vet faktisk ikke hvordan ting fungerer, at du liksom tar det fram på nytt og ser på hjulvispen og de her tannhjulene som går rundt

wheels that rotate and so, see what happens. And then [the pupils say]: "Wow, rotary beater, what kind of thing is that?", right.

og sånn, ser hva som skjer. Og så [sier elevene]: "Jøss, hjulvisp, hva er det for noe?", ikke sant.

[P16: 183 - 188]

Some teachers relate this phenomenon to the prosperity today's pupils are surrounded by. Our society's material prosperity and consumerism allow the pupil a negligence of human-made material values; how tools and artefacts work and how to maintain them. This development makes Benny point to an awareness of these values as a crucial competence for the pupils:

BB

What kind of competence do the pupils need related to technology?

BB

Hva trenger elevene for kompetanse i forhold til teknologi?

Benny

Well, they mostly need to, well, competence... what they need is to reflect a bit on... that... how things work. And wonder a bit, not take things for granted. Most kids now, they possess so many things, they have plenty of everything and they do not really need to think about working principles or how to maintain things, how things work.

Benny

Nei, de trenger mest å, altså kompetanse... det de trenger er å tenke gjennom litt og... at... hvordan ting virker. Og undre seg litt, ikke ta ting for gitt. De fleste unger nå, de har så mye, de har overflod av alt og de trenger ikke egentlig å tenke så mye på virkemåter og... å være opptatt av hvordan du skal ta vare på ting, hvordan ting virker.

[P2: 888 - 899]

He also states that today's kids are denied the opportunity to become familiar with everyday technology due to the specialisation of technological work and that everyday technological objects are 'closed'. As a consequence, pupils do not observe their parents repairing things as they used to do earlier:

Benny

Everything has become so closed, you cannot repair your car anymore. You cannot repair any domestic utensils around you, any tools. Because it is too specialised. (...) Kids who grow up today, they are used to things being closed, and they do not see adults repair anything at all anymore. Except that they may redecorate some walls and floors, put on tiles and so. But they do not repair anything that is defective. They don't repair anything, either it being shoes or clothes or upwards. If something is broken, it must either be sent back and returned in a repaired shape, but it... what happens inside that object, that is certainly as incomprehensible to adults as to kids, really.

Benny

Alt blir så lukket, du kan ikke reparere på bilen din selv lenger. Du kan ikke reparere noe husgeråd du har rundt omkring, noe redskaper. For det blir for spesielt. (...) Ungene som vokser opp nå, de er så vant til det der at ting er så lukka, og de ser ikke at voksne hjemme reparerer noe som helst lenger. Det er nå eneste at de kan pusse opp litt på vegger og gulv, legge flis og sånt. Men de reparerer jo ikke noe som går i stykker. De reparerer ikke noe, enten det er sko eller klær eller oppover. Går nå noe i stykker så må det enten sendes inn og så kommer noe tilbake i ferdig stand, men det... hva som foregår inni den gjenstanden, det er nå like gresk både for voksne og unger, egentlig.

[P2: 944 - 963]

Exemplified by Benny above, many of the teachers highly emphasise experience with *repairing* things as important when reflecting on aims for technology teaching, and relate this purpose to knowledge of how things work. Irene identifies the neglect of this type of knowledge as a modern as well as a city phenomenon, and asserts that rural people might be more competent in technology than people living in cities:

Irene

Maybe it has to do with the fact that when things were broken in earlier times, they needed to be repaired. You fiddled with cars, with mopeds. People living in cities do not do that, on the countryside they are much more clever with technology, I believe, they need to repair things that are broken.

Irene

Kanskje det har noe med det at ting gikk i stykker før, og så skulle det repareres. Altså, du skulle mekke på bil eller moped. Altså, byfolk gjør ikke det, på landet der er de mye flinkere til teknologi vil jeg tro, du skal reparere noe som har gått i stykker.

[P16: 197 - 201]

To counteract a growing neglect of technical knowledge, she wants technology teaching to focus on simple everyday technology, and denotes this to “move into reality”, in contrast to the artistic and aesthetic emphasis she assigns to the teaching of Art and Crafts, which she sees as moving *away* from reality:

Irene

Well, I am a bit concerned that we move away from reality, and with this [technology teaching] I feel that we move into reality in a way. Yes, you should have seen it, how Art and Crafts appears now, it has to be so much sculpture and art - and that's well enough, but where is reality, how should I put it, the things, we should not take for granted all the things we are surrounded by.

Irene

Nei altså, jeg er litt redd for at vi skal fjerne oss fra virkeligheten, og det her [teknologi-undervisning] føler jeg jo at vi går inn i virkeligheten, liksom. Ja, du skal bare se altså, sånn som på kunst og håndverksfag er nå, som skal være så mye sånn skulptur og kunst - og det er jo bra nok det altså, men hvor blir det av virkeligheten, altså sånn, hvordan skal jeg si det, altså de tingene, vi skal ikke ta alle tingene som en selvfølge heller vi har rundt oss.

[P16: 409 - 416]

The emphasis on what appears as a utilitarian perspective (“repairing things”) the teachers signal, may be seen as somewhat paradoxical, as they at the same time state that modern everyday life neither requires, nor facilitates, an ability to repair things or to understand how they work. So how then does the need for repairing artefacts warrant their working principles as a target for technology teaching? As suggested earlier, the teachers’ perspectives may not be purely utilitarian though they often appear as such. On the contrary, the teachers’ focus on knowledge of how things work and on how to repair them may be interpreted as an expression of a *cultural* rather than a utilitarian argument for technology teaching. This corresponds to the interpretation of the aim of building pupils’ individual confidence in engaging with technology that was made earlier in this chapter. The aim was seen as an *affective* one, rather than related to knowledge and skills in a utilitarian

perspective. On a collective level, technology teaching may be seen as upholding a cultural heritage of technological knowledge. As everyday technological knowledge is no longer transmitted to the pupils in the realm of their homes, they may – with a touch of nostalgia – see a need and a responsibility as teachers to maintain this heritage of knowledge in schools for *cultural* reasons.

To let pupil study traditional everyday tools or ‘yesterday’s technology’ may be part of maintaining awareness of our technological heritage. To some teachers, this may also serve the purpose of making pupils understand *today’s* technology. In the following interview sequence, Benny explains what pupils may gain from visiting a transport museum and studying old trams:

Benny

(...) To look at things that have had the same function over a period of time, that is, for example such a... at the tramway museum we have (...), you may see the technological development of a means of transport through a century. And reflect on, what on earth has happened, the principle in itself, that makes an electrical engine run, that is quite an old one, that hasn’t changed much. That is, the working principle, to make the engine run, but quite a lot has happened around that engine all the same, with comfort as well as control systems for currents. That is, the current comes from a wire that runs via some fuse boxes and into some mechanism that controls how much current that proceeds to the engine. That is the principle behind a tram, but the control systems are quite different, on old trams it is very easy to visualise how the technology works. Therefore I think it could be exciting to use that as an example.

Benny

(...) Å se på ting som har hatt samme funksjon over en tidsperiode, altså bare hvis du skal ta et sånn... det sporveismuseet som vi har (...), så kan du der få se den teknologiske utviklinga på et transportmiddel gjennom hundre år. Og tenke gjennom, hva i all verden er det som har skjedd, selve prinsippet, med å få en elektrisk motor til å gå, det er jo ganske gammelt, det har jo ikke forandret seg så mye. Altså virkemåten for å få motoren til å gå rundt, men det har skjedd ganske mye rundt den motoren likevel, enten det er med komfort eller det er med styrings-systemet for strømmer. Altså, strømmen kommer fra en kjøreledning som går via noen sikringsbokser og inn til en redskap som regulerer hvor mye strøm som går videre til motoren. Det er jo prinsippet bak en trikk, men styringssystemene er jo ganske forskjellige. På gamle trikker så er det veldig enkelt å anskueliggjøre hvordan teknologien virker. Derfor syns jeg det hadde vært artig å bruke akkurat det som et eksempel.

[P2: 859 - 873]

Benny’s desire to let his pupils study the old trams at the museum is not primarily founded on a wish to make them aware of the technological development, its impact on society or how transport technology has changed through history. He rather wants to show them what has *not* changed, that is, the basic technical principles of how a tram works. The lack of transparency associated with modern technological artefacts and systems makes their older relatives more appropriate for teaching about those principles.

The aim of familiarising pupils with technological surroundings by teaching them 'how things work' has in the above mainly been described in terms of working principles of *specific* objects. However, the aim also embraces an understanding of more *generalised* principles that can be utilised and combined for a range of purposes. In the following story, we will see how one of the teachers, Frederic, formulates learning objectives in technology as knowledge of such generalised technological principles, and how he systematically bases his teaching of technology on a related conception of technological knowledge. The story will, however, reveal that Frederic holds supplementary and rather different aims for his technology teaching than pupils' learning of technological principles. These aims will be conceptualised in the section following the story.

FOURTH STORY. TEACHING TECHNOLOGICAL PRINCIPLES

One teaching project Frederic is undertaking with his grade 8 pupils on the 'Technological Mondays' (see Appendix 1) at School F is a project on designing and making a mechanical toy. The toy consists of a frame with an axle attached to a handle running through it. Discs with various shapes are mounted to the axle. When the handle is turned, these discs induce figures on top of the frame to perform various movements.

In connection with this project, and as a response to a question on what a teacher needs to know in order to teach technology, Frederic presents a somewhat reductionist view of a technological knowledge base as consisting of a set of basic principles:

Frederic
It mostly surprised me when I started to reflect on technology, what is it that we really want to teach them? Then I think I see, when you start to look at machines, equipment, things, that there are rather few principles and techniques involved.

Frederic
For det overrasket meg mest når jeg begynte å tenke på teknologi, hva det er, hva er det egentlig vi skal lære dem? Da synes jeg jeg ser at når du begynner å se på maskiner, utstyr, ting, så er det ganske få prinsipper og teknikker vi bruker.

BB
And then one can get hold of those -

BB
Og da kan man ta tak i de -

Frederic
- Get hold of those principles, that's it. So it might be that we need know-

Fredric
- Ta tak i de prinsippene, altså, så det kan godt hende vi trenger kunnskap

ledge of which principles to present to the pupils.	om hvilke prinsipper er det vi ønsker å vise elevene.
BB In various contexts?	BB I ulike kontekster?
Frederic In various, yes, connections.	Frederic I ulike, ja, sammenhenger.
BB So you mean that you can take all technology and reduce to...	BB Så du mener at du kan ta all teknologi og koke ned til...
Frederic To some simple... simpler things, yes. But then we combine them in new ways. When we make a new machine, we use the same techniques, but put together in somewhat new ways.	Frederic Til noen enkle... enklere ting, ja. Men så kombinerer vi det på nytt. Når vi lager en ny maskin så har vi tatt de samme teknikkene, men bare satt sammen på en litt ny måte.
BB Everyone does not invent the wheel.	BB Alle finner ikke opp hjulet.
Frederic No, they do not! That is, one should know, when does one use drive belts, when does one use cogwheels, for instance. When does one use crankshafts? If you are to make something that moves, then it is drive belts, cogwheels, crankshafts of one or another sort, and camshaft. Those are the four things in use, you do not find anything else!	Frederic Nei, de gjør ikke det! Altså, at man vet, når bruker man reimskiver, når bruker man tannhjul, for eksempel. Når bruker man veivaksel? Hvis du skal lage noe som beveger seg, så er det reimskiver, tannhjul, en eller annen form for veivaksel og kamaksel. Det er de fire tingene man bruker, du finner ikke noe annet!

[P7: 814 - 848]

Frederic has identified technological knowledge and the learning objectives it implies as *conceptual*. It involves knowledge of certain basic principles and ways to combine them in order to arrive at a desired solution. This conceptual knowledge is correspondingly central in how he approaches his own teaching project on mechanical toys. As an introduction to the project, Frederic gives a lesson on the principles that may be combined to build a mechanical toy, identical to those mentioned in the above interview sequence. Further, the pupils are asked to bring a toy or tool with mechanical movement to school, and in the next session the class discusses how these devices work and identifies the basic principles applied in them. Among the objects pupils have brought are a wine opener, a rotary beater and toys of various kinds. Next, pupils investigate the possibilities of combining the principles provided by drawing and making simple models of out of

cardboard. Thereafter, the pupils work individually in making their own mechanical toy out of wood.

The task of designing and building a mechanical toy requires thorough planning and cautious adjustment of all parts in order to succeed. Therefore, Frederic encourages the pupils to make detailed drawings in order to make their ideas explicit before they cut out and glue the parts of their products. During the sessions, the pupils work according to their own plans, with assistance and suggestions from Frederic. The pupils complete the project by painting and decorating the toys, and an exhibition of their products is made.

The teaching project on mechanical toys is rather time consuming and occupies lesson time that could be used on subject elements specified in the formal curriculum. If the lessons only intended to teach the pupils technological principles and their use, the teaching could obviously have stopped with the models made out of cardboard. When Frederic is asked if he would consider this as a possibility he answers:

Frederic
No... it depends on how much effort you put into it, to draw nice things and figures that they make out of cardboard, but we didn't do that this time, it was only about the moving parts when we did the cardboard models.

Frederic
Nei... det spørs jo hvor mye arbeid du legger i det, å tegne fine ting og fine figurer som de lager i papp, men det gjorde ikke vi denne gangen da, så det gikk jo bare på de bevegelige delene, da vi gjorde det i papp.

BB
The principles in a way?

BB
Prinsippene liksom?

Frederic
Yes, the principles.

Frederic
Prinsippene ja.

[P10: 116 - 126]

Frederic's response indicates that building cardboard models alone could be considered if more effort was put into decorating the cardboard. When he has chosen to let the pupils build the final mechanical toys from wood, the role of the cardboard model is only to demonstrate and experiment with the *principles*. It hence appears that Frederic has more aims attached to his mechanical toy project than the teaching of technological principles that he earlier identified as intended learning outcomes of technology teaching. What these additional aims comprise, becomes clearer when he responds to a question on whether the time used on the entire project is worthwhile:

BB

But is it worth it, in a way, the time it takes?

Frederic

Yes, I think so, that we should take the time to make nice things that we are somewhat proud of.

BB

Is that essential, that they will be proud of it?

Frederic

Yes, I think so. That is certainly motivating! And... if all the time in school, because we have a lack of time, we never make anything that is nice, then it is no fun, there is nothing to display, there is nothing to be proud of! If all the time we are in a hurry and just keep rushing through our work.

BB

Men det er verdt det, på en måte, den tiden det tar?

Frederic

Ja, jeg syns det, at vi skal ta oss tid til å lage fine ting, som vi er litt stolte av.

BB

Er det et poeng, at de blir stolt av det?

Frederic

Ja, jeg syns det. Det er motiverende det! Og... hvis vi hele tiden i skolen, fordi vi har dårlig tid, aldri lager noe som blir fint, så blir det jo ikke noe moro, det er ikke noe å vise fram, det er ikke noe å være stolt over det! Hvis vi hele tiden bare må haste og slurve videre.

[P10: 128 - 143]

Frederic now asserts that it is important that the pupils are given the opportunity to make nice things that they can be *proud* of. He points to a problem of always being in a hurry to cover the curriculum in today's school, and that this leads to a situation where pupils are denied the chance to do work of high quality and to be proud of their products. His project on the mechanical toy, on the contrary, provides the pupils with the opportunity to spend a considerable amount of time on designing and making a product of high standards and of which they can be proud of.

Cultivating the pupil

In the beginning of the Fourth story it was shown that Frederic identifies technological knowledge as a set of basic principles and ways of combining these principles in order to achieve desired ends. This knowledge is central in how he approaches his teaching project on mechanical toys. Frederic's focus on the identification of conceptual principles as learning objectives and ways in which these can be taught, suggests that his thinking reflects an *academic curriculum design* (Zuga 1989). However, throughout the story there is a fundamental shift from an academic approach towards emphasis on *affective* aspects of pupils' development. The final part of the Fourth story suggests that Frederic's creation of

technology teaching can not barely be understood in terms of an aim of familiarising pupils with technological surroundings, or more specifically technological principles in common use. He emphasises how technology teaching can contribute to the pupils' development in a wider sense.

Frederic's viewpoints are shared by a significant part of the teachers in this study. As aims for technology teaching, their perspectives can be captured as '*Cultivating the pupil*'. In the following, we will see how the teachers in this study perceive the potential of technology teaching for '*Cultivating the pupil*', and how aims included in this category guide their realisation of technology teaching related to the TiS project.

The pupil as a creator: Nurturing pupils' pride and self-esteem

Frederic's technology teaching presented in the Fourth story appears to be strongly structured around how he perceives a knowledge component of technological principles. Yet he justifies the amount of time used on the project on mechanical toys by pointing to the importance of letting pupils be *proud* of their products. This aim for his technology teaching is given further prominence in how Frederic responds to a direct question of what he sees as intended learning outcomes of his teaching:

BB

What is it that the pupil should learn, or what do you want them to experience?

Frederic

I want them to experience that they are able to create a product from own thoughts, that they can participate in developing new products, dare to believe in it. Then there are of course some techniques we can teach them, and the subject matter that we relate to the projects.

BB

Hva er det elevene skal lære, eller hva vil du at de skal erfare?

Frederic

Jeg vil at de skal erfare at de er i stand til å skape et produkt fra egne tanker, at de kan være med å utvikle nye produkter, tørre å tro på det. Så er det selvfølgelig en del arbeidsteknikker som vi kan lære dem, og det faglige innholdet som vi knytter til prosjektene.

[P7: 875 - 882]

Though Frederic acknowledges the aim of teaching pupils techniques and 'subject matter', it appears that his concern for pupils' attitudes towards themselves as *creators* is as important. The meaning of this aim is not essentially to *enable* pupils to act as creators by teaching them knowledge and skills. The aim rather operates on an affective level; the pupils should learn to *believe* in themselves as creators, and they should *dare* to believe in their own potential in contributing to development of technology.

The importance of 'the pupil as a creator' in how Frederic perceives technology teaching is confirmed in the final sequence of Frederic's argumentation for technology

teaching referred to earlier in this chapter, where Frederic states that he wants the pupils to:

Frederic

- see that they can create things, based on... yes, that they have the potential of creation, that they are able to create things and also believe in that they are able to do it.

Frederic

- se at de kan skape ting, ut i fra... ja, at de er skapende, at de er i stand til å skape ting og også tro på at de er i stand til å gjøre det.

[P7: 226 - 228]

Frederic's focus on cultivating the pupil through teaching that nurtures pupils' pride and self-esteem is shared by other teachers who, like Frederic, appear to emphasise a knowledge component in their teaching of technology. This may be illustrated by revisiting Ann and her teaching of the buggy project described in the First story. Her technology teaching had an emphasis on the technical quality of the pupils' products, and contained a significant component of conceptual knowledge and practical skills taught in an apprenticeship manner. However, listening to Ann's reflections on her technology teaching alters the picture of her teaching as 'subject-centered' or 'knowledge-driven'. Below she is asked whether she considers practical skills as important in technology teaching:

BB

[Are practical skills important?]

BB

[Er praktiske ferdigheter viktig?]

Ann

Well, practical... do you mean... what does one think of, practical skills..?

Ann

Ja, praktiske... tenker du på... hva tenker man, praktiske ferdigheter..?

BB

That it should be... for example that you showed them techniques for making things at a right angle.

BB

At det skal være... altså du har vist dem måter for å få ting vinkelrett for eksempel.

Ann

Yes. But that has to do with whether you will be proud of your product afterwards or not. And when one puts much effort into a thing, then it is important that the kids have an opportunity to be proud of their product, I think. But it is also related to how much... to me it is related to how much time one uses on a thing, I could certainly use very little time on something, and then it doesn't matter how it looks afterwards if they have learnt how one can do things, and how one can do things at home later. But maybe also, like in a cultural session where they had the opportunity to choose among different things and have expectations towards the session, then it is important to me that they feel that they can

Ann

Ja. Men det har jo med om du blir stolt av produktet ditt etterpå eller ikke. Og når man legger mye arbeid i en ting så er det viktig at ungene har en mulighet til å bli stolt av produktet sitt synes jeg. Men det har også med hvor mye tid man bruker på en ting, altså jeg kan godt bruke veldig kort tid på en ting, og da spiller det ikke så stor rolle hvordan det ser ut etterpå hvis de har lært hvordan man kan gjøre ting, og hvordan man kan gjøre ting hjemme etterpå. Men kanskje også litt sånn i en kulturøkt hvor de har fått mulighet til å velge forskjellige ting og har litt forventninger til den økta, så er det viktig for meg at de føler at de får til noenting og

cope with it and manage to make something that is a bit nice and a bit good. That it is not something that we just do because we should do something to keep us occupied. So, that's why I try to include the stuff that makes things a bit better than if one didn't think of it, like making things at right angles and...

føler at de får til noe som er litt fint og noe som er litt bra. At det ikke bare blir noe vi skal holde på med fordi vi skal gjøre et eller annet og fylle tida med noenting. Så derfor prøver jeg å få med de tingene som gjør at ting kan bli litt finere enn hvis man ikke har tenkt på det, sånn som å få ting i vinkel og...

[P1: 659 - 684]

Initially, the question generates no resonance, and an example is required in order to make Ann respond. She now explains her focus on skills and knowledge by expressing a wish for letting pupils be *proud* of their work, and her argumentation shows striking similarities to Frederic's concern expressed in the Fourth story. To fulfil the aim of pupils being proud of themselves and their products, it is essential to Ann that the products hold high technical quality, which in turn requires knowledge and skill.

Both Frederic and Ann include a significant body of conceptual knowledge and skills in their technology teaching. The way they reflect upon it suggests, however, that the principal aim they hold for their teaching is the building of pupils' self-esteem and confidence – that they should be proud of the products of their work and thus of themselves as creators.

The view of the pupil as 'creator' is also found to be given a deeper meaning than their ability and self-esteem related to creation of artefacts as expressed by Frederic and Ann. David speaks about pupils as creators in a more all-pervading sense, and upholds that technology as a subject is only meaningful to him to the degree that it forms part of a holistic view of the pupil as creator:

David

To me it is more interesting if it is an important part of a greater totality, which is about pupils' activity, about interest and so on. The possibilities to create something, really.

David

For meg er det mer interessant hvis det er en viktig del av en større helhet, som handler om elevaktivitet, om interesse og så videre. Mulighet for å skape noe, rett og slett.

[P3: 453 - 455]

David's focus on providing pupils with possibilities to create also applies to other areas than the creation of physical objects. For example, he describes his intentions with working with information and communication technology (ICT) with pupils this way:

David

The main point with the work with data is that the pupils create. Right, we don't use data so much for seeking information, or gathering information, as we use it as a mode of

David

Hele hovedpoenget med den data-jobbinga er at elevene skal skape. Ikke sant, vi bruker ikke data i så stor grad til informasjonssøk, eller informasjonsinnhenting, men vi bruker

expression. That they are to use film, video and so on to impart something.

det som uttrykksform. At de skal bruke film, video og sånn forskjellig til å formidle noe.

[P3: 45 - 49]

In similar ways as with ICT, working with Design & Technology means letting pupils express themselves by creating. As will be shown in the next section, David extends the meaning of creation to involve creating an agenda for a meaningful life.

Fostering the pupil's agenda

In Benny's teaching presented in the Second story, we have seen an empowering of the pupil in defining the *agenda* of the technology projects. This entails freedom for pupils, not only in making decisions on *how* to carry out the projects, but also on what the projects are essentially about. Other teachers also express views on technology teaching that can be interpreted as an aim of *fostering the pupil's agenda*. For example, Henry and Hanna, who have worked with a joint project on making a mirror frame with a support mechanism with pupils in grade 5 and 6 respectively, give the following answers to a question on whether the appearance of pupils' products, in terms of their attractiveness, is important:

BB

Is it important that it becomes attractive?

Henry

For the pupils, you mean, or for...?

BB

Yea... if it is a point in itself...

Hanna

For some pupils I feel it is very important, because they are so meticulous and want to make it so nice that they feel they have not succeeded if it is distorted. For others, on the other hand, it is not so, they are satisfied though it is a bit distorted and out of shape.

Henry

Some are satisfied just to get finished also actually. But we have those who are really diligent and take great pains. However, you always have some that come and tell "now I have finished, what to do now?" It is not everybody who is so diligent and cares so much about it.

BB

Er det viktig at det blir fint?

Henry

For elevene mener du eller for...?

BB

Jaa... om det er et poeng i seg selv...

Hanna

For enkelte elever føler jeg at det er veldig viktig, for de er så pertentlig og skal gjøre alt så fint at hvis de ser at det blir skeivt så føler de at da er det mislykket. Men for andre så er det liksom ikke så, de er fornøyd om det er litt skeivt og skakt.

Henry

Noen er fornøyd bare de blir ferdige også, egentlig. Men så har vi dem som er skikkelig nøye og gjør seg flid ja. Men du har jo alltid dem som kommer og sier at "nå er jeg ferdig, hva skal jeg gjøre nå?" Det er ikke alle som er like nøye og bryr seg så veldig om det.

[P9: 278 - 297]

The way Henry and Hanna respond to the question suggests that the importance of the products' appearance is an issue to be left to the pupils. They do not address the question in terms of how they see it themselves, but in terms of differences in how it is seen by the pupils. Further, they do not consider it as a problem if a product is 'distorted', as long as the pupil is satisfied with it. This position can be related to the principle of individual adaptation emphasised in the curriculum L97, that is, that all pupils are to be given challenges corresponding to their abilities (KUF 1993). However, their view seems to be more comprehensive, as not only should expectations of achievements be adapted to the individual's abilities, yet also the direction of the criteria of success is defined by the pupil's agenda. This applies even within the rather strongly framed activity Hanna and Henry run with their pupils. What they do indicate as a problem in the end of the quotation, is pupils who do not actively engage in the activity, but who just want to get away with it. Hence, 'no agenda' within the project does not count as a pupil's agenda. This interpretation is supported by how they later discuss the problem of underachieving pupils:

Henry
There are some I require more from, tell them they need to take more care, of course there are.

Henry
Det er noen jeg stiller litt mer krav til, sier de må være litt mer nøye, selvfølgelig er det det.

BB
Because you know they can do better?

BB
For du vet at de kan bedre?

Henry
I know they can do better, yes. Such lack of effort I don't appreciate much, they have to...

Henry
Jeg vet at de kan bedre ja. Sånn underyting syns jeg ikke noe om, de må...

Hanna
No, if it is negligence and carelessness that means that it doesn't look good, then I think we must tell them that this is not good enough, you can do this better.

Hanna
Nei, hvis det er travelhet og slurv som gjør at det ikke blir fint, så syns jeg at da må vi si at det er ikke bra nok nei, det klarer du bedre liksom.

[P9: 312 - 323]

Both Henry and Hanna convey that they intervene with pupils, not primarily to improve the quality of the products, but to improve the pupils' effort – or even to improve the *'quality of the pupil's agenda'*.

These teachers approval of the pupil's agenda in their learning process is also highly visible in how Hanna reflects on the dynamics of pupils' group work, in this case related to a project of building constructions from paper tubes:

Hanna
What I have noticed with the paper tube constructions, is that it is customarily one or

Hanna
Det jeg har lagt merke til med akkurat den biten med rørkonstruksjoner, er at det er som

two who have many ideas and have in a way “we do it like this and we do it like that”, and we have one or two who are quite happy with making the paper tubes, they roll paper and deliver to the ones who construct, so I would like to have all engaging more with the construction task, but it is not always easy, because those who make the tubes in fact find themselves quite satisfied with it!

BB

They have a ‘factory’ that functions!
(...)

But then you may get, even if the group functions as such a ‘factory’, that if the same ones who sit and roll paper or do that kind of work, then they don’t really face any challenges.

Hanna

Yes, I see nothing wrong in that some sit and roll if they are satisfied with doing so, but there have been cases where they say that “oh, I am not allowed to participate in the constructing, I am left with making the tubes” in a way. Then I feel that the adult needs to intervene and tell them to assign the parts somewhat, and let the others contribute to the construction, because it is not right if they are not happy just sitting there making tubes, that they have to do it, then the leader is too dominating, in always doing it him/herself, that will not be right.

regel en eller to som har veldig mye ideer og har liksom ”sånn gjør vi og sånn gjør vi”, og så har vi den eller de som er såre fornøyd med å sitte og rulle, ruller og leverer til dem som bygger, så jeg kunne tenkt meg å fått med alle mer i selve konstruksjonen der, men det er ikke bestandig like enkelt, for de som sitter og ruller de syns jo egentlig de er fornøyd med det og!

BB

Da har de en ‘bedrift’ som fungerer!
(...)

Men da kan du jo få at, selv om gruppa fungerer som en sånn ‘bedrift’, at hvis det er de samme som sitter og ruller rør eller gjør sånn type arbeid, så får de aldri prøvd seg helt.

Hanna

Ja, jeg ser jo ikke noe galt i at det er noen som sitter og ruller hvis de er fornøyd med det, men det har jo og vært tilfeller der de sier at ”åh, jeg får ikke hjelpe til å bygge, jeg må lage bare rørene” liksom. Da føler jeg at da må den voksne gripe inn og si at nå må dere prøve å fordele rollene litt og la den få lov til å gjøre litt på selve byggverket, for det blir jo ikke riktig hvis de ikke syns det er noe artig å sitte bare å lage ruller, at de må gjøre det, det blir jo ikke riktig, da blir den jo for dominerende den lederen da, som hele tiden skal gjøre det selv, det blir jo ikke riktig.

[P9: 527 - 559]

Hanna conveys that she is concerned about the phenomenon that some pupils are left with dull work in the projects, as the leaders become too dominating in doing the real task themselves. However, she sees nothing wrong with this labour division as long as the ‘paper rollers’ are happy with the situation. The situation turns into a problem only if it is at odds with these pupils’ agenda.

The above represents fostering the pupil’s individual agenda in terms of what defines the end and the criteria of success within technology projects that the teachers present to pupils. This may be seen as reflecting what Zuga (1989) has conceptualised as a personal curriculum design. The educational thinking is also found to operate in a broader sense among the teachers. David holds a rather radical view of what compulsory education should be about, in accordance with the experimentation with implementation of new ways of working at school D (see Appendix 1 for a brief description). He expresses that cultivation of pupils, in the

sense of identifying and supporting potential agendas for them, is an essential task for compulsory education:

David

It is about catching the pupils on what they are good at, we must look for where the individual pupil has his or her potential for development. And apparently, for many pupils that has to do with technology! Or, let us say, with practical things, with handiness, with... Many of these boys who are tired of school, because they cannot stand theory, doing things like this is absolutely perfect for them.

David

Det handler litt om å fange elevene på det elevene er faktisk bra til, vi må være ute etter hvor den enkelte eleven har sitt utviklingspotensiale. Og det er klart, for mange elever så handler jo det om teknologi! Eller la oss si, om praktiske ting, om fingerferdighet, om... Mange av disse guttene som kopler ut fra skolen, for at de ikke makter teori, det er jo midt i smørøyet når du holder på med såne ting som det her.

[P14: 301 - 306]

David's argumentation about 'catching the pupil' can be understood in terms of the *political argument* (Layton 1993) for technology teaching. School D is situated in an area with many social problems, and a high frequency of pupils have motivational and behavioural problems and are at risk of getting into larger problems such as criminal behaviour or drug abuse. In order to 'catch' them and motivate them, David sees it as important to let them engage in what they are good at – whatever it is:

David

Those pupils should have been allowed to work more with the things they are clever at, in order to motivate them. We have seen in the technology projects that it is the pupils who are the weaker ones theoretically who flourish within practical... things, and that it has a infectious effect.

David

De elevene skulle fått jobbet mer med ting de er flinke til, for å motivere dem. Det har vi sett i de teknologiprojektene også at det er elever som i utgangspunktet er svakere teoretisk som blomstrer innenfor praktiske... ting, og det har en smitte-effekt.

[P3: 528 - 531]

David's fostering of the pupil's agenda also involves making pupils active in *creating* their agenda. This means to challenge and contest some pupils' negative and apathetic attitudes, which David describes below by imitating a conversation with one of them:

David

Some are simply just negative, they do not want to try anything, they just want to do nothing. You can talk to them, and they tell you that the best is simply to sit and relax. One of our goals is just to [make them] see "*but what about in the long run?*", right. When you challenge them on "*well, what do you think, what do you think about just sitting there?*" - No, that's top, right. - "*But does it make anything happen?*" No... it is boring. To make them understand that ok, they may

David

Noen er rett og slett bare negative, de har ikke lyst til å prøve noe nytt, de vil bare gjøre ingenting. Du kan snakke med dem, og de sier at det beste er bare å sitte og slappe av. Et av målene våre er bare å [få dem til å] se at "*jammen i lengden da?*" ikke sant. Når du begynner å gå inn på "*jammen hva syns du da, hva syns du om bare å sitte der?*" - Nei, det er topp, ikke sant. - "*Jammen skjer det noe da?*" Nei... det er kjedelig. Få dem til å skjønne at greit, de kan godt skape seg en

perfectly well make school very boring, that is very easy. "But give it a try, try something you initially didn't believe was alright, give it a try!"

veldig kjedelig skole, det er veldig lett. "Men prøv da, prøv noe du trodde i utgangspunktet ikke var alright, prøv litt!"

[P3: 1001 - 1009]

The need for making those pupils create an agenda constitutes an important base for David's teaching of technology as well as his teaching more generally. This implies that his teaching aims at exposing pupils to a range of different domains of activities in order to make them discover *something* they might find interesting to go on with. One example of such a domain is the one of building and flying glider models. Through this project, he provides the pupils with experiences which might initiate and stimulate their interest in this direction. He points to the possibility of making flying represent parts of the pupil's curriculum in lower secondary school:

<p>David (...) You can in fact start taking flying lessons at age 15. So in fact it could be possible during lower secondary school for some to decide that "I want to work more with this", that flying as a project in fact could be the pupil's main subject. "I want to make more out of things with the aeroplane", right. And it might be taken as far as going on an excursion to the airport, to visit the aeroplane society, one might as time goes by in fact take flying lessons on gliders. Before having finished lower secondary school, on a glider.</p>	<p>David (...) Du kan faktisk begynne å ta flytimer på seilfly som 15-åring. Så faktisk så vil det kunne ligge muligheter i løpet av ungdomstrinnet til at noen velger at "det her har jeg lyst til å gjøre mer med", så flyvning blir faktisk elevens prosjekt som fordypning. "Jeg vil gjøre mer ut av det her med flyet, jeg", ikke sant. Og da kan det være faktisk så langt som å fare ut på Værnes på ekskursjon, besøke flyklubben, etter hvert komme så langt at en faktisk tar flytimer. Før en er ferdig med ungdomskolen altså, på seilfly.</p>
---	--

[P3: 977 - 984]

In David's scheme of cultivating the pupil, technology teaching this way plays the role of providing pupils with experiences that may assist them in creating their own agenda. This shows parallels with the concept of 'opening doors' that was earlier discussed within the economic argument and the need teachers see for pupils to experience what technological work means in order to do informed career choices. David's way of 'opening doors' for pupils does, however, operate on a much more general level, where technology represents one of the 'doors' that might be opened, not only into technological careers but also into a meaningful life.

Maintaining general educational goals

When reflecting on what pupils may gain from technology teaching, many of the teachers in this study emphasise the potential of technology teaching in fulfilling educational goals that are rather general in nature. They point to how technology teaching can contribute to the development of pupils' interpersonal abilities such as co-operation skills and ability to plan and structure their work together.

To some of the teachers, the potential of technology teaching in cultivating pupils by developing their interpersonal abilities appears to be the dominant one of how they perceive the aims of technology teaching and in how they realise technology teaching related to the TiS project. For example, Henry describes how he utilises projects in technology, such as the building of paper towers, as an opportunity to train pupils in group work and co-operation. He invites them to reflect on the conditions for success in group work and the importance of everybody's constructive contribution in the group:

Henry

We usually have an evaluation after the session, where they explain how the group functions, the co-operation. Because I see it as rather important that they manage to co-operate when they are in group processes, and it is not to be about individuals, rather they have to tell whether the group functioned, they are not to say that specific persons have not done their job, rather it must be that the group didn't work well, that they have not managed to do any-thing else because of too much goofing off perhaps, or that they chose the wrong approach for that sake.

BB

So that is also part of the aim -

Henry

- I think it is rather important, at least with the co-operation, that they should learn to co-operate.

Henry

Vi har pleid å ha en slags evaluering etter økta, der de forklarer hvordan gruppa fungerer, samarbeidet. For det setter jeg som ganske viktig at de skal klare å samarbeide når de er i gruppeprosesser, og da skal det ikke gå på enkeltpersoner men de må si om gruppa har fungert, så de kan ikke si at den og den ikke har gjort jobben sin, men det må i tilfelle være at gruppa har ikke virka, at de har ikke fått gjort noe annet på grunn av mye tull kanskje, at de har kanskje tatt en feil løsning for den del.

BB

Så det er også en bit av målsettingen -

Henry

- Jeg syns det er ganske viktig, i hvert fall det med samarbeidet, at de skal lære seg å samarbeide.

[P9: 512 - 526]

Henry maintains that learning to co-operate acts as an important aim for technology teaching. Other teachers convey that, though this was not an intention initially set for technology teaching, they have discovered how technology projects contributes to the attainment of general educational goals such as development of co-operation skills:

Irene

(...) And what we saw, was that the pupils became so kind to each other, they became helpful and they asked and got answers, got help and made plans, who does this and who does that and socially it became very good. That those being weak in ordinary lessons, theoretical subjects, they could show other sides of themselves. And as I said, that they even could take the lead position of the group and organise the entire work.

Irene

(...) Og det vi så, det var jo at elevene ble så greie med hverandre, de ble hjelpsomme og de spurte og fikk svar, fikk hjelp og planla, hvem gjør det og hvem gjør det og sånn sosialt sett så ble det veldig bra. Altså det at de som var svake i vanlige timer, teoretiske fag, de fikk jo da vist andre sider ved seg selv. Og sånn som jeg sa, at de til og med kunne jo da ta overtaket og bli en slags leder på gruppa og organiserte hele arbeidet.

BB
That they didn't usually do?

BB
Som de ikke pleide å gjøre?

Irene
Yes, usually they were just quiet and anonymous in class, because they knew they would not succeed in Norwegian and Maths. Suddenly there appeared a completely new arena for them.

Irene
Ja, til vanlig så var de jo bare helt sånn stille og anonyme i klassen, for de visste at de kom til kort i norsk og matte. Plutselig her så var det en helt ny arena for dem.

[P16: 132 - 132]

According to Irene, technology projects have improved the atmosphere in her class and made pupils more able to organise their work and co-operate better. She also points to how technology teaching can benefit pupils of low academic ability and this way contribute to social equity. She describes technology teaching as 'a new arena' where pupils who do not succeed in academic subjects are given the chance to keep up with the others. Her concern for these pupils parallels the view presented by Benny in the Second story – that technology teaching benefits pupils who struggle with traditional school subjects as it provides them with opportunities to demonstrate their abilities in other directions.

The interpersonal abilities pointed to by teachers above are of course always part of what teaching in compulsory school aims at. The teachers do, however, emphasise the advantage of the type of technology teaching they have become acquainted with through the TiS project for the advance of such abilities, due to the fact that material products are expected as a result of the technology projects. This challenges and exposes the pupils' ability in co-operation and structured work more thoroughly than is the case with many of the other activities pupils undertake in school.

Summary and concluding remarks

This chapter has explored the aims teachers participating in the TiS project formulate for technology teaching, and how these aims are reflected in their realisation of technology teaching related to the project. The exploration departed from the set of arguments for technology teaching reviewed in Chapter 3. Though elements of these arguments can be identified in how teachers formulate aims for technology teaching, it is found that the teachers' aims in many cases go beyond those that can be derived from the arguments or other 'typologies' found in literature on technology education. The aims expressed by the teachers in this study have hence been conceptualised within categories developed on the basis of interpretations of empirical data themselves. These aims tend to exceed the official aims set for the TiS project as well as aims that one would associate with the subject Design & Technology that have functioned as a model for the introduction

of technology as a subject of teaching in Norwegian schools. Rather than being imparted by the project or by the ideas from Design & Technology conveyed by the project, the aims appear to be the teachers' 'own', and can be interpreted as a manifestation of the teachers' professional frames (Barnes 1992) for teaching. The TiS project, earlier in this thesis interpreted as an activity account, partly serves as a tool for the participating teachers in fulfilling their own aims for technology teaching. This interpretation will be further explored in later chapters, which will reveal how technology teaching associated with the TiS project is utilised by some teachers in pursuing an agenda for educational change on a yet more fundamental level.

The aims conceptualised in this chapter are different in character. Some have their focus on introducing pupils to technology as *knowledge*, both the knowledge possessed by a professional technologist and knowledge relevant for the pupils as members of a technological society. Other aims have a strong focus on the pupil's individual development in other regards, where knowledge associated with technology and how it can be appropriately presented to pupils appear peripheral. The category of aims denoted 'Cultivating the pupil' captures this focus on the pupil in its outermost form, and examples are given on how teachers see technology teaching as contributing to pupils' emotional development as humans and to their acquisition of interpersonal skills.

These differences in focus can also be found between the individual teachers that act as cases in this study. However, a disparity between 'subject-centered' and 'pupil-centered' curricular thinking can not be found between the teachers or the aims they express for technology teaching. Nor is the difference essentially due to differences in how epistemic features of technology are perceived. Rather, the differences between the teachers can more aptly be described as differences in the *role* they assign to knowledge in the technology classroom.

The various roles of knowledge in technology teaching can be illuminated by revisiting the four previous stories. In the First story Ann's technology teaching was described as containing a significant component of practical skills and conceptual knowledge taught in an apprenticeship manner. She did not, however, essentially see this component as representing learning objectives for pupils. Rather, the knowledge and skills functioned as *tools* in her ultimate aim of cultivating the pupil by letting them create products they could be proud of. Knowledge and skills are seen as *prerequisites* for the technical quality that is required to fulfil this aim. The teacher-led nature of Ann's teaching also appears to be consistent with her demand for technical quality.

In Benny's technology teaching presented in the Second story, knowledge plays a different role. To him, cultivating the pupil implies leaving the structuring of the project and the criteria of success to the individual pupil's decision. This means that the pupil is given the opportunity to *exhibit* and *develop* the knowledge he or she already possesses. Though an outcome of specific knowledge is not a pre-defined feature of Benny's curriculum, knowledge is also seen as a *result* of the teaching by way of pupils interacting independently with the broadly defined task and the materials available.

In the Third story Eric conveyed a picture of 'the pupil as technologist', and gave a rather articulated view of the elements of technological knowledge. Eric's overall aim for his technology teaching is to give pupils access to this domain of mainly practical knowledge. As a component of the experience of '*being a technologist*', this knowledge functions as a '*door-opener*' for pupils into possible careers in technology.

Finally, the Fourth story showed how Frederic has identified conceptual knowledge as intended learning outcomes in technology teaching. Like in Ann's teaching, this knowledge plays the role of a tool in cultivating the pupil by letting them create high quality products and thus nurture their pride and self-esteem. However, the effort he makes in identifying a knowledge base of technology and learning objectives related to it suggests that an aim of familiarising pupils with this knowledge operates *in parallel* with his broader aim of cultivating the pupil.

The various roles assigned to knowledge in the technology classroom represent various expressions of the teachers' focus on the pupil. They are all based on the teacher's considerations of how pupils may benefit from technology teaching in a broader sense than can be captured by specific learning objectives. In their approaches, the pupils' benefit stems from *exposing* their knowledge, *acquiring* knowledge or from *utilising* technological knowledge in their activities, respectively.

CHAPTER 10

FRAMING THE SUBJECT

The foregoing chapter has given an analysis of the *aims* teachers in this study assign to technology as a new subject area in the curriculum. The presentation of aims has also revealed aspects of how the teachers perceive what can perhaps be captured by the common, but rather elusive, notion ‘*content*’ of the technology teaching. The present chapter addresses more systematically how the teachers participating in the TiS project perceive technology as a curricular subject to be *about*; what it embraces, its underlying structure and how it relates to the other subjects in the curriculum. This also includes what they see as essential ideas in the subject Design & Technology and how they respond to these ideas.

The title of this chapter, ‘Framing the subject’, may be read as referring to the well-known metaphor of defining what belongs to the picture and what is defined on the outside. Though this reasonably covers the issues dealt with in this chapter, the title is also meant to refer more specifically to the conceptual tools developed by Bernstein (1971) and referred in Chapter 3. These tools, developed for analysis on a systemic level of education, will be used for the purpose of analysing perceptions expressed by the individual teachers in this study. How do the teachers identify what ‘may be taught’ within technology as a distinct subject, that is, how do they *frame* the subject they are creating? And further, how do they see the structure of contents of technology teaching and the relationship to other subjects?

The TiS project itself can be seen as formulating an extremely weakly framed subject, as there are no strong boundaries for what belongs and what does not belong within teaching related to it. The participating teachers thus have a corresponding freedom in choosing what to teach within technology as a subject, and one might argue that the notion ‘may not be taught’ is irrelevant in this case. However, the concept of framing is relevant for how the teachers *perceive* technology as a subject. As will be shown, most of the teachers express some conception of *boundaries* for what ‘may be taught’ and ‘may not be taught’ in how they look upon technology teaching, and that there are some common patterns as well as differences in the boundaries they make.

What does ‘technology’ embrace?

The teachers’ identification of what technology teaching entails is not merely a product of ideas presented to them in an educational context such as the TiS project; it is also found to be influenced by their initial comprehension of what the concept of ‘technology’ itself means. In turn, it appears that participation in the TiS project has influenced their conception of ‘technology’. Examples of both will be shown in the present and in the subsequent sections.

How do the teachers assign activities to what may, or respectively may not, be taught in technology teaching? Analysis of data in this study has identified one specific implicit criterion the teachers participating in the TiS project often use for assigning teaching activities to what they perceive as ‘technology teaching’. This criterion is related to what the teachers see as genuine ‘technological’, and it appears that the essence of this concept is some kind of *physical movement* related to human-made objects. Physical movement may typically be represented in the moving devices of a mechanical toy, the buggies that moves by means of inflated balloons, electrical movements in electronic circuits and in the induced movement of a projectile that is the function of the siege machines. Products may also be ‘technological’ in that they carry a *potential* of (often unwanted) physical movement, as is the case with bridge models and towers made from paper tubes. This corresponds in some sense to how Raat and de Vries (1987) have described the general characteristics of technology; formulating technology as concerned with an alteration in shape and / or position of the three pillars matter, energy and information. Their formulation of *alteration* corresponds to the criterion of *movement* in the teachers’ perception of what ‘technology’ means. However, the teachers’ criterion appears to apply to the artefact *itself*, that is, movement must be associated with the technological product, not only with technological processes that the product results from.

This interpretation of what the teachers see as genuine ‘technological’ is warranted by what they *exclude* when they identify technology as a subject of teaching, that is, how they frame the subject by conceptualising boundaries towards ‘what may not be taught’ in technology teaching. One example of how physical movement arises as a criterion of technology teaching is found in how Hanna and Henry undertake a project with their pupils in grade 5 and 6 on making a mirror frame. The mirror frames the pupils create are to have a mechanism that makes the frame stand upright on the table. When some pupils wish to have their mirror hanging on the wall – not an unreasonable placement of a mirror – and thus intend to refrain from constructing the mechanism, the teachers intrude and state that the frame still needs to have the mechanism. They describe the situation this way:

Henry

Some in my class said they didn't want to have a standing mirror, they wanted to hang it on the wall. But of course, then one ought to decide that they can hang it on the wall when they come home, but it must be possible to make it stand upright also. I think the requirements we set were important. (...)

BB

And then it becomes a more technical thing also, than just...

Henry

Yes, (...) because then they would only have the design part really, if they didn't make the things on the backside. It needs to function also. So it is handy that they see that it works.

BB

And if you were to hang it on the wall, it would always "work"?

Henry

Yes.

Hanna

Yes, to fasten a little loop is no problem, everyone can do that, so that is no challenge.

Henry

Noen hos meg begynte å si at vi skal ikke ha speilet stående likevel, vi vil henge det på veggen. Men det er klart, da må en jo bestemme at dere kan få henge det på veggen når dere kommer hjem, men det skal være sånn at det skal gå an å sette det opp og, stående. Jeg synes det er viktig med de kravene vi stilte. (...)

BB

Og det blir på en måte en mer sånn teknisk ting også, enn akkurat det...

Henry

Ja, (...) for da hadde de nesten fått bare designdelen egentlig, hvis det ikke hadde blitt det bak. Så det må jo fungere det og. Så det er greit at de ser at det virker.

BB

Og hvis du skulle henge det på veggen så ville det jo alltid kunne "virke"?

Henry

Ja.

Hanna

Ja, det å sette på en liten hempe er jo ikke noe problem, det klarer jo alle, så det er jo ikke noen utfordring.

[P9: 241 - 265]

The support mechanism of the mirror frame represents a potential of movement, and thus makes the activity belong within 'what may be taught' in technology teaching. Without this mechanism, Hanna states that the activity would not represent a challenge for the pupils. 'Challenge' must here be understood within the technological context, as making and decorating the frame surely could challenge pupils' skills and creativity in a different sense. This, however, is something Henry in the above quotation denotes the 'design part' of the activity, where 'design' thus appears to be associated with the aesthetic appearance of the product. Without the potential of movement the support mechanism represents, the activity would be considered as belonging to 'design', but not to 'technology' in these teachers' view.

One element of content associated with the TiS project is activities on moulding artefacts from plastic. The resulting artefacts from these activities do not always meet the criterion of movement or potential of movement in the artefact itself (though it *might*, in cases where the plastic objects are chassis for buggies or covers for electronic circuits). The reason why plastic moulding is still seen as 'what may

be taught' in technology teaching might be that it represents a new element in the curricula of Norwegian schools. It is not already covered by the subject Art and Crafts, and is thus 'available' for inclusion in a new subject. However, it is found in this study that some teachers question the placement of certain activities involving plastic moulding within technology as a subject. This is evident in the quotation below, where Irene expresses her impression of the subject Design & Technology taught in England and Wales:

Irene

I found it very much like Art and Crafts, really, more than technology perhaps, or more like... I am thinking of the books they made with a plastic cover. That is design, I mean, what was technology there?

Irene

Det var jo veldig mye kunst og håndverk, tenkte jeg på da, altså mer enn teknologi kanskje, eller mer sånn... Jeg tenker på de der bøkene de lagde med sånn plast utenpå. Det er jo formgivning, altså, hva var teknologi der?

BB

You think of it as two different parts?

BB

Du tenker på det som to ulike deler?

Irene

No, well, if we are to weight it now. And the subject is denoted Technology and Design, it was a greater share of design than of technology. (...)

Irene

Nei, altså, hvis vi skal vekte det nå. Og faget heter teknologi og formgivning, så var jo det en større bit av formgivinga enn av teknologien. (...)

BB

It is not technical?

BB

Det er ikke teknisk?

Irene

No.

Irene

Nei.

[P16: 490 - 508]

Irene refers to an example of students' work where they had designed and made plastic covers for notebooks as a project in Design & Technology, and she asks the rhetorical question: "*What was technology there?*". Her standpoint of questioning the activity as 'what may be taught' in technology may be assigned to the fact that the activity in question fails to meet the criterion formulated above, the one of movement or potential of movement associated with the product itself. The same argument might apply to a specific activity presented to the teachers during the course they attended. They were designing and making a board game by means of CAD software, which was transferred to a bag manufactured from textile. The teachers rarely have access to this software, but the activity can easily be modified by drawing the game board manually or by other means. When attending the course, the teachers expressed enthusiasm about the activity, yet none of them were observed to apply it as part of their technology teaching at their schools. Was it not seen as 'technological' due to lack of movement associated with the product?

The subject Design & Technology that the teachers have become acquainted with through the TiS project contains a component denoted ‘food technology’. Though this component was not represented at the course the teachers attended, many of them are well aware of its presence in the subject. Many teachers find the idea of embracing working with food under the headline of ‘technology’ unfamiliar, as it does not fit with what they associate with the concept of technology itself. This arises for example in an interview with David, while he reflects on how he would like to see technology as a future curricular area in Norwegian schools:

David

I would have strengthened the subject as a subject area within art, that design within art is to be emphasised, and everything that relates to technology, I mean things like electronics, or technology, is heavily emphasised within Science. And my opinion is that if you take a look at what is present there, in Science, you will find a great deal of technology, within several areas, such as medicine and...

BB

That is technology also?

David

Yes, it is partly so, it depends on how you define it. Some talk about technology even within food. But I don't think that way, to me that is not technology.

David

Jeg hadde villet styrket faget som et fag-område innenfor forming, at design innenfor forming skal vektlegges, og alt som har med teknologi, altså ting som, altså elektronikk, eller teknologi, blir også vektlagt kraftig innenfor naturfag da. Og det mener jeg hvis en går tilbake og ser på hva som ligger der, i naturfag, så ligger det helt klart en del teknologi, innenfor flere områder, når det er snakk om medisin og...

BB

Det er også teknologi?

David

Ja, delvis så er det jo, det spørs jo hvordan du definerer det da. Noen vil jo snakke om teknologi innenfor mat, til og med. Men jeg tenker ikke det, for meg er det ikke det da.

[P3: 1110 - 1123]

David's conception of ‘technology’ embraces medicine, which he mentions as an example of technological topics within Science as a school subject. He does, however, see it as a matter of definition whether ‘technology’ embraces this field. When it comes to ‘food technology’, he is more clear, though he is aware of the use of this concept he refuses to consider ‘technology’ as embracing the making of *food* products.

In realising technology teaching at their schools, the teachers utilise many of the specific activities that have been presented to them through the TiS project. Their selection from the ‘activity account’ provided is, however, not arbitrary. It appears from the above that the teachers’ initial comprehension of what technology means, indicated as related to movement associated with the product itself, has been acting as a *filter* for what the teachers adopt in their technology teaching. This filtering process contributes to a transformation of ideas inherent in the subject when transferred into Norwegian classrooms.

Framing technology towards existing subjects

The teachers' identification of technology as a subject also involves a comprehension of boundaries or other kinds of relationships to existing subjects in the curriculum, and is hence affected by how these subjects are already framed. The preceding example of teachers who exclude food technology from 'what may be taught' in technology teaching can thus be assigned not only to how they perceive the meaning of 'technology', but also to the fact that food technology may be seen as already covered by the subject Home economics. In the following, we will take a closer look at how some of the teachers in this study conceptualise relations between contents of technology teaching and other subjects in the curriculum.

Art and Crafts

A major part of the technology teaching the teachers create from the TiS project is structured around activities where pupils make or study *artefacts* and thus carry a comprehension of technology as human-made *objects*. As will be shown later, some teachers also express a comprehension of technology as the *process* resulting in those artefacts. Both these conceptions of technology make it relevant to consider how the teachers conceptualise a boundary between their technology teaching and Art and Crafts, a subject that also entails the creation of artefacts.

In the quotation to follow, Irene gives a description of the boundary between Design & Technology and the traditional subject of 'sløyd' (see Chapter 3) where she relates this boundary to *design*. She uses a project she has been running with her pupils on designing and making chairs out of wood as an example:

Irene
['Sløyd' involves making things]. But that is not technology, in a way.

BB
Where is the border between 'sløyd', or Art and Crafts and -

Irene
- Well, when our pupils made those chairs, then I thought that was Technology and Design, because earlier, if I made chairs, then it would be, I would perhaps give them a drawing, and told them to build it, a shelf or whatever. And they would not need to think, they just made it, hammered and nailed and completed it. But now, first needed to draw a chair, they were to, yes, design a chair, in perspective. And Norwegian pupils and teachers are not used to that. Perspective, and

Irene
[På sløyden lager de en del ting]. Men det er liksom ikke teknologi, på en måte.

BB
Hvor går grensen der mellom sløyd, eller kunst og håndverkfaget og -

Irene
- Altså, når elevene våre laget de stolene, så syns jeg egentlig at det var teknologi og formgivning, fordi at tidligere, hvis jeg skulle laget stoler, så hadde det vært, de hadde kanskje fått en tegning, og sagt at "Nå lager du denne", en hylle eller hva som helst sånn. Og så slapp de å tenke, og så bare laget de den, hamret og spikret og ferdig med den. Mens nå, så måtte de først tegne en stol, de måtte lage, ja, designe en stol da, i perspektiv. Og det er ikke norske elever eller lærere

these things with ratios, and they were to make a model out of cardboard. And then they discovered, when they started to make that model, that this won't work! Something is wrong, it is not steady enough here, or, I thought three legs and that won't work, because then it will turn over like this, they saw it, right. And then they modify it and adjust it so and so, and then they start with it, in wood. And then it is joints, ways to join things together. Should there be screws, should it be supported, are there to be pegs and so on. And it results in completely individual chairs, and then you need to consider wood and the properties of wood, right.
(...)

BB
But that was to you something you call 'technology', and not 'sløyd' in a classical sense?

Irene
Yes. Technology and Design. Technology, that is the things about figuring out solutions and forces and... what is steady and not steady and... When you are to fasten a leg, you cannot really just nail it up like this, "Will that be steady? It will just fall off", right.

flinke til. Perspektiv, og så var det der med målestokk da, også skulle de lage en modell i papp. Og så så de jo da, når de begynte å lage den modellen, at det her går jo ikke an! Her blir det noe feil, her er den ikke stødig nok eller altså, jeg tenkte tre bein og det går jo ikke an, for da vil den jo bikke sånn, så de jo, ikke sant. Og så modererer de det og tilpasser det og sånn og sånn, og så går de i gang med det, med tre. Og så er det jo da liksom sammenføyninger, måter å gjøre det på. Skal det skrus, skal det støttes opp, skal det være noe plugger og sånn og sånn. Og da er det jo helt individuelle stoler som blir laget, og da er det litt med tre og treets, holdt på å si, egen-skap da, som man må se på, ikke sant.
(...)

BB
Men det ble for deg noe som du kaller 'teknologi', og ikke 'sløyd' sånn på klassisk vis?

Irene
Ja. teknologi og formgivning. Teknologi, det er jo det der med å tenke ut løsninger og krefter og... hva er stødig og ikke stødig og... Når du skal sette på et bein, du kan ikke egentlig bare spikre det opp sånn, "Vil det være stødig? Det vil jo bare løsne", altså.

[P16: 343 - 382]

Though pupils create things in the traditional area 'sløyd' within Art and Crafts, Irene is reluctant to assigning these activities to technology, in accordance with how Sjøberg (1995) has maintained that 'sløyd' may be seen as an 'opposite' to what is understood as 'technology' in Norwegian schools. The quotation exhibits that Irene distinguishes Design & Technology from Art and Crafts by the presence of a *design component*, by which she means that pupils have to figure out solutions for the construction on their own. Noteworthy, the criterion of movement or potential of movement is met in Irene's example, as she refers to the need for making the chair construction *steady*.

Frida also conceptualises a boundary between technology teaching and Art and Crafts. She directs technology teaching more towards Science and Mathematics:

Frida
[We need ideas for projects] that links it to Science and Mathematics and that is not a task within Art and Crafts. We do wish to make a distinction from Art and Crafts,

Frida
[Vi trenger ideer til prosjekter] som knytter det opp mot realfagene og som ikke er en formingsoppgave, altså kunst- og håndverksoppgave. Vi ønsker jo å skille det fra kunst

otherwise it could have been included in that subject. So, therefore, at some of the courses we have been, that is the English variant is much design and art that I feel belong naturally in our subject Art and Crafts. When we are doing projects, it should be an element of technology, that is, mechanics or electronics or something. It needs to be distinct from the Art and Crafts subject.

og håndverk, ellers kunne det jo inngått som en del av det faget. Så derfor, på noen av de kursene der vi har vært, altså den engelske varianten er jo mye design og mye form-giving som jeg føler er naturlig i vårt kunst og håndverksfag. Når vi skal ha prosjekter så bør det være et element av teknologi, det vil si mekanikk eller elektronikk eller sånn. Det må skille seg fra kunst og håndverksfaget.

[P7: 377 - 385]

Frida calls for technology projects that distinguish themselves from what could be undertaken within Art and Crafts. Technology teaching should hence involve “mechanics, electronics or something” which she denotes “an element of technology”. This conception of technology is in accordance with her wish for relating technology teaching closer to Science and Mathematics than what is the case with Design & Technology in England and Wales. It also reflects the focus on these subjects in the policy for the TiS project presented in Chapter 6. Compared to the link she makes to Science in technology teaching, she associates the ‘original’ Design & Technology as more related to design, which she conceptually allocates to the subject Art and Crafts in Norwegian schools.

Social Studies

The importance of technology as part of society and history makes it relevant to see technology as a subject in relation to the subject Social Studies. The interaction between technology and other parts of society is not found to be at focus in the technology teaching observed in this study, though it is represented in one of the official aims for the TiS project. Below, Frederic is challenged to reflect on what this aim, “to place technology in a historical and societal context”, entails:

BB

But what do pupils need to know about, in a way, technology in a historical and societal context?

BB

Men hva trenger elevene vite om, liksom, teknologi i historisk og samfunnsmessig sammenheng?

Frederic

Yes, what one thinks of is to understand the industrial revolution, and see how society changes related to technological inventions and innovations, and what it means for our lives, and what it has meant, and how... yes. How have all the technical things we have got in the home affected family conditions and home conditions, try to understand that.

Frederic

Ja, man tenker jo på å forstå den industrielle revolusjon, og hvordan samfunnet endrer seg i forhold til teknologiske oppfinnelse og nyvinninger, og hva det betyr for livet vårt, og hva det har betydd, og hvordan... ja. Hvordan har alle de tekniske tingene vi har fått i hjemmet påvirket familieforhold og hjemme-forhold, prøve å forstå det.

BB

Do you address these issues with pupils?

BB

Tar dere opp det med elevene?

Frederic
Well, I don't have that much Social Studies, but at least, it is, the industrial revolution is absolutely there.

BB
So that will be Social Studies?

Frederic
That will be connected to Social Studies, yes.

Frederic
Nå har jo ikke jeg så mye samfunnsfag, men i hvert fall, det er jo, den industrielle revolusjonen er jo absolutt med.

BB
Så det blir samfunnsfag?

Frederic
Det blir jo knyttet mot samfunnsfag.

[P10: 327 - 350]

Frederic points to the impact of the industrial revolution on society and human life as an example of what the aim means. However, when he is asked whether this aspect of technology forms part of his technology teaching, Frederic exhibits a view that this belongs to Social Studies, which is not his subject of teaching. Between the lines is a logic that appears to be that societal and historical aspects of technology do not belong to technology as a new subject, due to the fact that it is already present in an existing subject. This parallels the need for distinguishing technology teaching from Art and Crafts expressed by Frida in the previous section. Thus the content of existing subjects in the curriculum contributes to defining 'what may be taught' in the subject by excluding what it does *not* contain.

Science

The logic indicated above, that the contents of other subjects serve as a basis for framing technology as a subject by means of *exclusion*, does however seldom apply to how the teachers perceive the boundary between technology teaching and *Science* as a school subject. For example, while Frederic above defines social and historical aspects as external to technology teaching due to its presence in the subject of Social Studies, he wishes to make a *closer* connection to Science:

Frederic
We have gathered many ideas from England, Design & Technology, and there it is rather much design, art, in the projects. So we have to consider how, what is needed to connect it perhaps even closer to physics and that kind of technology, more mechanics. So we are in a way searching for good projects that involve mechanics in our projects than what we have done so far.

Frederic
Vi har jo hentet mange ideer fra England, Design & Technology, og der er det ganske mye design, forming, som ligger i de oppgavene. Så vi ser litt på hvordan, hva må til for å knytte det kanskje enda nærmere til fysikkfaget og til den type teknologi, mer mekanikk. Så vi er på en måte på jakt etter gode prosjekter som går på mer mekanikk i prosjektene våre enn det vi har gjort så langt.

[P7: 353 - 358]

In accordance with how Frida above framed technology towards Art and Crafts, Frederic proposes technology teaching that is more closely related to physics than

what he sees in the English subject Design & Technology. Hence the logic above is reversed, and ‘good teaching projects’ are identified as those that *include* topics from Science. This indicates that the teachers create a technology subject with a weaker framing towards Science than towards other subjects.

Taking the aims for the TiS project and NITO’s policy for the project into account, the weak framing towards Science is not surprising. As exposed in Chapter 6, a close connection to Science is signalled in that the project aims at supporting Science as a school subject and at promoting better understanding of the relationship between technology and science. How the teachers interpret these aims and relate technology and technology teaching to science conceptually as well as in their teaching hence deserves a more comprehensive analysis, which will be undertaken in Chapter 11.

Conceptions of design

In the foregoing sections, various conceptions of what ‘design’ means can be detected among the teachers. Irene used the concept for distinguishing technology teaching from Art and Crafts (pp. 175-176). She associates design with functionality and the development of technical solutions. Hence, her project on chairs was placed within Technology and Design rather than within Art and Crafts (‘sløyd’) because the project involved pupils figuring out technical solutions on their own rather than being given ready-made instructions for how to build the chair. This conception of what ‘design’ means contradicts how for example Hanna and Henry have earlier used the concept (p. 172). To them, the ‘design part’ appears to be restricted to the aesthetics of the product. The task of creating a picture frame would in their view solely involve *design* and not represent a technical task if the pupils were not to make the mechanism that makes the frame stand upright. Thus ‘design’ now signifies what remains when the technical challenge is *removed*.

The above contradiction between conceptions of design corresponds to a tension Donnelly (1992) has noted in reviewing literature on technology education and described as “a radical fracture between design understood as a component of the expressive arts, and design understood as instrumental and functional” (p. 127). However, though they use the concept ‘design’ differently, the conclusions Irene on one hand and Hanna and Henry on the other arrive at by means of this concept are identical when it comes to defining ‘what may be taught’ in (Design & Technology).

Jim encapsulates both these conceptions of design in how he describes characteristic features of the English subject Design & Technology:

BB

How will you describe the Design & Technology subject they have in English schools?

Jim

What characterises it is in a way the scientific component of technic, everything from in a way wood to metal to physics to cooking almost. Then they include one important thing, a dimension of design, that we have [not] - We do not have weak traditions for design in Norway, but we have a classic understanding of design, that is in a way directed towards craft. And here [in England] they do, it is perhaps a stroke of genius because... how should I put it, what makes it so fascinating is that you include a new dimension in working with all these things, that they should look good also. Because in the end that's what will determine the purchaser.

BB

Yes. It is not enough that it works...

Jim

No, it is not always enough that it works very well! Because the consumer is the final link, and the seller as the second final link, and have little idea perhaps of the specific technical quality of a product, but will have a feeling of whether it is pleasant to hold, or that it looks good visually. And then we see a fusion here that has, at least in a Norwegian context, not been present. They have it abroad, it is not only in England. And design is not only the facade, design is in a way simplification of construction.

BB

Yes, and functionality also.

Jim

Yes, and functionality. Instead of pushing five knobs you can do it with one, figuratively speaking.

BB

Hvordan vil du beskrive det Design & Technology faget som de har i engelske skoler?

Jim

Det som er kjennetegnet er jo på en måte den vitenskapelige biten i teknikk, alt fra på en måte tre til metall til fysikk til matlaging nesten. Så drar de inn en viktig ting, en dimensjon av design, som vi [ikke] har - Vi har ikke dårlig tradisjon for design i Norge, men vi har en klassisk forståelse av design, som går på en måte mot håndverk. Og her [i England] gjør de, det er kanskje en genistrek for... hvordan skal jeg si det, det som gjør det så spennende er at du drar inn en ny dimensjon i det å på en måte jobbe med alle disse tingene, det er at de skal se ut og. For til syvende og sist, så er det det som vil avgjøre kjøperen, i siste instans.

BB

Ja. Det holder ikke at det virker liksom...

Jim

Nei, det holder ikke alltid at det funker veldig bra! Fordi at forbrukeren står som siste leddet, og selgeren som nest siste leddet, og har veldig liten snøring kanskje på de helt spesifikke tekniske kvalitetene på et produkt, men de vil ha en følelse av at den er god å holde i, eller at den gjør seg veldig godt rent sånn visuelt sett. Og da ser en jo egentlig en sammensmeltning her som har, i hvert fall i norsk sammenheng, nesten ikke vært tilstedeværende. I utlandet så har det, og det er ikke bare i England. Og design er ikke bare fasaden, da er design på en måte forenkling av konstruksjon.

BB

Ja, og funksjon også.

Jim

Ja, og funksjon. Isteden for at du skal trykke på fem knapper så skal du kunne gjøre det på en, for å si det litt sånn billedlig da.

[P17: 170 - 205]

Jim describes design as related to the visual and physical appearance of things, and states that this aspect in the end is more important for the marketing of products than the technical aspect. He does, however, relate design to technical issues and

functionality, through what he calls *simplification of construction*. Design is the essential feature in how Jim perceives the nature of the subject Design & Technology. He describes the “stroke of genius” in this subject as the inclusion of a design dimension to subject areas such as woodwork, metal work, physics and (“almost”) cooking. He asserts that this dimension is missing in Norwegian traditions, and that our conception of design runs more in the direction of craft.

Technology as a process

As described in Chapter 3, the formation of Design & Technology as a subject in England and Wales has been marked by the conception of a design *process*. Teachers in this study also express views of technology as a process, but what this means and the implications for teaching is found to run in various directions whereof some differ significantly from what is represented by the process approach in Design & Technology.

These views of technology as a process will be presented and discussed in the following sections. Firstly, the teachers’ expressed views on technology in itself as a process will be presented. It will be shown that this represents a broadening of the technology concept, which gives rise to a learning objective for pupils that adds to those identified in the previous chapter. Secondly, teachers’ commenting upon the idea of a ‘design process’ associated with Design & Technology in England and Wales will be presented and interpreted. Finally, a process view of technology as a working method will be presented. This view implies that pupils’ *knowledge* in diverse areas is the outcome of a process they undertake in technology teaching.

The presentation and discussion of these views as they arise from the empirical data will use the Fifth story of this thesis as a starting point. The story presents how Benny introduces the unit on technology teaching described in the Second story by conceptualising technology as a process for his pupils. His introductory session to technology as a subject will be considered in some detail, and tape-recorded sections of the session as well as Benny’s own reflections upon it will be presented and interpreted.

FIFTH STORY. A SWEET INTRODUCTION TO TECHNOLOGY

As an introduction to his technology unit, Benny runs a session that draws pupils attention to what ‘technology’ means. For this purpose, he has bought one ‘Kinder Egg’ – a chocolate egg that contains a small toy or puzzle inside it – for each pupil. The class is gathered around a large table to discuss the Kinder Egg, which is a well-known product to the pupils. Since Benny has already run the unit with two groups in grade 7, the pupils in the third group, whom we will be visiting in this story, are already aware that they will be given a Kinder Egg in the first session in technology. Benny opens the session by asking if anyone has figured out *why* this rather unconventional happening forms part of technology teaching ⁶:

Benny Has anyone talked about <u>why</u> we have given out Kinder Eggs in the start-up of this topic we call Technology?	Benny Er det noen som har snakket noe om <u>hvorfor</u> vi har delt ut kinderegg i den her oppstarten på det emnet vi kaller for Teknologi?
Pupil It is for surprise?	Elev Det er til overraskelse?
Pupil It is technical to build the things...	Elev Det er teknisk å bygge tingene...
Benny Mm. It is technical to build the things inside, yes.	Benny Mm. Det er teknisk å bygge sammen tingene inni, ja.
Pupil Not if you get a completed figure!	Elev Men ikke hvis du får en hel figur!
(...)	(...)
Benny Then, what do you think of when we say the word 'technology'?	Benny Hva er det dere tenker på når vi sier ordet 'teknologi', da?
Pupil Lots of wires and buttons and...	Elev Masse ledninger og knapper og...
Pupil Computers...	Elev Datamaskiner...
Pupil Lots of fat grey wires connected to a computer.	Elev Masse feite grå ledninger som stikker ut av en datamaskin.

[P18: 24 - 51]

⁶ “Pupil” designates various pupils in the class.

Benny wants to see whether the pupils associate the Kinder Egg with technology. When one of the pupils suggests that it is 'technical' to build the object contained in the egg another objects that this does not apply in cases when the egg contains a readymade object. This leads to a loud exchange of views among the pupils, exposing strong preferences regarding the content of Kinder Eggs (not included in the quotation above). What the kids are supposed to *do* with the content of the Kinder Egg appears to be essential for whether they associate it with technology or not. Benny then initiates a dialogue with the pupils on what they associate with technology more generally. Not surprising, the pupils' responses go in the direction of computers and electronic gadgets. Following the sequence above, Benny proceeds with bringing pupils' attention back to the Kinder Egg, and explains to them that all parts of the object represent technology; the toy in the middle of the egg, the plastic container that surrounds the toy, the chocolate, the metallic foil wrapping and the cardboard box which contains three Kinder Eggs. He introduces the concept of a *process* to describe what technology is, and thus persuades the pupils that even chocolate is a technological product:

Benny
Do you associate chocolate with technology?

Benny
Forbinder dere sjokolade med teknologi?

Pupil
No!

Elev
Neei!

Benny
No. But it is. Because the word technology means... it says something about a process. From a thing is raw material, then you do something with that material, and you get a finished product. And the raw material in the Kinder Egg, in the chocolate egg, that is [reading the packaging] sugar, non-fat milk powder, fat, dried milk, cocoa butter...All those ingredients alone, mixed together, that doesn't taste chocolate. If you had taken... mixed them together completely aimlessly. They are put together following a recipe, and then it is technology. There is a technological process going on. And it corresponds to when you are in the Home economics kitchen, and... what you did last year, did you make buns for example? High-technology!

Benny
Nei. Men det er det. For ordet teknologi, det betyr... det sier noe om en prosess. Fra en ting er en råvare, så gjør du noe med den råvaren, så får du et ferdig produkt. Og råvarene i kinderegget, i selve sjokoladen, det er [leser emballasjen] sukker, skummetmelkpulver, fett, tørrmelk, kakao-smør... Alle de ingrediensene hver for seg, blandet opp, det smaker ikke sjokolade. Hvis du hadde tatt... og rørt det sammen uten mål og mening. Det er satt sammen etter en oppskrift, og da er det teknologi. Det foregår en teknologisk prosess. Og det samme er når dere er på skole-kjøkkenet, og har... det gjorde dere i fjor, bakte dere boller i fjor, for eksempel? Høyteknologi!

[P18: 266 - 283]

Benny illustrates the concept of a process by stating that the need for a *recipe* makes the production of chocolate technological. The ingredients are put together in specific and purposeful ways based on knowledge and experience. With reference to this definition, he then argues that baking is also an example of technology.

Benny's intention with this discussion appears to be to broaden the pupils' view of what technology means, from mainly electronic gadgets to a perspective on technology as a purposeful process. The following discourse, where Benny brings an example from Art and Crafts to stage, indicates that Benny has now succeeded in fulfilling this aim:

Benny Have you worked with textiles this year?	Benny Har dere hatt tekstilforming i år?
Pupils Yes.	Elever Ja.
Benny What did you do... did you make...	Benny Hva gjorde dere... laget dere...
Pupil Knitting.	Elev Strikking.
Benny Knitting? Well, is knitting technology?	Benny Strikking? Er strikking teknologi da?
Pupil Yes!	Elev Ja!
Benny It is. Then, how is knitting technology? What makes it technology?	Benny Det er det. Hvordan er strikking teknologi da? Hva er det som gjør det til teknologi?
Pupil You fumble with the loops and...	Elev Du fikler med løkkene og...
Pupil ... must have a recipe... (...) keep it going.	Elev ... må ha oppskrift... (...) keep it going.

[P18: 284 - 308]

The pupils now agree that *knitting* represents technology, and they make use of the definition Benny has introduced, the need for a recipe, in arriving at their conclusion.

The further discussion of the Kinder Egg in Benny's class encompasses a wide range of aspects of the designing, making and selling of this product. Regarding the cardboard packing, Benny points to the intricate shape of the cardboard when folded out, and discusses with the pupils how someone must have put much effort into the design of the packing. The function of the packing is also discussed, and together with the pupils Benny identifies several needs that the package fulfils: protection against breakage while transporting, easier to stack when the shape is cubic, protection from breakage and infection from customers in the store, a location for advertising and a means for making higher sales when packing three Kinder Eggs in one package. The placement of the products in a store to enhance the sale of it is also discussed.

The lesson also addresses the considerations that have to be taken into account when the toy inside the egg is designed: It must be attractive to kids, it must be made small enough to fit in the egg and it has to be kept within the economic constraint, that is, the materials and production must be cheap enough to keep the price of the Kinder Egg at the desired level. The last issue raises a new boost of pupil discussion, this time about which shop in the neighbouring area sells the cheapest Kinder Eggs. (The pupils exhibit detailed knowledge in this regard.)

When summing up the discussion, Benny attempts to bring pupils' attention to the importance of having an *idea* when you intend to develop a technological product. He uses the design of the toys inside the Kinder Eggs as example, but soon finds himself in a struggle to retain pupils' motivation:

Benny So, if we are to summarise, it is like... What is the first they need to do to before they can make a Kinder Egg figure?	Benny Så hvis vi skal oppsummere, så er det sånn at... Hva er det første de må gjøre før de lager en kinderegg-figur?
[No answer]	[Ingen svar]
Benny [Naming pupil], do you... what would you... if you were to make a Kinder Egg figure, what is the first you would have to do?	Benny [Navngir elev], har du... hva ville du... hvis du skulle lage en kinderegg-figur, hva er det første du måtte gjøre?
Pupil [other than the approached] Travelled to Kinder...	Elev [annen enn den spurte] Reist til Kinder...
Pupil [the approached] Had a computer.	Elev [den spurte] Hatt en datamaskin.

Benny
Had a computer, but there is something else I would have had before I would have that computer.

[Disturbance in class]

Benny [raising his voice]
If you were to make a Kinder Egg figure, what would you make, to ask about that?

[No response]

Benny
You get one minute, then you are to have an idea for a Kinder Egg figure, because that is the first thing. First thing in order to succeed with a Kinder Egg figure, that is namely an idea!

Benny
Hatt en datamaskin, men jeg hadde ville hatt noe annet før jeg ville hatt den datamaskinen.

[Uro i klassen]

Benny [hever stemmen]
Hvis dere skulle laget en kinderegg-figur, hva hadde dere ville laget, for å spørre om det?

[Ingen respons]

Benny
Dere skal få ett minutt, så skal dere ha en ide til en kinderegg-figur, for det er nemlig det første. Første budet for å få til en kinderegg-figur, det er nemlig en ide!

[P18: 585 - 612]

Benny announces the importance of having an *idea* for a product before he solves the motivation problem by giving pupils the task of developing an idea for a new Kinder Egg toy. The pupils then discuss, with renewed enthusiasm, possible inventions for a toy inside a Kinder Egg.

Benny concludes his session on the Kinder Eggs with an account of the next stages in the development and production of the Kinder Egg toy; making sketches, developing the details and measures, making moulds for production and (suggested by a pupil) decorating the figure:

Benny
The first the ones who make the Kinder Egg figures must (...) The first they do is, in other words, that they need to have an idea. The next is that they must draw a sketch of that idea. They must... in a way... from thoughts, down on a paper so that other can see what it is about. The third they need to do, after having drawn the sketch and maybe a drawing of how they would like to see it completed. The design study, then they need to start considering the single pieces of it (...) Because [uses a

Benny
Det første de som lager Kinder Egg-figurene må (...) Det første de gjør, det er med andre ord at de må ha en ide. Det neste de må gjøre er at de må tegne ut en skisse av den ideen. De må kunne... liksom... fra tanke, ned på et papir så andre kan se hva det dreier seg om. Det tredje de må gjøre, etter at de har tegnet den skissen og kanskje en sånn tegning av hvordan de ser den for seg fiks ferdig. Designstudiet, da må de begynne å tenke på de enkelte delene av det (...) For [bruker en figur som eksempel] Den

figure as an example] This idea, first, when they make a sketch, they need to think about... the head, should it look this way, with measures, accurate measures... what colours... The single pieces need to fit to each other, so the measures are very important. And they must make casting moulds that make the pieces fit together.

Pupil
Then they must paint it...

Benny
Then it must be painted and finished and put together to... the shape it is to have. All this is quite a number of processes!

ideen her, først, når de tegner en skisse, så må de tenke på...hodet, skal se sånn ut, med mål, nøyaktige mål... hvilke farger... De enkelte delene skal passe inn i hverandre, så akkurat målene er veldig viktig. Og de må lage støpeformer som gjør at delene passer sammen.

Elev
Så må de male den...

Benny
Så må den males og ordnes og settes sammen til ... den formen det skal ha. Alt det der er ganske mange prosesser det!

[P18: 658 - 679]

Benny's final comment suggests that pupils' awareness of the vast number of processes involved in designing and producing the small figure for a Kinder Egg represents an intention with the session. This is confirmed when Benny reflects on the use of Kinder Egg as a starter for technology teaching after the session:

Benny
I do think the Kinder Eggs are an ingenious invention. Though they have some silly advertising of it, the fact that you in fact have a thing that is so small, that is to be so cheap and that is... possible to put inside the tiny plastic box in the middle, and having a function! It is really a great deal of thinking work. So I am a bit fascinated, and... most of those buying Kinder Eggs are fascinated by the phenomenon Kinder Egg. So it is a great intro really, for the kids are enthusiastic when they just... most because they get goodies at school, but... you can use everything from innermost to outermost to say something about that it in fact... everything we are surrounded by is the result of a process. And that is what technology is, the process from raw material til it comes out as a completed product in the other end.

Benny
Jeg syns jo kindereggene er en genial oppfinnelse. De har jo en del dustete markedsføring av det, men det at du faktisk har en ting som er så liten, som skal være så billig og som skal... kunne puttes inn i den lille plastboksen i midten, og kunne ha en funksjon! Det er et ganske bra stykke tankearbeid det, altså. Så jeg er litt fasinert, og det... de fleste som kjøper kinderegg er jo fasinert av det... fenomenet kinderegg. Så det er jo en takknemlig intro egentlig, for ungene er jo ville bare de... mest med tanke på at de faktisk får 'snavel' på skolen da, men... du kan bruke alt fra innerst til ytterst for å si noe om at det faktisk... alt vi omgir oss med er resultatet av en prosess. Og det er jo det som er teknologi, den prosessen som går fra det du tar en råvare og til den kommer ut som et ferdig produkt i andre enden. Da har du jo både alt

Then you have everything from shape... and you have the chocolate, which has been the result of a technological, high-technological process in order to become that chocolate egg. Which the kids have perhaps not thought much about, really. You get the design part, you get that nutritional technology is... is also technology. The ones working in domestic occupations certainly work with high-technology! And one can say much about packaging and... that the shape of the package is not... there is nothing arbitrary anywhere. It is to be easy to produce, it needs to be solid, and... that materials are not arbitrary. So you can utilise it for making the kids aware of a number of things around them.

fra form... og du har sjokoladen som har vært resultatet av en teknologisk, høyteknologisk prosess for å bli det sjokolade-egget. Som kanskje ungene ikke har tenkt så mye over, altså. Du får inn desigbiten, du får inn at næringsmiddelteknologi er... også er teknologi. De som jobber på husmor-skolen jobber med høyteknologi, de! Og en får sagt mye om emballasje og... at formen på emballasje ikke er... det er ikke noen tilfeldigheter som er med i spillet noen plass. Det skal være lett å lage, det skal være solid, og... at materialene ikke er tilfeldig. Så du kan bruke det til å gjøre ungene oppmerksomme på en del ting rundt seg.

[P2: 233 - 255]

Benny's reflections above contain two main intentions with the teaching session worth commenting upon. Firstly, he expresses that the Kinder Egg is useful for developing pupils' awareness of technological products in their surroundings, indicating that his teaching fits in the aim of 'extending the horizon of registration' conceptualised in Chapter 9. For example, he wants to make pupils aware of the fact that the shaping of the cardboard box is not arbitrary but carefully designed according to various requirements and concerns.

Secondly, related to his comprehension of technology as *process*, Benny emphasises that the teaching may lead pupils to understand that products they previously have not associated with technology, such as chocolate, are results of technological processes. In connection to this, he claims that domestic occupations represent high-tech work. Making use of the definition of technology as a process from raw material to a product, Benny negotiates a broadening of the technology concept with his pupils.

Broadening the technology concept

The Fifth story has shown how Benny introduces his unit on technology with a discussion of what technology represents. It appears that the conception of technology as a purposeful process from raw material to a product forms a main learning objective in his teaching of this session. Compared to pupils' initial conception, this represents a *broadening* of the technology concept, accentuated by his use of the Kinder Egg for discussing the meaning of technology with pupils.

Benny's broad conception of technology is consistent with how School B as a whole approaches technology in the curriculum. Related to their participation in the TiS project, they have read the curriculum L97 with 'technological eyes', and found technological approaches to subject content within a range of subjects and across the age range. School B also arranged an 'open day' with focus on technology. There were exhibitions of pupils' work in various subject areas and also pupil performances that parents and others could visit during the afternoon and evening. The exhibitions showed, among other things, woven products, models of houses build from cardboard boxes, bridge constructions and science experiments guided by pupils. Pupils had also made baked goods for sale, referred to as 'food technology'.

Benny is aware that this broad understanding of what 'technology' and hence 'technology teaching' mean is somewhat at odds with what is commonly associated with technology. He reveals that the school has experienced reactions from parents who expect technology teaching to be more 'high-tech' than weaving mats and building house models in cardboard:

Benny

We have tried to focus on the fact that technology is more than just gadgets-and-buttons approaches to it, because that's what most people think of when it comes to technology. I have also maybe got this feeling that some parents also expected that... when they hear the word 'technology', then it should be... then it is something high-tech on its way, then the school has taken the move into the 21st century. They are maybe surprised if we present that pupils weaving mats in fact can be technology, but it... and it was actually requested, in grade one, "what is done with... the technology in grade one?" By some parents. But the project on model houses was technology as good as anything else.

Benny

Vi har jo prøvd å fokusere på at det er mer enn liksom sånn dippetutt-tilnærminger på det, for det er det de fleste tenker på når det gjelder teknologi. Jeg har jo kanskje fått følelsen av at noen foreldre også forventer at... kommer ordet 'teknologi', da er det liksom... da er det noe high-tech på gang her altså, da har skolen tatt skrittet inn i det 21. århundre. De blir kanskje overrasket hvis vi presenterer det at ungene lager brikkevev faktisk kan være teknologi, men det... så det ble vel etterlyst, faktisk, i 1. klasse her, "hva har blitt gjort med... teknologi liksom, i første?" Av noen foreldre. Men det husprosjektet var jo teknologi mer enn nok, det.

[P2: 592 - 601]

The quotation shows that Benny is very aware that not everybody shares his broad conception of technology. Again it is indicated – in the very beginning of the quotation – that this broadening of the technology concept is seen as an aim in itself in his technology teaching.

Benny's conception of the technology embracing all processes from raw material to a product, including food products, departs from how most of the other teachers in this study frame technology as a subject of teaching. It is also at odds with the earlier described criterion of movement associated with the products itself.

As earlier indicated, other teachers in this study are reluctant to include working with food products as part as what they consider as 'what may be taught' in technology teaching because food does not fit with their understanding of what technology means. The sequence below illustrates how the question of whether food products belongs in technology teaching is mediated between teachers' prior associations and reflections on what technology really means. The sequence is initiated by how Gina and Gerhard identify Science and Art and Crafts as key subjects in the teaching of technology as cross-curricular projects, and then proceeds through Social Studies to Home economics:

Gina
(...) You need to have the Science and Mathematics teachers in as key persons, and the Art department.

BB
But that's the two subjects that...

Gina
Social Studies is also - there are several subjects that are affected by it (...).

Gerhard
Home economics perhaps.

Gina
Perhaps.

Gerhard
I haven't thought about it earlier, but...

Gina
All subjects can be expanded in that direction, really, but that won't be done.

BB
But why Home economics?

Gina
(...) Du må på en måte ha realistene inn som nøkkelpersoner, og formingsseksjonen.

BB
Men det er de to fagene som blir...

Gina
Samfunnsfag er jo også - det er jo flere fag som er berørt av det (...).

Gerhard
Heimkunnskapsfag kanskje.

Gina
Kanskje.

Gerhard
Jeg har ikke tenkt over det før, men...

Gina
Alle fag kan jo utvides i den retning, kan du si, men det vil det jo ikke bli gjort.

BB
Men hvordan heimkunnskap?

Gina
Using tools and...

Gina
Bruke redskaper og...

Gerhard
The technology is not only about mechanics, it is about chemical processes and so. How to use raw materials. That can certainly be part of Home economics also.

Gerhard
Teknologien går jo ikke bare på mekanikk, det går jo på kjemiske prosesser og forskjellig. Hvordan bruke råvarer. Det kan jo kanskje komme inn i heimkunnskap-sammenheng altså.

[P8: 402 - 435]

It is evident that ‘food technology’ is not included in what Gina and Gerhard initially associate with ‘technology’. However, through the development of the discourse, they seem to come to an acceptance of that that food production could be placed under the headline of ‘technology’. They arrive at this conclusion by referring to the use of *tools* and by indicating a definition of technology similar to the one Benny has given above, that is, technology as a process from raw materials to a product. They do not, however, address food products as a result of any *industrial* process.

It seems that the broadening of the technology concept described above is due to the teachers’ participation in the TiS project. This gives rise to what can be denoted a ‘*double conception of technology*’ among the teachers. This means that their use of the notion ‘technology’ and how they talk about ‘technology teaching’ depends on whether the context is the TiS project or not. Outside the context of the project, they still use the concept technology in a more narrow sense consistent with its use among colleagues, pupils and in the overall cultural setting. Gina describes how the teachers participating in the TiS project have developed a shared understanding of the meaning of ‘technology’:

Gina
Those teachers working with technology, we have regularly meetings with them and exchange ideas for activities, and have in a way a shared understanding for what technology is, in this connection. But we often see when we discuss with others, that they do not assign the same to the concept. If you are to promote the subject as an elective unit, or you talk about it to other teachers or external people from whom we have received support and so, they don't assign the same to the concept 'technology' as we do! So that is part of the problem with the subject being new and that there are no traditions guiding it, that you do not communicate about the same things.

Gina
De lærerne som jobber med teknologi, de har vi jo jevnlig samlinger med og utveksler opplegg, og har på en måte en felles forståelse for hva teknologi er da, i den sammenhengen her. Men vi ser ofte når vi diskuterer med andre, at de ikke legger det samme i begrepet. Hvis du skal markedsføre liksom faget som valgfag, eller du skal snakke med andre lærere om det eller folk utenfra som vi har fått midler fra og sånn, så legger de ikke det samme i begrepet 'teknologi' som oss! Så det er jo litt av problemet med at faget er nytt og at det ikke er noen tradisjon for det og, at du kommuniserer ikke om de samme tingene.

BB
Do you have any examples?

Gina
When we got support from the Federation of Norwegian Manufacturing Industries, they thought immediately about computers and RoboLego, that is technology. It ought to be data, computers and that approach, and it is very often one thinks, it ought to be machines and advanced...

BB
'High-tech'?

Gina
'High-tech' yes, so there are many who think in that direction.

BB
Har du noe eksempel på det?

Gina
Når vi fikk midler fra Teknologibedriftenes landsforening, de tenkte jo med en gang på det med data og RoboLego, det måtte være teknologi. Det måtte være data, datamaskiner og den vinklinga, og det er veldig ofte at en tenker, det må være maskiner og avanserte...

BB
'High-tech'?

Gina
'High-tech' ja, så det er veldig mange som tenker i den retningen.

[P13: 1190 - 1214]

Gina shows that 'technology' is often understood in a more narrow sense than how the concept is comprehended through the TiS project. This more narrow understanding relates 'technology' mainly to computers and machines on an advanced level. An example of consequences of the differing conceptions of technology is that equipment the schools get from supporting institutions directs technology teaching in direction of the more narrow understanding.

Gina confirms that her participation in the TiS project has influenced her comprehension of technology. Initially, she possessed the more narrow comprehension as described above:

Gina
That's what I believed it to be myself when I was going to England, right, what it was all about! But then I understood that ok, TiS is something different [laughing]. It is many other things and simpler things and materials and production methods and so. Industry, how to make things and...

BB
You use the word in different ways dependent on whether you are in the TiS context?

Gina
Yes, I do. But at least I know how it is defined in the encyclopaedia! [laughter] But not everyone using the word knows what is said in the encyclopaedia, about what technology is.

Gina
Jeg trodde jo det var det selv når jeg skulle til England, ikke sant, at det var det det gikk ut på! Men så har jeg skjønnet at ok, Teknologi i Skolen er noe annet. [Latter]. Det er mye andre ting og enklere ting og materialer og produksjonsmetoder og sånt. Industri, hvordan lage ting og...

BB
Du bruker det ordet på ulike måter avhengig av om du er i den Teknologi i Skolen konteksten?

Gina
Ja, jeg gjør det. Men i hvert fall, jeg vet i hvert fall hva det står i leksikon! [latter] Men det vet ikke, alle som bruker ordet vet ikke hva det står i leksikon, hva er teknologi.

BB
What does it say?

Gina
Methods and techniques and knowledge of materials in order to produce, that is utilising of materials, utilising of raw materials, processing of raw materials. I was almost surprised that this was what it said, I associated it much more with advanced equipment, exploiting new knowledge and the making of new things. And it is only improvement, improvement, improvement; it does not have to be new products all the time. It is not more technology if you have a newer computer! So it is something there, that the word is not used so much here that one uses the same meaning of it. But it is used very much in a certain way!

BB
Hva står det?

Gina
Metoder og teknikker og læren om materialer og teknikker for å produsere, altså utnyttning av materialer, utnyttning av råstoffer, foredling av råvarer. Jeg ble nærmest overrasket over at det sto akkurat det da, jeg tenkte mye mer på det med avanserte ting, utnytte ny kunnskap og lage nye ting. Og det er bare forbedring, forbedring, forbedring; det trenger ikke å være nye produkter hele veien. Det er ikke mer teknologi om du har en nyere data-maskin! Så det er noe der altså, at det ordet er ikke brukt så mye her at en mener det samme med det. Men det er mye brukt på en bestemt måte!

[P13: 1219 - 1246]

Gina has looked 'technology' up in an encyclopaedia, and found a definition similar to the conception of technology as a process expressed by Benny in the Fifth story. She adds a new facet to the narrow view of technology as mainly 'computers', which also involves that technology denotes *new* things. In her broadened view, Gina points out that a *new* computer is not *more* technological than an old one.

Perceptions of a design process

Benny's conceptualisation of technology as a process in the Fifth story also involves a meaning of the concept related to the idea of a 'design process' that was prominent in the shaping of Design & Technology as a compulsory subject in England and Wales. This idea is evident in how he indicated the first steps in a design process: development of ideas followed by refining and communicating ideas by means of drawing. Later, when Benny has completed the project on buggies described in the Second story, he refers more explicitly to the steps in a design process:

Benny
(...) They have had a process on the way that they have followed really, the steps... that are required in such a process. They had to reflect on what the purpose was, they must try to make a sketch and shape it, and after they have designed it they have built it and tested it out. Found that there was room for improvement, like it is in 98% of the cases, if not to say 101%. And then they have tried to improve it and tested it again. And after that

Benny
(...) De har jo hatt en prosess underveis som de har fulgt egentlig, stegene ... som skal til i en sånn prosess. De har måttet tenke gjennom hva som er hensikten, de må prøve å lage en skisse og finne en form på det, og etter at de har formgitt det så har de prøve-bygd, og testa. Funnet ut at det var rom for forbedring, det er det jo i 98% av tilfellene, for ikke å si 101%. Og da har de prøvd å forbedre og testa på nytt. Og etterpå prøvd å tatt en runde på

tried to discuss, what was the cause for ... why is it that it functions better, in a way. Then we have achieved an evaluation of the project also. Orally, though.

hva som var årsaken til at... hvorfor er det sånn at den fungerer bedre enn den, liksom. Så har vi fått en evaluering av prosjektet også. Muntlig da, riktignok.

[P2: 367 - 376]

The design process can be seen as forming an integrated code (Bernstein 1971) for the technology subject Benny is creating. The concept of a generic design process or skills related to such a process are, however, not addressed explicitly in connection to the pupils' work with their technology projects in Benny's teaching. In the quotation above he refers to the process as steps the pupils *de facto* are undertaking while working with their buggies, not as something to be taught as such, let alone assessed. One of the other teachers, Frederic, does, however, refer to a process when asked about how the pupils' work is assessed in technology teaching at School F:

BB

I don't know whether you mark their work or not, but what characterises a pupil who is competent within, good at technology as such a, as a cross-curricular subject area?

BB

Jeg vet ikke om dere setter karakter på de arbeidene som de gjør, men hva er det som kjennetegner en elev som er flink innenfor, som er dyktig innenfor teknologi som et sånt, som er tverrfaglig, som et fagområde?

Frederic

Effort is important, that they put effort into it and work concentrated in all working processes towards a completed product, towards evaluation. We wish our projects to contain some sketch drawing and brain storming and so, that they are active all the way in that process, towards what they want to do. If you spend some time and do it thoroughly, then the product will be nice and well done.

Frederic

Innsats er jo viktig da, at de legger innsats og jobber konsentrert i alle arbeidsprosessene fram til ferdig produkt, fram til evaluering. Vi ønsker jo i prosjektene også å ha en del sånn skissetegning og idedugnad og sånne ting, at de er med hele veien på den prosessen der, fram til det de ønsker å gjøre. Hvis de bruker litt tid og gjør det grundig, så blir også produktet fint og gjennomarbeidet.

[P7: 549 - 560]

Again, the process is described as the activity pupils *de facto* are undertaking in technology projects. Frederic describes a good pupil as one who is active and puts effort into all phases of this process, without reference to any skills in performing the process as such.

When the teachers refer to a process in technology teaching, it is sometimes related to skills in using *drawing* as a tool in developing a technological product. Many were impressed by drawings made by pupils in the English schools they visited, and drawing skills are often referred to as a missing element in Norwegian curricula and teaching. For example, Ann points to drawing skills as one element

of what would be important in a possible future technology subject in Norwegian schools:

Ann

But I think, there is several things that need to be included, among others what is, it is apparent how important it is to learn how to draw, drawing skills. I think that is important in such a subject, if... that the process is as important as they say. To put it this way, if it is not to become like trial and error, a "create funny things - subject", I think it is important to learn proper drawing skills.

Ann

Men jeg tror, det er jo flere ting som må inn, blant annet det som er, en ser jo hvor viktig det er å lære å tegne, tegneferdigheter. Det tror jeg er viktig i et sånt fag, hvis... at prosessen er så viktig som man sier. For å si det sånn, at det ikke bare skal være sånn prøve og feile, "lage seg morsomme ting - fag", så tror jeg det er viktig med det å lære seg skikkelige tegneferdigheter.

[P11: 294 - 300]

Ann relates drawing to a design process, but her expression "if the process is as important as they say" suggests that she is not convinced by the appropriateness of the idea of a generic design process.

In general, the idea of a design process in the meaning it was given in the implementation of Design & Technology in England and Wales is not found to have any considerable influence on how the teachers in this study interpret technology teaching or how they create technology as a subject at their schools. None of them refer to a 'design process' as any generic transferable ability that can be taught through technology teaching, or address the issue in the teaching observed in this study.

Technology teaching as a working method

In the Fifth story, Benny has expressed a yet different comprehension of what technology as a process means. This comprehension applies to the *curricular* context, that is, the meaning of technology teaching in the landscape of school subjects to be taught to pupils. In this landscape, he describes technology as a *working method* for covering elements of all other subjects in the curriculum. This implies a view of technology not as a subject that adds to the existing subjects, but rather as a way of teaching the contents of *other* subjects. This view is, of course, partly due to the fact that the teacher is bound by the requirements set by the formal curriculum L97, where technology is not a specified subject. Benny formulates how he relates to the curriculum L97 while planning technology teaching as a working method in diverse subjects this way:

Benny

We cannot go outside L97, and then we need to relate to what is there. As long as the technology concept is as wide as it is, it is no problem to find approaches to every subject

Benny

Vi kan ikke gå utenom L97, og da må vi ta tak i det som fins der. Så lenge begrepet teknologi er så vidt, så er ikke det noe problem å finne innfallsvinkler mot hvert fag

that has to do with technology. And then we must look upon it as a working method within the subject. Hence the time resources must be taken from English, Norwegian, Art and Crafts, Mathematics... There is plenty of maths in technology, if you are to make a house model, you need to relate to scales and ratios and it needs to be correct ratio between things. And angles and... it does have elements from many subjects.

som har med teknologi å gjøre. Og da må vi jo betrakte det som en arbeidsmåte innenfor faget. Så da, tidsressursen må du jo ta fra engelsk, norsk, kunst og håndverk, matematikk... Det fins jo mye matte i teknologi, skal du lage et modellhus, så må du jo forholde deg til skala og målestokker og det skal være riktige forhold mellom ting. Og vinkler og... det har jo elementer fra mange fag.

[P2: 651 - 659]

The fact that Benny's technology unit is placed under Art and Crafts in the timetable does not mean that it is essentially seen as a part of this subject. Benny maintains that technology is a working method, but that Art and Crafts is an easy choice in order to acquire the required time resources:

BB

But does that mean that you look upon it as a craft subject? Since you have used those lessons...

BB

Men betyr det at dere ser på det som et formingsfag? Når dere har brukt de timene...

Benny

No, well, it isn't a subject, but you need to take the lessons from somewhere. It is a working method more than anything else, and then Art and Crafts is perhaps an easier subject to get them from. Some of the activities have had an approach towards Social Studies, for example, regarding topics in history, with fortresses and defence, used that as a starting point. And it may be used in English if you want them to create directions for use for something. You can include other subjects in a project you work with that has a technological background.

Benny

Nei altså, det er jo ikke noe fag, men en plass må man ta timene fra. Det er jo en arbeidsmetode mer enn noe annet, og da er jo kunst og Håndverk kanskje det faget som det er enklest å plukke fra. Noen av oppgavene har jo vært vinklet inn mot samfunnsfag, for eksempel, i forbindelse med historie-tema, med borger og forsvarsverk, tatt utgangspunkt i det. Og det kan jo også brukes fra engelsk hvis du ønsker at de skal lage en bruksanvisning til noenting. Altså du kan trekke inn andre fag mot et prosjekt du jobber med som har en teknologisk bakgrunn da.

[P2: 29 - 43]

(The potential contradiction of seeing technology as a working method within a range of subjects but at the same time addressing a need for allocating extra time for technology teaching was not followed up in the interview.) From the above, Benny appears to see technology as a way of teaching pupils *anything*, by means of the process of creating artefacts. This process view of technology teaching can be seen as represented by an extremely strong *integrated* code (Bernstein 1971), where the 'contents' can be exchanged with virtually *any* other content.

Benny's view of technology teaching can be seen as reflecting the idea of project work as a working method in the curriculum L97. As described in Chapter 5, L97 proposes project work as a pedagogical tool for active and meaningful learning in all subjects and in cross-curricular areas. As opposed to the idea of *applying*

knowledge inherent in the subject Design & Technology in England and Wales, project work in the Norwegian curriculum is seen as a teaching method where pupils' active learning and *gaining* of knowledge in meaningful contexts is emphasised. The conception of technology teaching as a working method for contents of subjects in the curriculum also links to an interdisciplinary approach to technology teaching, which will be explored in the following sections.

Technology as interdisciplinary teaching

Some teachers participating in the TiS project see technology as a new subject that might be included in compulsory schools in Norway. For example, the Third story earlier in this thesis has exhibited how Eric conceptualises an independent knowledge base of technology and how this justifies its establishment as an independent subject. However, not all teachers see technology as a new and independent subject, even in principle. As will be shown in the following sections, technology is rather seen as an essentially *interdisciplinary* area of teaching, thus framing the 'subject' in ways fundamentally different from identifying the contents of the subject and its boundaries to other subjects.

Technology – not essentially a new subject?

Though the discourse related to the TiS project has often focused on the idea of introducing technology as a new subject of teaching in Norwegian schools, many of the teachers in this study see technology teaching associated with the project better suited as interdisciplinary approaches or as project work across the curriculum. It appears that this view applies *in principle* among the teachers, and not only related to the current situation where technology is not a specified subject in the curriculum. For example, Benny states that if technology is to become a new subject in the curriculum, it must be put together by elements currently included in other subjects:

BB

But if our new Minister of Education figured out that "yes, technology is to be a specified subject in Norwegian schools", what do you think such a subject should contain?

BB

Men hvis den nye utdanningsministeren fant på at "jo, teknologi skal være et eget fag i norsk skole", hva skulle et sånt fag inneholde, syns du?

Benny

Then it must be taken out from other subjects which it - in a sense lies within now. It must be something about processes in... both regarding food, what is baking powder for example? What happens to the baking powder when a flat pancake becomes a high

Benny

Da må det jo trekkes ut i fra de fagene som det - holdt på å si - ligger inne i nå. Det må jo være noe om prosesser i... både når det gjelder mat, hva er bakepulver for eksempel? Hva er det som skjer med bakepulveret når en flat lefse blir til en høy kake? (...) Det går jo

cake? (...) It is about basic principles in our surroundings. It can be many things; it can be model building as well as making biscuits or whatever, but in addition to making the biscuits you may get the task of packaging them and selling them. It is a different way of thinking, you think around... maybe, that it results in a final product. And then you may build very much into it related to that product. If you are to make the biscuit packaging, you may have as an additional task of writing the text on it, that is a Norwegian exercise, right.

på grunnleggende prinsipper i det som er rundt oss. Det kan jo være så mangt; det kan jo være både modellbygging og det kan være å lage kjeks eller hva som helst, men du kan jo i tillegg til å lage kjeksen også få i oppgave å emballere den og selge den. Det er en annen måte å tenke på, du tenker rundt... kanskje, at det blir et sluttprodukt av det. Og så kan du bygge veldig mye inn mot det produktet da. Skal du lage den kjekspakken, så kan du jo få som tilleggsoppgave å skrive teksten på den, det er jo norsk-oppgave, ikke sant.

[P2: 663 - 687]

Benny's argument is in accordance with the view he has expressed earlier, that technology teaching is about processes in many areas. If it is to be defined as a self-contained subject it must be put together by extracting content from existing subjects. This view of technology as not principally a subject but as a combination of elements from other subjects is also found among other teachers in this study. It is for example evident in how Gina describes the subject Design & Technology in England and Wales, that acts as a model for the TiS project:

BB

The subject they have in England, can you say something about what you consider as, what distinguishes it? You talked about ways of working -

BB

Det faget de har i England, kan du si noe om hva du oppfatter som, hva som kjennetegner det? Du snakket om måten å arbeide på -

Gina

- Yes, it is project work within many topics, we don't have much of that type of project work where pupils can work with diverse materials, in our school. That subject takes in subjects, or elements of subjects, that we have in other subjects here. Art and Crafts is within it, home economics - cooking is incorporated in that subject in England, and parts of science are within it. But they have approached the whole thing differently; they see the connection between the parts that by us are distributed in different subjects. There is strictly speaking not so different content perhaps, than what pupils here ideally should learn, governed by the curriculum; they are supposed to touch upon all of it, or at least some of the same topics here. But you have so few opportunities to work practically. They [in England] work with it practically and look at products, look at needs, approach it differently, and put it together as a subject. (...)

Gina

- Ja, det er jo prosjektarbeid innenfor mange emner, vi har ikke så mye av den type prosjektarbeid hvor elevene får jobbe med ulike materialer vi, i skolen her. Det faget der trekker jo inn fag, eller deler som vi har inne i andre fag her da. kunst og håndverk er jo inne i det, heimkunnskap - matlaging er jo inne i det faget i England, og deler av naturfagen er inne der. Men de har vinklet hele greia annerledes da; ser sammenhengen mellom de bitene som hos oss ligger fordelt på forskjellige fag. Det er egentlig ikke så mye annerledes innhold kanskje, enn det elevene her ideelt sett skal lære, som er styrt av læreplanen, så skal de borti alt, eller mye av det samme her. Men du har så få anledninger til å jobbe praktisk. De [i England] jobber praktisk med det og ser på produkter, ser på behov, vinkler hele greia annerledes, og snekrer det sammen til et fag.

(...)

So it is a successful way of working with projects for the pupils, co-operation and to look a bit beyond the walls of the classroom in fact.

Så det er en vellykket måte å jobbe med prosjekt for elevene, samarbeid og å se litt lenger enn veggene i klasserommet altså.

[P13: 645 - 677]

Gina sees Design & Technology as merely a combination of subject elements already present in our Norwegian curriculum. In her view, what makes the subject special is how the subject elements are put together in meaningful contexts that facilitate practical project work. What one gains with this type of recombination of subject elements is, according to Gina, more practical work in realistic contexts, holistic approaches to project work and more co-operation between pupils.

Frida is more critical to the “English model”, and claims that working with interdisciplinary projects is a better approach:

Frida

We have constantly considered the English model, with Design & Technology, and at least [according to] what we have discussed earlier, we think the approach we have developed here in Norway with running it as projects, where you pick elements from both Norwegian and Social Studies - which is very natural to include - and of course the sciences [is better]. I think this approach would be a favourable way of doing it. And it is very much consistent with the new curriculum, to work with projects. I think it would be a constraint to... to have to limit it to one subject area.

Frida

Vi har jo vurdert hele tiden den engelske modellen, med Design & Technology, og i hvert fall det vi har diskutert tidligere så syns vi at den formen vi har funnet på det her i Norge med å kjøre det som prosjekter, hvor du tar elementer både fra norsk og samfunnsfag, som er veldig naturlig å trekke inn i det, og naturfagene selvfølgelig [er bedre]. Jeg tror at den vinklingen der hadde vært en heldig måte å gjøre det på. Og det er jo veldig i tråd med ny læreplan at man skal jobbe med prosjekter. Jeg syns kanskje det vil bli en begrensning å... det å skulle begrense det til ett fagområde.

BB

So you look upon it as primarily interdisciplinary, not as a subject?

BB

Så du ser på det først og fremst som tverrfaglig, ikke som et eget fag?

Frida

Yes. Because you will have elements from all the subjects I mentioned, and from Art and Crafts, of course.

Frida

Ja. For du vil jo ha elementer fra alle de fagene der, også fra kunst og håndverk selvfølgelig da.

[P7: 440 - 455]

As technology teaching will contain elements from several subjects, Frida describes it as principally *constraining* if technology would have to be limited to one subject area.

The teachers referred above present somewhat dissimilar views on technology teaching and its potential in schools. Nonetheless, they share one important perspective on technology teaching in that they do not identify technology teaching

as something that adds a substantially new component to the curriculum. Rather, it is seen as a new way of approaching subject matter already present in the curriculum.

The possibilities technology teaching associated with the TiS project provides for interdisciplinary teaching is appealing to all of the teachers in this study, and several express that technology should not be established as a specified self-contained subject, but be further developed as an interdisciplinary area of teaching in Norwegian schools. However, some argue that it needs to be specified as a subject in order to “force” its existence into schools:

Elna

I think that in order for it to be included, I believe that the most effective way is to force it through is that it becomes a specified subject.

Elna

Jeg tror for at du skal få det inn, så tror jeg kanskje at den mest effektive måten å tvinge det gjennom på er at det blir et eget fag.

BB

In order to not escape from it, in a way?

BB

For å ikke kunne slippe unna det, liksom?

Elna

Yes, I think so. But it is such a... if it is to have its main weight on craft, or if it should be on the sciences, I am not sure about that. But it is between those two subjects, as I see it. But I think that, in order to accomplish it, then I believe [it needs to be a] separate subject, then you are obliged to do something about it.

Elna

Ja, det tror jeg. Men det er jo et sånt... altså om det er hovedvekt på forming, eller om det er hovedvekt på realfagene, det er jeg ikke så sikker på. Men det ligger mellom de to fagene, sånn som jeg ser det. Men jeg tror at for å, for at en skal gjennomføre det, så tror jeg at [det må være et] eget fag, da er du nødt til å gjøre noe med det.

[P5: 581 - 595]

Elna sees technology as “between” the subjects Art and Crafts and Science, a formulation that appears to imply a combination of elements from those subjects. However, as the teaching of practical technology requires time, material resources and often extra work, she indicates that the only way of avoiding that it ‘slips away’ from the classrooms may be to implement it as a regular subject. Hence, her argument for specifying technology as a new subject in the curriculum is not epistemic, but *political* in nature.

Covering the curriculum through interdisciplinary teaching

The above view of technology teaching as a combination of elements from other subjects may imply a view of technology teaching as a way of covering the curriculum in these subjects. This is represented in how Frida in the previous section talked about “picking elements” from other subjects, where the meaning must be that these elements will be covered by the technology projects they run. She mentioned the subjects Norwegian, Social Studies, Science and Art and Crafts as subjects that can be integrated through technology projects. Benny has earlier given a similar view where he also has pointed to Home economics, English and Mathematics as relevant subjects (p. 196). As a general impression, it appears that when the teachers talk about their technology teaching as interdisciplinary, they see the teaching as *better* when a *greater* number of subjects are able to be integrated into it. This phenomenon can be further illustrated by how Hanna and Henry shift into technology as interdisciplinary when talking about their use of LegoDacta for construction activities:

Hanna

And with LegoDacta, there were exercises where they were to answer questions, and at least in my class we did those exercises. I think that was instructive, they needed to reflect on what made it like that, and why it was so and they needed to think a bit! And I think that was a bit important.

Hanna

Og der var det jo sånn med de, LegoDacta, at det var oppgaver de skulle svare på spørsmål på sånne arbeidsark, så det, i hvert fall i klassen min så gjorde vi det da. Det tror jeg var litt lærerikt, de skulle tenke etter hva var det som gjorde at det ble sånn, og hvorfor ble det sånn da og de måtte tenke litt! Og det tror jeg var litt viktig.

Henry

Then we get, can take in Norwegian and all kind of things, to be able to put into words what is happening, things like that, how things are. So it is handy to take the subjects into it.

Henry

Da får vi jo, bør jo trekke inn norsk og alt mulig, klare å sette ord på hva som skjer, sånne ting, hvordan ting er. Så fagene er jo greit å trekke inn i det.

BB

But do you see it as something that is typically interdisciplinary or do you think that it is a subject, that technology is an independent subject area?

BB

Men ser dere på det som noe som er typisk tverrfaglig eller synes dere at det er et fag, at teknologi er et eget fagområde?

Henry

I don't know, really...

Henry

Jeg vet egentlig ikke jeg...

Hanna

Well, it becomes interdisciplinary in a way now, when we need to take [time resources] from all subjects, they get some Norwegian, and they get craft and mathematics does come in when measuring with a ruler, that comes nicely in. English I don't know whether we get, it depends... The Science part comes a bit in.

Hanna

Altså, det blir jo tverrfaglig på en måte nå, når en må ta [tidsressurser] fra alle fag, de får jo inn litt norsk, og de får jo inn forming og matematikk kommer jo inn med å måle med linjal, det kommer jo fint inn. Engelsk vet jeg ikke akkurat om vi får inn, det spørs jo om det er... Naturfagbiten kommer jo inn litt.

[P9: 421 - 443]

It is not entirely clear what it means when Hanna and Henry refer to subjects 'coming in' in technology teaching. A reasonable interpretation is that technology teaching as a cross-curricular area covers curriculum elements from the other subjects, along similar lines as Benny's perception of technology teaching as a working method. It might, however, be asked whether the examples mentioned by the teachers do not sometimes appear somewhat implausible or out of focus, for example technology teaching as a way of teaching mathematics because pupils measure with a ruler or a way of teaching English because pupils might make instructions for use in English. It is not plausible that the teachers see the technology activities as the most effective ways of teaching the mentioned subjects. This is warranted by the fact that Henry does not want to allocate mathematics lessons for technology projects, despite the fact that mathematics might be integrated in them. He regrets that it is like this, but assigns it to the demanding content of this subject:

Henry
It is a pity that it is like that, because there might be other ways we could make use of the mathematics.

BB
Yes. And like you say, that it is included, one does make use of mathematics -

Henry
- One makes use of it by looking at geometrical figures and all such things, and understand a bit of it and calculations and so, so it is included in the subject. But I never feel like using a lot of mathematics lessons for Technology in Schools really, because I need them for the theoretical content we work with. That is a pity, I think.

Henry
Det er litt synd at det skal være sånn, det fins sikkert andre måter en kunne brukt matematikken på og.

BB
Ja. Og sånn som dere sier, at det inngår jo, man bruker jo matematikk -

Henry
- En bruker jo det med å se på geometriske figurer og alt mulig sånne ting, og skjønne litt av det og utregninger og sånt, så det er jo med i det faget der. Men jeg føler aldri at jeg ville brukt masse matematikktimer på Teknologi i Skolen egentlig, for jeg har bruk for dem egentlig til det teoretiske vi holder på med. Det blir litt dumt syns jeg da.

[P9: 692 - 703]

Further, observations of the teachers' actions in the classroom suggests that explicit covering of curricular elements from ordinary subjects is not their main agenda, though pupils may *do* some measuring or writing as part of activities. This leads to a search for other explanations.

One possible interpretation of the above can be drawn from how Hanna has asserted that "it becomes interdisciplinary in a way now, when we need to take time resources from all subjects". A similar concern, that all teaching must be undertaken within the framework of L97, was also expressed by Benny and presented earlier (pp. 195-196). This may signal that the teachers see intrinsic

values in technology teaching that they want to offer to their pupils regardless of what the curriculum requires. Their phrasing of technology teaching as a way of covering elements in the subject specifications may simply acts as a *justification* of the time resources used for technology projects, and they may see the justification as stronger the more subjects they can point to as covered in the projects.

However, the described phenomenon may also be a sign of what Venville *et al.* (2002) have indicated as two conflicting paradigms of schooling. They claim that integration is a particular ideological stance about curriculum with roots planted in a view of knowledge that can be described as worldly, experiential, contextual and organic (p. 47). This stance is at odds with the disciplinary structure of schooling they describe as mechanistic, objective and framed within subjects. Thus, explicit or implicit questions, including those posed by the interviewer in the present study, about the gain of interdisciplinary approaches with regards to learning goals from specific school subjects may be situated in the disciplinary paradigm, while what the teachers are doing lies within the integrated paradigm. Their attempts to articulate their actions in one paradigm by means of the language of the other inevitably leads to results, such as quotations cited in this chapter, that appear as incongruous or even bizarre.

Though the claim that a range of elements from the subject specifications are covered by technology teaching might not be convincing, the teachers' realisation of technology teaching is nonetheless highly consistent with the intentions in the general parts of the curriculum L97. Their approach may thus be seen as fulfilling the intentions stated in the Core Curriculum and the Principles and Guidelines for compulsory education. Accordingly, the following quotation shows that Frederic refers to the perspectives presented here rather than to the curriculum's subject specifications in his argumentation for allocating a significant amount of time to technology projects:

Frederic
It is not always that we can find arguments for running our projects in the subject specifications. But the general part is as important, perhaps, as the subject specifications, and then you can find good arguments for running technology projects enlightened in the general part. About co-operation and... among others, a holistic human being...

BB
And it says a lot about technology also.

Frederic
Det er ikke alltid vi greier å finne argumenter for å drive de prosjektene våre i fagdelen. Men den generelle delen er jo vel så viktig kanskje som fagdelen, og da kan du finne gode argumenter for å drive teknologiprojekter belyst i den generelle delen. Dette med samarbeid og... blant annet, helhetlig menneske...

BB
Og det står jo masse om teknologi der også.

Frederic

Yes. So it is not difficult to find sentences in the curriculum that shows that we should do technology teaching.

Frederic

Jada. Så det er ikke vanskelig å finne setninger i læreplanen som viser at vi skal drive teknologi-undervisning.

[P7: 776 - 787]

Though Frederic's technology projects, such as the one on mechanical toys described in the Fourth story, can be seen as 'containing' elements from subjects such as geometry in mathematics, Frederic asserts that good arguments for technology teaching can easier be found in the general part of the curriculum. Thus Frederic sees technology teaching more as a way of 'covering' the general goals of the curriculum than the subject specifications. Interestingly, when considering this part, he does not in the first place refer to what the curriculum is actually saying about *technology*; his focus is on the general aspects of developing the individual human.

A possible mismatch between the paradigm underpinning the general part of the curriculum and the one underpinning the subject specifications in L97 could be worth a further exploration, yet this is beyond the scope of this thesis. The following section will, however, present problems teachers see in interdisciplinary project work, whereof some might be traced back to conflicting rationales underpinning this way of teaching and the one underpinning the subject specifications.

“Much inter and little discipline”; Problems with interdisciplinary project work

Though the teachers express loyalty towards the curriculum's requirement of interdisciplinary teaching and project work, some of them also identify problems related to this kind of teaching. The problems they address do not essentially entail a critique of the ideas presented in the curriculum as such; they rather point to obstacles in realising these ideas in schools. Gina tells how interdisciplinary projects fail to meet the intention as she sees it:

Gina

Ideally we should have worked together a couple of subjects and achieved something that is between those subjects and included a bit here and a bit there. But it becomes, the projects we run become... the subject teachers are more used for guarding the pupils or, we don't get the subjects into it very much, we don't. It becomes little subject content really, in the projects we have had, at least in the large interdisciplinary projects.

Gina

Ideelt sett skulle du kanskje jobbet sammen et par fag og fått noe ut av det som er mellom de fagene og trukket inn litt her og litt der. Men det blir en sånn, de prosjektene våre det blir... faglærerne blir mer brukt til å sitte vakt for elevene eller, vi får ikke inn fagene så veldig mye, vi gjør ikke det. Det blir lite faginnhold egentlig i de prosjektene vi har hatt, i hvert fall de store tverrfaglige prosjektene.

[P13: 723 - 729]

Gina sees it as problematic to make subjects contribute to the large interdisciplinary projects pupils undertake. One problem is that the projects fail to

include substantial subject matter, and that subject teachers are mainly used for managing the pupils rather than managing the subject and its contribution to the projects. David describes the common approaches to interdisciplinary projects in similar ways:

David

When one thinks of interdisciplinary projects and so, then one thinks perhaps often interdisciplinary in the sense that we will have an interdisciplinary project, we allocate time for an interdisciplinary project. Then the subjects give away so and so much time, and you try to make your subject represented in the project as much as possible, and then... I use to say that it is very much inter and little discipline, in a way, right.

David

Når en tenker tverrfaglige prosjekter og sånn, så tenker en kanskje ofte tverrfaglighet ved at nå skal vi ha tverrfaglig prosjekt, så setter en av tid, at her er det tverrfaglig prosjekt. Så avgir fagene så og så mye, og så prøver du å få inn faget ditt i prosjektet så godt som du kan, og så... Jeg pleier å si at det blir mye tverr og lite fag, på en måte ikke sant.

[P14: 281 - 287]

David's characteristic of interdisciplinary teaching as "much inter and little discipline" touches upon the tension Venville *et al.* (2002) pinpoint with their rhetorical question "If you must have 'the subject', can you also have 'integration'?" (p. 47).

More concrete, the teachers' experience of absence of substantial subject matter in the projects can be illustrated by how Gina tells about a project run in grade 10:

Gina

We had a project this winter about the future, "the road ahead" was the working title, "thoughts about the future" became the final title, where they were to choose something related to it within, appreciably within a subject or several subjects, to get something out of it! But the pupils are not really capable of seeing how they can get some subject content into it, they simply interview somebody about what they think about the future, whether they believe in fate or not, the cessation of the world or not, like...

Gina

Vi hadde jo prosjekt nå i vinter som gikk på framtida, "veien videre" var arbeidstittlen, "tanker om framtiden" ble tittelen til slutt da, hvor de skulle velge noe som hadde med det å gjøre innenfor, gjerne innenfor et fag eller flere fag, få noe faglig ut av det da! Men elevene klarer ikke helt å se hvordan de kan få faglig innhold i det, de bare intervjuer noen om hva de tror om framtida, om de tror på skjebne eller ikke, verdens undergang eller ikke, sånn...

BB

But there is a lot within Science that has to do with... gene technology...

BB

Men det er jo masse innenfor naturfag som har med... genteknologi...

Gina

Yes. Some looked at transport, transport plan for Trondheim, gene technology - none of mine pupils chose that topic, but I know there were some in other classes who did it, but the class I have is not especially strong in any regards. So they didn't manage really to

Gina

Ja. Noen så på transport, transportplan for Trondheim, genteknologi - det var ingen av de elevene som jeg hadde som valgte det, men jeg vet det var noen i andre klasser som klarte det da, men den klassen jeg har er ikke spesielt sterk, på noen måte. Så de klarte ikke

utilise it. Some worked on fashions in the future, found out what kind of fashions that would come for youth towards the summer. But that isn't really enough - just speaking to one or two people, they haven't learnt to seek out relevant sources, and to get a lot of material. They pick some pieces where they find them and "that's it". They talk to one person or two, and then they have in a way - Choice of occupations in the future, one group worked with that, what kind of occupations will be needed in the future, they interviewed the father of one of the pupils, right, his opinion on the issue. And then they stop there, and in the end they dramatise an interview [as a presentation of their project]!

helt å utnytte det. Noen hadde om moter i framtiden, fant ut hva slags moter som kom til å komme fram til sommeren på ungdomssida. Men det blir litt spinkelt, for at de snakker kanskje med en eller to personer, de har ikke lært seg å oppsøke relevante kilder, og få mye stoff. De plukker litt der de finner det og "that's it". Så de snakker med en person eller to, og så har de på en måte - Yrkesvalg i framtiden, en gruppe som hadde om det, hvilke yrker er det behov for i framtida, så intervjuet de faren til en av elevene, ikke sant, hva han mener om det. Og da stopper de der, og så dramatiserer de et intervju [som presentasjon av prosjektet]!

[P13: 779 - 803]

Despite the good intentions of interdisciplinary projects related to 'the future', Gina identifies several problems in running projects like this one: The focus is too much on organising the projects, the projects suffer from a lack of substantial content, the potential in the related subjects is not utilised, pupils are not capable of choosing good approaches to their projects and they fail to identify and utilise sources of information.

Technology teaching as a catalyst

Gina has in the above pointed to a lack of substantial subject matter in interdisciplinary projects. This does not, however, mean that she does not appreciate the idea of interdisciplinary approaches to the teaching of subject matter. Conversely, she sees the subjects as tending to be too isolated from each other and from practical contexts where they might come to use:

Gina

Ideally we should have achieved a lot through interdisciplinary approaches, but it is a fact that we are mainly subject teachers in lower secondary school, so we keep on with our subjects and then there will be some theory as well, instead of interdisciplinary work and do some practical things and bring the theory into it. It is difficult to work that way in lower secondary schools the way it is today. And technology certainly is a subject that is interdisciplinary, where pupils can have the chance to work that way.

Gina

Ideelt så burde en jo fått til mye gjennom tverrfaglighet da, men det er jo fakta at vi er jo stort sett faglærere i ungdomsskolen sånn at vi holder jo på med våre fag og da blir det jo litt teori også, isteden for å jobbe tverrfaglig og få gjort praktiske ting og trekke teorien inn i det. Det er vanskelig å jobbe på den måten i ungdomsskolen sånn som det er nå i dag. Og teknologifaget er jo et fag som er tverrfaglig, hvor elevene kan få jobbet på den måten.

[P8: 752 - 759]

Gina points to subject teachers as too concerned about their own subjects and that this may prevent practical interdisciplinary teaching. This adds to the problems with

interdisciplinary approaches to teaching she has identified in the previous section. However, at the end of the quotation, technology teaching comes up as a *solution* to the problems Gina has identified. She indicates that technology is an area that facilitates meaningful interdisciplinary approaches.

Technology teaching as solution to problems of realising the intentions in L97 in this regard also appears in how Irene expresses her enthusiasm for teaching technology and design:

Irene

To me it became a kind of catalyst really, in the curriculum. That is, it is a soft transition, it became so concrete to approach, when we work with projects, if you can use such a task then you have in a way connected Art and Crafts, Science, perhaps Mathematics, and you may include a bit Norwegian and maybe other things. It is so easy to approach it and make use of it. But, when I say that the curriculum, or that the school is theoretical and so, the pupils experience it that way because there are few teachers who bother to make it exciting, right? That is, I am sure there are many who work with excellent projects, independently of technology and design, of course there are. But it is so easy to approach it, it is so logical!

Irene

For meg så ble det her som en slags katalysator egentlig, inni læreplanen. Altså, det er en veldig sånn myk overgang, det ble så konkret å ta tak i, når vi jobber liksom i prosjekt, hvis du kan bruke en sånn her oppgave så har du på en måte koblet sammen kunst og håndverk, natur og miljø, kanskje matematikk, og så kan du legge inn en norsk-bit og eventuelt andre ting. Det er så lett å ta tak i det og få brukt det. Men, når jeg sier at læreplanen, eller at skolen er teoretisk og sånn, så oppleves den sånn av elevene for det er jo så få lærere som gidder å gjøre det spennende, ikke sant? Altså, det er sikkert mange som jobber med flotte prosjekter, uavhengig av teknologi og formgivning, selvfølgelig er det det. Men det er så lett å ta tak i det, det er så logisk!

[P16: 170 - 182]

Irene uses the metaphor of a '*catalyst*', that is, a device that makes things happen, when describing her participation in the TiS project. As with other teachers referred earlier, she tends to describe projects as being better the more subjects are included in it. She does, however, indicate that there are obstacles to the realisation of interdisciplinary teaching, due to a lack of functional and accessible approaches or even to a lack of concern among teachers. In this problem area, technology teaching acts as a catalyst in making it possible to create meaningful interdisciplinary teaching.

What makes technology teaching associated with the TiS project act as a catalyst in this regard? From the quotations from Gina and Irene above, certain qualities of technology projects that make them appropriate for the purpose can be identified. Firstly, they represent *practical* activities where pupils have an active role. They do not involve the use of textbooks and teaching approaches the teachers denote 'theoretical'. Secondly, they provide opportunities to run *cross-curricular projects* that contains some substantial content. Finally, technology projects as those

associated with the TiS project provides the teacher with *concrete and accessible ideas* that are manageable to realise in schools. The TiS project has thus functioned as a tool for teachers in fulfilling educational intentions set by L97.

Summary and concluding remarks

This chapter has given a presentation of how teachers participating in the TiS project frame technology as a subject of teaching. The analysis has included interpretations of what they see as embraced by the concept ‘technology’ in the educational setting, what they describe as the characteristics of the subject and the boundaries and other kinds of connections they make between technology and other subjects in the curriculum.

It is shown that the teachers’ initial conceptions of what ‘technology’ entails to some extent has influenced what they perceive technology teaching related to the TiS project to be *about*. They tend to associate technology teaching with topics such as mechanics and electronics, and a more general criterion of movement associated with the products pupils make in technology teaching appears to have acted as a *filter* for what the teachers have adopted from Design & Technology into their own teaching. However, a much broader view of technology as any process leading to a product is also found, represented by Benny in the Fifth story. This gave rise to the identification of a broadening of the technology concept as a learning target for the pupils. The results also indicate that participation in the TiS project has broadened some teachers’ conceptions of what technology is, and that they may hold a double conception of technology, where the context determines how they comprehend and communicate its meaning.

The teachers’ identification of ‘what may be taught’ in technology teaching is also found to be affected by the content of other subjects in the sense that technology as a subject is partly framed by means of *exclusion* of what is taught in these subjects. The boundaries the teachers’ make towards *Science*, however, appear to be weaker. How they connect technology teaching to this subject will be a theme in the next chapter.

Though a conception of technology as a *process* is found to be held by some teachers in this study, they have generally not adopted the process approach that was prevailing in the initiation of Design & Technology in England and Wales. Instead, technology as a process is given other interpretations. One is the view of technology as a *working method* for subject matter from diverse subjects in the curriculum, where the boundaries between technology and other subjects collapse. A related view with a corresponding weak framing is the perception of technology

as a new *combination* of subject elements rather than a new subject that potentially adds to those already present in the curriculum.

These two views, technology as a working method and technology as a new combination of subject elements, strongly reflect the emphasis on respectively *project work* and *thematic structuring* of subject matter in the curriculum L97. Not only do the teachers' perceptions of technology teaching *match* the intentions in L97; technology teaching associated with the TiS act as a *catalyst* for fulfilling these intentions.

CHAPTER 11

RELATING TECHNOLOGY TEACHING TO SCIENCE

In Chapter 2 of this thesis, a span of views on how technology is related to science was presented. It was shown that technology and science could be seen as two separate and distinct areas of knowledge and activity, as areas interrelated in various ways, as essentially indistinguishable areas or as forming a seamless web. This was followed up in Chapter 3 by a presentation of how the relationship is reflected in a corresponding range of approaches to the *teaching* of science and technology, ranging from science and technology as independent subjects to technology taught as mainly applications of science.

As indicated in Chapter 6, the TiS project may be seen as somewhat ambiguous in how it places technology as a curricular area relative to science teaching. On one hand, a strong link to science is made in the aims formulated in the official project policy. Science is highlighted firstly by stating that the project aims at supporting mathematics and the sciences understood as the school subjects, and secondly by the aim formulated as “promote better understanding of the relationship between technology and science”. These aims suggest an approach to technology teaching through the gateway represented by the established subject of school science. On the other hand, an important feature of the project and the general discourse related to it is the promotion of technology as a new curricular area that reflects technology as an independent subject with its own knowledge base and structure. The latter is consistent with the use of the subject Design & Technology in England and Wales as a model in a conceptualisation of technology as a new subject, and with the training the participating teachers have received at the college in England. As described in Chapter 3, this subject is not characterised by any strong link to school science and its content.

How do the teachers participating in the TiS project respond to this tension when realising ideas from Design & Technology in their schools? What connections are made to science in their technology teaching? What is the teachers’ comprehension of a relationship between science and technology, and how does this relate to their perceptions and realisation of technology as an *educational* topic? Has the link made to science in the project policy influenced the transfer of ideas from Design & Technology to Norwegian schools?

This chapter presents aspects of what the link between science and technology

teaching means to the teachers participating in the TiS project. The presentation starts with showing how the participating teachers *associate* technology with science and proceeds with an analysis of how teachers in this study comprehend the potential of technology teaching associated with the TiS project in ‘supporting science’ as formulated in the official project policy. This presentation has an emphasis on those teachers with an affiliation – through their education and subjects of teaching – with the natural sciences. A comparison with other teachers, in search for an influence of teachers’ subject background in the realisation of technology as a new subject of teaching, will be undertaken in the final discussion of this thesis (Chapter 13), where it can draw on all the stories presented throughout the thesis.

The chapter then gives an overview of various ways in which teachers in this study interpret the relationship between science and technology as school subjects more generally. The teachers’ positioning of the two subjects of teaching will be discussed in light of the framework provided by Fensham and Gardner and presented in Chapter 3. The last part of this chapter analyses teachers’ responses to NITO’s aim of ‘promoting better understanding of the relationship between technology and science’. This part addresses several issues. Firstly, it addresses a question on how teachers perceive a relationship between technology and science *per se*. It then investigates how their perception of such a relationship relates to their position on the role of technology teaching with regards to school science. Finally, the teachers’ comprehension of ‘understanding of the relationship between technology and science’ as a learning objective for pupils will be examined.

Throughout this chapter it is essential for the reader to bear in mind that the school subject denoted ‘Science’ in this thesis refers to the Norwegian school subject ‘natur- og miljøfag’. The name of the subject is elsewhere translated to ‘Science and the environment’ (e. g. KUF 1996). However, a more direct translation of the Norwegian subject’s name would be ‘*Nature and environmental studies*’. This notion does in fact not carry any reference to *science* (‘naturvitenskap’) understood as the professional enterprise of doing research on material phenomena, as is the case with the term used in English language. Nor does the former name ‘naturfag’ (‘Nature studies’) which is still occasionally used in informal settings. Thus, when teachers in this study talk about relating technology to *school* science or science *teaching*, they should not be interpreted as giving their view on a relationship between the human enterprises denoted ‘technology’ and ‘science’. As indicated above, their comprehension of such a relationship will be analysed separately.

Another notion that does not easily transfer from Norwegian to English language, and whose misleading translation is especially relevant in this chapter, is the one of ‘realfag’. This notion has a similar function (yet a very different meaning) to the

English notion ‘humanities’. It embraces the natural sciences, mathematics and related subjects. In this thesis, ‘realfag’ is translated to ‘science and mathematics’, in accordance with dictionaries’ directions (e.g. Kunnskapsforlaget 1998). Correspondingly, ‘realfag’ used in the context of compulsory education will normally refer to the two school subjects Science and Mathematics. The reader should, however, be aware of the fact that the notion in common usage also carries connotations towards technology and engineering. Hence, when teachers talk about ‘realfag’, they may have these connotations in mind, and not necessarily refer to Science and Mathematics as specific school subjects or disciplines. Obviously, this may affect the meaning of the translated text somewhat. In the presentation of quotations from interviews, the bracket [realfag] is added to ‘science and mathematics’ in the English translation in order to signify that this notion is used.

Associating technology with science

As referred in Chapter 1, earlier studies have suggested that teachers interpret technology as a new subject within the framework of their own subjects’ subcultures, and that especially science teachers tend to look upon technology as applied science and approach the teaching of technology accordingly. The TiS project entails high degrees of freedom for the teachers in how they focus their technology teaching. One could hence, in line with the above, anticipate that science teachers make a stronger connection to science in their interpretation and realisation of technology as a new subject of teaching than what other teachers do. Teachers with other kinds of background may correspondingly emphasise other aspects of technology, such as technical skills, aesthetic design or societal and cultural aspects of technology.

The interview data show that many of the teachers in this study – on a discursive level – *associate* technology teaching with science. This applies to teachers with a background in science as well as those with their background in other subjects. The degree and nature of how they relate their actual teaching of technology to science is, however, a different matter. Classroom observations do reveal differences among the teachers in this regard, but the differences will be shown to go in somewhat surprising directions.

Some teachers express their motivation for joining the TiS project as directly related to science teaching, of which examples will be given later in this chapter. As one would expect, this applies especially to teachers who have their educational background in the natural sciences and for whom Science is among their subjects of teaching. However, teachers with background in other subjects are also found to associate the project – and technology teaching more generally – with science and

also mathematics. Irene, who has her educational background in the humanities, can act as an example in this regard. She describes why she chose to join the TiS project:

Irene

It was mostly that it was practical work. I have attended many courses, and I thought that if I am to attend a course, it needs to be something related to practical work (...) But 'technology' in itself, that sounded very 'gloomy' to me.

BB

Why gloomy?

Irene

Mathematics and physics are not really my subjects, and technology ... and I thought a bit about IT and then I thought of the technological corporations we have nearby, Aker Maritim and those things that represent things that I haven't a clue about. So I thought, if it is to be used in school then it must be, then I need to learn how to use it in school! So I was positive to it, I wanted to find out more about it.

Irene

Det var egentlig det at det var praktisk arbeid. Altså, jeg har gått på mange kurs, og tenkte at hvis jeg skulle gå på et kurs, så måtte det være noe som hadde med praktisk arbeid å gjøre. (...) Men 'teknologi' i seg selv, det hørtes veldig sånn 'skummelt' ut.

BB

Hvorfor skummelt?

Irene

Matematikk og fysikk er liksom ikke mine fag, og teknologi... og så tenkte jeg litt på data og så tenkte jeg på de teknologiske bedriftene vi har i nærområdet, Aker Maritim og de her tingene som representerer ting som ikke jeg har peiling på. Så tenkte jeg, hvis det skal brukes i skolen så må det jo være, jeg må jo læres da opp til å bruke det i skolen! Så jeg så jo positivt på det, jeg hadde jo lyst til å finne ut noe mer om det.

[P16: 11 - 29]

Irene's principal motivation for joining the project is connected to the familiar need for 'making school more practical' and the possibilities the project provides in this regard. The link to science is not part of her motivation. The opposite is rather the case, as she states that mathematics and physics are not her subjects and that 'technology' hence sounded 'gloomy' to her. Though the link to these subjects acted more as an obstacle than a motivation to Irene, the quotation shows that she nevertheless *associates* technology teaching with science and mathematics.

Meanings of technology as 'supporting Science'

NITO's official project policy states that one aim for the TiS project is that it is to "support mathematics and the sciences". What kind of 'support' these subjects need, and what the aim implies for realisation of technology teaching associated with the project is, however, not made explicit. The following analysis presents how teachers participating in the project interpret this aim, and the potential they see in technology teaching as 'supporting science'. The analysis draws directly on teachers' responses to questions on what the above referred aim for the TiS project

means to them, but also on interview data and observations obtained in other settings.

Firstly, I will be telling a story on how one of the teachers, Elna, strongly links technology teaching to her teaching of Science, and how she makes her realisation of the TiS project provide for a *revitalisation* of school science, which involves broadening the scope of the subject. The sections following the story present other teachers' comprehension of the potential of technology teaching in supporting school science by providing *learning opportunities* and *application opportunities*, respectively.

SIXTH STORY. REVITALISING SCIENCE TEACHING

Elna's educational background consists of a combination of natural sciences (biology and chemistry) and art (textile). When joining the TiS project, she saw an opportunity to combine her two main subjects of teaching, that is, Science and Art and Crafts. She also relates her motivation more intrinsically to Science⁷ as a school subject:

BB
How come you joined the [TiS] project and the course in England?

Elna
It was because of... What fascinated me, was that it was something more practical, to have something practical connected to... the theory. To combine the two subjects Art and Crafts and Science [realfag]. I think Science become too theoretical, and that the pupils have too much theory.

BB
Especially in Science [realfag] or generally?

Elna
Generally. And to be able to combine, that Science [realfag] not only is a

BB
Hvordan hadde det seg at du ble med på det [TiS] prosjektet og kurset i England?

Elna
Det var fordi at... Det som fascinerte meg, var at det skulle være noe som var mer praktisk, altså kunne få noe praktisk knyttet opp til... teorien da. Å kombinere de to fagene kunst og håndverk og realfagene. Jeg syns at realfagene blir for teoretiske, og at elevene har for mye teori.

BB
Spesielt i realfagene eller generelt?

Elna
Generelt. Og det der å kunne kombinere, at realfag ikke bare er et

⁷ Elna here talks about 'realfag', that is, science *and mathematics*. The notion is in this quotation translated to merely 'science', as it became clear later in the interview that she is mainly referring to this subject.

'book-subject', so that they can see that this can be useful. In practice.

bok-fag, sånn at de kan se at det her kan komme til nytte. I praksis.

[P5: 43 - 62]

Elna addresses the aim of 'making school more practical' with regards to variation in the teaching context ("the pupils have too much theory"). Her concern is, however, not only directed towards the *pupils*, but in fact also towards Science as a *school subject*. She wants to show the pupils that Science is not only a "book-subject" and that it can be useful in practice. Elna may hence be interpreted as having a desire to change the 'ethos' of school science towards utilitarian perspectives, in other words, to reinforce aspects of the utilitarian argument for science education. The way Elna contrasts a 'book-subject' with something that is 'useful in practice' suggests that what she is referring to is utility when operating in the *material* world.

Elna also gives an account of the 'ethos' of school science and mathematics in terms of which *pupils* the subject speaks to and how they portray themselves to pupils more generally:

Elna

My concern is that Science and Mathematics [real-fag] should receive a fresh impetus. (...) That one should not associate it with something that is theoretical and difficult and all that.

Elna

Jeg er litt opptatt av at realfagene skal få litt blest i seilene igjen. (...) At en ikke skal knytte det opp til at det er noe som er teoretisk og vanskelig og alt det der.

BB

That it may be practical and enjoyable also?

BB

At det kan være praktisk og morsomt også?

Elna

Yes. And that it is... to demystify the matter that it is so difficult that we will not succeed in this.

Elna

Ja. Og at det ikke er... å avmystifisere det her med at det så vanskelig at dette her greier vi ikke.

BB

Do the pupils have the attitude that Science, or Science and Mathematics [real-fag], is so difficult and we can not succeed with it?

BB

Er det elevenes holdning at naturfag, eller realfagene er vanskelige og det greier vi ikke?

Elna

They find it difficult. They find Science... or they say, the issues about the body are straightforward. But the other issues they find difficult, and they consider the textbooks as writing difficult.

Elna

De syns det er vanskelig. Naturfag syns de er... eller de sier, det med kroppen er greit. Men det andre syns de er vanskelig, og de syns at bøkene skriver vanskelig.

[P5: 145 - 167]

She describes Science as having an image of being theoretical and difficult, and she claims that the subject conveys a message – manifested through the textbooks – that high ability is required in order to succeed in them. According to Elna, these characteristics of the subjects need to be changed in order to give the subject ‘a new impetus’.

From the above, Elna may be interpreted as possessing an aim of ‘*revitalising science teaching*’. This revitalising involves making the subject more practical, useful and meaningful to pupils with varying academic ability and interest and less enclosed by traditional and academic teaching approaches that are governed by the use of textbooks.

As described in Appendix 1, technology teaching associated with the TiS project is realised in several ways at School E (see Appendix 1). In addition to technology offered to pupils as electives, Elna also runs technology projects incorporated in her Science lessons. One of these technology projects is the building of an ‘electrical wire game’ which she relates to electricity as a curricular topic in grade 9. In this project pupils make printed circuit boards with transistors, diodes and condensers. The circuit also contains a buzzer, which gives an alarm when the wire is touched.

In the session subsequent to the ‘electrical wire game’ project, the pupils investigate printed circuit boards from electronic devices such as television sets. In the following sequence, Elna describes this session and how the investigation of circuit boards brought about a discussion on the function of some of the devices:

Elna

We did make these printed circuit boards by soldering. And afterwards we have found some boards from televisions. One of the boys brought various circuit boards he had taken from diverse electrical things that were defective. And then you could look at them, you could sit and look and tell what was a resistor for instance, light emitting diodes, what a condenser is... That you could distinguish some specific components when you saw them.

BB

Even if you did not understand the

Elna

Vi har jo kobla de kretskortene. Og da har vi jo funnet en del kretskort fra fjernsyn. Det var en gutt her som kom med kretskort som han har plukket ut fra forskjellige sånne elektriske ting som var defekt. Og da kunne du jo se, kunne du sitte og si hva som var motstand for eksempel, lysdiode, hva er en kondensator... At du kunne plukke ut enkelte sånne komponenter når du så det.

BB

Selv om du ikke skjønnte hele kretsen,

whole circuit...

Elna

Yes. You notice, ok this is a printed circuit board, and that is so and that is so and that is so. Some of the things. To me that is some of the intention, to orient them.

BB

That they recognise...

Elna

Yes. Know what it is. Know what it is about; know what a resistor is for example, what it looks like. The light emitting diode, they started with the diode on... the light on the TV. That little red lamp which tells whether it is stand-by or not. And then some started to let their imagination run riot: Yes, it does go out a bit slowly, so maybe it is such a condenser there, attached to the diode, that makes it...

BB

That it does not go out immediately?

Elna

Yes. That was one of the thoughts, because that buzzer, it had a longer lasting sound, because of the condenser they have there. And then they got into this, concerning the light emitting diode, maybe it could be the same device that made it? And then I feel that they have reflected upon it somehow. I don't know whether it is correct or not. But they have reflected upon it.

så...

Elna

Ja. Så ser du, ok det her er et kretskort, og det er det og det er det og det er det. Altså en del av de tingene. Det synes jeg også er litt av hensikten, å orientere dem.

BB

At de kan gjenkjenne...

Elna

Ja. Vet hva det her er. Vet hva det dreier seg om, vet hva en motstand er for eksempel, hvordan den ser ut. Lysdioden, de begynte jo med den der dioden på... lyset på TV'n da. Den der røde lappen som sier at den er stand-by eller ikke. Og da begynte noen å fabulere: Ja, den går jo litt sakte ut, så da er det kanskje en sånn kondensator der da, til den lysdioden, som gjorde at...

BB

At den ikke slukner momentant?

Elna

Ja. Det var en av de tankene, for da var det jo den buzzeren da, den har jo en litt sånn lengre lyd, på grunn av den kondensatoren som de har der. Og da var det det de var inne på, med den lysdioden, kanskje det kunne være den samme greia som gjorde det? Og da føler jeg liksom at du på en måte har tenkt. Jeg vet jo ikke om det er riktig eller ikke, altså. Men de har tenkt det altså.

[P5: 408 - 450]

Elna's electronics session does not intend to 'support Science' in the sense of using electronics as a tool for teaching the 'subject content' related to electricity in the Science curriculum. She formulates the intention as "to orient them", which can be recognised as one aspect of the aim *'Familiarising pupils with technological surroundings'* described in Chapter 9. In the specific teaching project on the electronic devices, this intention is fulfilled when pupils experience that they can recognise

components from their own small electronics project. She formulates learning objectives as 'knowing what it is all about', which includes being able to distinguish components when you see them, know what they look like and how they are named.

Elna also appreciates that the pupils ask questions like "why doesn't the television lamp go out immediately when it is switched off?" and that they can state hypotheses by linking the observed phenomenon to the function of a condenser and see parallels to how the electrical wire game worked. To teach the pupils the actual working principles of the electrical circuit does not appear to be the main aim to Elna. In fact, she confesses that she is not sure whether their hypothesis is true or not. Her emphasis is rather on pupils' development of ability, and motivation, to reflect on such phenomena and working principles as those described above.

How does Elna's teaching project on electronics correspond with the aim conceptualised as revitalising science teaching? The year after she undertook the electrical wire game project with her pupils, she reflects on it this way:

Elna

I believe that my class, if they were to say something they memorised, I actually think it would be the soldering event from last year. Because they felt that then we were not constrained by the material in the book, or read some material in the book and then you are to do exercises, or you do exercises and then you are to link it to some subject matter.

BB

It was not predictable in the same way?

Elna

No, it wasn't. And they found nothing in the book that told them that they were supposed to do so and so. (...)
And that they could recognise the components, the few components they had, we looked at such, in old TVs and radios, and they set about and were able to tell that this is a

Elna

Jeg tror at klassen min, hvis de skulle si noe som de husket igjen, så tror jeg faktisk at det ville være den loddegreia de gjorde i fjor. Fordi de følte at da var vi ikke knyttet til stoffet i boka, eller lese et stoff og så skal du gjøre øvelser, eller at du gjør øvelser og så skal du knytte det til et stoff.

BB

Det var ikke forutsigbart på samme måten?

Elna

Nei, det var det ikke. Og de fant ingenting i boka som fortalte at sånn og sånn skulle de gjøre liksom. (...)
Og at de kunne kjenne igjen de komponentene, de få komponentene de hadde, så så vi på sånne, i gamle TVer og radioer, og så gikk de inn og kunne si at det der var en motstand,

resistor, that one is a condenser, that they could recognise the components. (...)

I think that to show them... link theory and practice to each other, see that what you read about, it has in fact, it is in fact all around you.

og det er en kondensator, altså at de kjente igjen komponentene.

(...)

Jeg synes at det å kunne vise... knytte teori og praksis sammen da, se at det du leser om, det har en faktisk, det er faktisk rundt omkring deg.

[P5: 567 - 593]

Elna confirms several aspects of her aim of revitalising science teaching as she has earlier expressed them. Her concern for presenting Science as something different from – or more than – a ‘book-subject’ is provided for by the fact that the pupils could not find instructions in the textbook on how to carry out the project. Further, the project did not follow the usual school science script of first reading material in the textbook and then doing exercises related to it, or alternatively doing exercises or practicals with the aim of relating it to subject matter in the textbook. The subject hence appears as less abstract. Elna also states that the teaching project “linked theory and practice to each other”, an expression that in this context appears to imply making pupils aware that what they read about (in the Science textbook) is in fact to be found all around them. There is a clear correspondence between the problems Elna sees in the teaching of school science and how she formulates the gains of technology projects. Through technology, she may have found a way of revitalising science teaching and make the subject speak to a broader range of pupils than the academically oriented ones.

A similar approach to science teaching as the one described above can be identified in how Elna is currently teaching optics in a grade 10 class. In this class she incorporates a project where pupils make simple cameras from cardboard boxes and magnifying lenses. They will later develop the photographs taken with these cameras on paper in the darkroom at School E. To achieve a good, or at least acceptable, photograph with this equipment is not a trivial task. For example, the appropriate length of exposure time is uncertain, and Elna needs some systematic experimentation to be undertaken:

BB

It is not exactly easy, from a technical point of view?

BB

Det er ikke helt lett, altså teknisk sett?

Elna

No. I have tried, and I didn't get a good result, but we will get by. I have told my class that they are to be... to give me experience, and we will try

Elna

Nei. Jeg har prøvd, og jeg har ikke fått godt resultat, men det skal gå. Så jeg har sagt til klassen min at de skal nå være... gi meg erfaring, og vi skal

with dissimilar shutters, how long they need to be open, to lighten up the motive. They have to be careful about this, and we will take down notes. And see what is best, how long we must expose in such sunny weather [as today] for example.

BB
Then you include a bit such, that is, systematic experimentation -

Elna
Yes, that's what I tried to tell them, that they must help me with. So we have ten cameras lying down there, cardboard cameras.

prøve med forskjellig lukker, hvor lenge de er oppe, belyser motivet. Det må de være litt nøye med, og så skal vi skrive ned. Og se hva som er best, hvor lenge vi må eksponere i sånt solvær [som i dag] for eksempel.

BB
Da får du jo litt sånn, altså å utprøve ting systematisk -

Elna
Ja, det var det jeg prøvde å si til dem, at de må hjelpe meg med. Så vi har ti kameraer liggende nede, pappkameraer.

[P15: 145 - 160]

Again, conceptual knowledge is not in focus in Elna's teaching of technology in Science lessons. In the above quotation, she demonstrates a commitment to making the cameras *work*, rather than to teaching pupils the principles that *make* them work. She wants the pupils to undertake systematic experimentation with the factors that affect the quality of the photo. To Elna, the purpose of this experimentation is not to make pupils learn about *experiments* as such – as hinted at by the interviewer – but rather, again, to actually make the cameras *work*.

The building of cameras is not one of the activities in the 'activity account' associated with the TiS project and described in Chapter 8. Neither is it a common 'practical' in the traditions and curricula of school science. Therefore, it was natural to ask Elna where the idea came from, and how she acquired the necessary knowledge for making the cameras with pupils:

BB
Where have you learnt how to do things like that?

Elna
Well, I think I saw it in a Swedish book, and I saw it in the teachers' guide for Art and Crafts, 2D-3D-CD, where there also is a description of it. And I think, when I was young, it was, Rolf Victor had such a youth program on TV. And sometimes we were allowed to send in projects, and it was these things about the cardboard camera among other things. So I have

BB
Hvor har du lært hvordan man gjør sånt?

Elna
Nei, det tror jeg jeg så i en svensk bok, og så så jeg i lærerveiledningen for forming, 2D-3D-CD, den har også en beskrivelse av det. Og så tror jeg, i min spede, eller i min ungdom så var det, Rolf Victor hadde et sånt ungdomsprogram i TV. Og der var det av og til sånn at vi skulle sende inn oppgaver, og der var det og blant annet det der med det pappkameraet.

done it once before in... I got a photograph I sent to the television company and got a diploma for it, it was a small shadow photograph.

BB
When you were a young girl?

Elna
Yes, 11-12 years old. My sisters and I had made cameras. So I knew from that time that it was possible. But I didn't remember anything of how I did it before I found it in the Swedish magazine.

Så jeg har gjort det en gang før i... jeg fikk et bilde som jeg sendte inn til NRK og fikk diplom for, det var et litt sånn skyggebilde.

BB
Da du var ungjente?

Elna
Ja, 11-12 år. Jeg og søstrene mine hadde laget til kameraer. Så jeg visste vel fra den tid at det gikk an. Men jeg husket ikke noe av det jeg gjorde da, før jeg fant det i det der svenske bladet.

[P15: 164 - 182]

Elna explains that she has got descriptions of how to make cameras from several written sources. Most important, however, appears to be Elna's *experience* of making cameras together with her sisters when she was a young girl. Seeing the description in a Swedish magazine or book reactivated the memory of this experience, how it can be done, and *that* it in fact can be done.

From the above, Elna's aim of revitalising science teaching appears to entail a broadening of the subject to include technology as a component, where learning objectives go beyond what is commonly comprehended as content and processes of science. Elna does not, however, appreciate a change of the subject in other directions. In current educational debates, *societal* aspects of science and technology are highly emphasised, and catchwords like 'scientific and technological literacy' are often associated with a need for including socio-scientific issues in the teaching of science and technology in general education (e.g. Kolstø 2001). This represents a broadening of the scope of the subjects that Elna does not approve. Her position on these matters becomes explicit at the end of an interview where Elna is asked whether she wants to add anything:

Elna
But I thought of another issue here. I feel that science⁸, the way it has become now, Science in schools, it has become very much social studies.

Elna
Men jeg tenkte på en annen ting her. Jeg føler at naturvitenskap, sånn som det er blitt nå, natur- og miljøfag hos oss, så har det blitt veldig mye samfunnsfag.

⁸ Elna here uses the word 'science' as equivalent with 'real science' (*naturvitenskap*), not the school subject (*natur- og miljøfag*).

BB

That Science-?

Elna

School science has become very much like social studies, argumentation, discussing. And little factual knowledge.

BB

That it, like about the role of science in society?

Elna

Yes, that it is very much directed towards environment, and to be able to discuss damages it leads to and how you can make improvements and so.

BB

You would rather have...?

Elna

I think it is difficult for them, without knowing... basic knowledge, to form arguments and discuss. Because I feel, especially I noticed on the Oslo test we now have had, it included argumentation, they presented a small article about fat food, or an investigation showing that we eat too much sugar -

BB

Nutrition?

Elna

Yes, nutrition. But we eat healthier now than we used to. And you get... blah-blah-blah, yes we do, I agree on that and so on. Without going into the substance, what is it that is wrong with the sugar, for instance, that we get too much sugar. It doesn't have... yes, I felt it was a bit on the surface, like social studies, if you knew some social science, then...

BB

Mm. That one needs to know some

BB

At natur-?

Elna

Natur- og miljøfag er blitt veldig mye liknende et samfunnsfag, argumentasjoner, argumentering. Og lite faktakunnskap.

BB

At det, sånn om rollen til naturvitenskapen i samfunnet?

Elna

Ja, at det er veldig mye rettet på miljø, også skal du kunne diskutere skader det fører til og hvordan du skal gjøre forbedringer og sånt.

BB

Du ville heller hatt...?

Elna

Jeg synes det er vanskelig for dem, uten å vite... basiskunnskap, å sitte å argumentere og diskutere. Fordi jeg føler, eller spesielt, jeg så på den Osloprøven nå vi har hatt, så var det argumentasjon med, de hadde kommet med en liten artikkel om fet mat, eller undersøkelse om at vi spiste masse sukker -

BB

Kosthold?

Elna

Ja, kosthold. Men vi spiser sunnere nå enn før. Også får du... bla-bla-bla, ja det gjør vi, jeg er enig i det og så videre. Uten å gå ned i materien, hva er det som er galt med sukkeret for eksempel, at vi får for mye sukker. Det har ikke... ja, jeg følte at det var litt sånn på overflaten, ala samfunnsfag, kunne du en del samfunnsfag så...

BB

Mm. At man må kunne noe substans

substance to be able to participate in such a discussion?

for å kunne være med på en sånn diskusjon?

Elna

Yes, I think so. That it is forgotten, because you feel that you can... you can say something about it [anyway].

Elna

Ja, jeg syns det. At det blir glemt, fordi at du føler at du kan... du kan si noe om det [uansett].

[P15: 455 - 497]

Elna does not appreciate the increasing emphasis on societal issues in Science curricula, teaching and testing. This does not mean that she disregards the importance of empowering pupils in dealing with science-related questions in contemporary society. On the contrary, she sees science content knowledge as a better basis for participating in debates of socio-scientific character than argumentation skills and understanding of the debating as such. When confronted with the current 'trend' in science education of viewing scientific literacy as comprehension of science that goes beyond the factual knowledge - in order to give her the opportunity to modify her statement - she keeps her argument:

BB

But it is very much like, I would almost say 'in' in the science education community, to connect it [science] to society and make it relevant... There is nobody who remembers everything they have learnt, as facts, relations and understanding... But that what they should keep with them is a type of literacy that goes beyond this pure knowledge.

BB

Men det der er jo veldig sånn, jeg vil nesten si 'in' i fagdidaktiske kretser, at det [naturfag] skal koples til samfunnsrelevans og gjøres relevant og... Det er ingen som husker alt de har lært, som fakta, sammenhenger og forståelse... Men at det som skal sitte igjen er en form for allmenndannelse som går utenfor den her rene kunnskapen.

Elna

Well, then I don't agree completely with this. Because I think that you lose some of the subject that way. But that is how it has become, apparently.

Elna

Det er vel ikke jeg helt enig da. For jeg syns at, jeg tror du mister litt av faget på den måten. Men sånn er det blitt, ser det ut som.

[P15: 499 - 508]

Elna points to a risk of 'loosing the subject' in the current trend of giving more priority to societal aspects in the subject. Seen from Elna's perspective, this trend does not fit with the aim of revitalising science teaching.

Broadening the scope of school science

The Sixth story has explored Elna's aim of revitalising science teaching. The need she sees for revitalising the subject is based on her experience of the subject as presenting itself as abstract, difficult and irrelevant to the pupils. Revitalising the subject involves exhibiting its utilitarian and practical aspects and altering the subject's ethos as a difficult and abstract 'book-subject', which requires a special academic ability to succeed in. Elna's concern is not new on the educational scene; the problem she is addressing clearly echoes what has long ago been characterised as 'the tyranny of abstractions' in school science (see Layton 1973).

Technology teaching and participation in the TiS project represent tools for Elna in her desire to give her teaching of Science what she calls a new impetus. To Elna, technology teaching 'supports' the subject in the sense that it moves it away from 'the tyranny of abstractions' and from teaching that is bound by the textbook and towards practical activities with the intention of making things work. This involves a broadening of the content, purpose and intended learning outcomes of the subject itself, in order to make the subject more useful and motivating, and to make it communicate with a broader range of pupils. Worth noting, however, is that Elna's approach is fully consistent with the requirements of the formal curriculum for Science. The audit undertaken in Chapter 5 revealed that L97 provides for inclusion of technological topics in Science the way Elna does. The 'ethos' of the subject she describes is hence not due to the curriculum's requirements; it probably represents features of the subject as it appears in traditions and common approaches to the subject.

The projects and technological topics Elna includes in her science teaching are addressed in their own right, not as a way of pursuing new and better ways to teach the content of school science by means of technology. Nor does her teaching convey any view of technology as 'applied science', apart from the fact that her technology teaching is an integral part of Science as a school subject. Elna's inclusion of technology in science teaching thus appears to function as a vehicle in fulfilling her aim of *revitalising* school science, rather than as a 'vehicle for teaching science' (Jones & Carr 1992). Her approach rather shows similarities with a 'technoscience' education which Bencze (2001) has advocated as an alternative to the 'tyranny of school science' represented by the subject taught in an academic way mainly for selection purposes.

Technology as learning opportunities

With the focus more on the body of conceptual knowledge that is already present in the Science curriculum and in the traditions of science teaching, some teachers see, and utilise, technology teaching as a source of *learning opportunities* for science

content knowledge. As described in Chapter 9, some teachers point to lack of prior experiences with the material world as an obstacle in pupils' learning of science and in making meaning of the content matter presented to them in school science. David emphasises the potential of technology teaching in this regard, as it provides possibilities for fulfilling the need for building experiences in order to enhance learning and pupils' motivation for learning. The role of technology teaching in school science has, however, a broader meaning to David than the building of experiences prior to the 'real' teaching. As has earlier been referred, David denotes technology a '*problem-solving approach to Science*', and contrasts it directly to 'what is written in books'. To David, technology represents one possible approach to the teaching of a given content, or to 'cover the subject':

David

(...) what I think of as technology, is when I work with practical problem solving tasks related to the making things. Then you have in a way covered the subject, I feel.

David

(...) det som jeg tenker på som teknologi, det er når jeg jobber med praktiske problem-løsende oppgaver knyttet til det å lage noe altså. Da har du på en måte dekket faget, føler jeg da.

[P14: 791 - 793]

Examples of the problem solving tasks David uses in his science teaching are making a hot air balloon from silk paper, making 'siege machines' and buggies from cardboard and wood, creating animation movies that illustrates aspects of the particulate nature of matter and building model planes and make them fly. In the perspective of a science subject aiming at teaching pupils scientific conceptual knowledge, one may question the approach David makes when including those activities as an extensive component of his teaching of Science, and the fact that he considers himself to 'cover the subject' that way. His approach might be associated with 'discovery learning' and an empiricist view of science knowledge, that is, that science knowledge follows from pure sense experience. Being quite heavily challenged on this idea by the interviewer, David justifies his standpoint as follows:

BB

It doesn't go without saying -

BB

Og det gir seg jo ikke selv -

David

No, it doesn't.

David

Nei det gjør det ikke.

BB

Even if you make a buggy that contains, that is, a buggy that rolls will always involve friction, but it is not self-evident that the pupil learn about friction?

BB

For det om du har, altså hvis du lager en bil hvor det inneholder, altså en bil som triller vil jo alltid innebære friksjon, men det er jo ikke dermed sagt at eleven lærer om friksjon?

David

No, it is not.

David

Nei, det er det ikke.

BB

Just because the phenomenon is present, in a way.

David

But then you have at least created a potential for talking about things. The same with the siege machine, it is not hopeless to talk about energy and energy transfer and so related to siege machines for example.

BB

But it doesn't go without saying?

David

No, it doesn't, it does not emerge by itself, and it can easily slip. Sometimes. But I think, I think like this, and one ought to realise this soon, during 13 years in school, where they do almost the same things in primary school as in lower secondary as in upper secondary, and most of the pupils are fed up as they go along. That's the reason why they quit it, so I want to state it in its extreme form and say that a 'happening' does at least not do any harm, there are too few 'happenings' in Norwegian schools, right? But we must try, of course we must try to relate the subject to it. If the 'happenings' involve sending up hot air balloons, if the happenings involve that you work with mechanics in some sense, or with... There is subject content in it, in almost all the activities we have done, building towers and so, the subject is there! But it is not so evident, that is, it does not automatically display the theory all the time, it requires some experience in a way to do it, and maybe you don't succeed the first time you do the project either. But I think you will improve after a while in seeing where you could have done more, and then you do it later. So I think it is... More 'happening'. I think it is a 'happening' when we send up those four hot air balloons outdoors, it is a 'kick', the pupils run. How much of the physics in it they learn, that's... But there is a potential for doing it! They don't learn any more physics when you in a way stand there and talk about it. I am absolutely sure about that.

BB

Bare at fenomenet er til stede, på en måte.

David

Men da har du i alle fall laget et potensiale for å snakke om ting. Det samme med kastemaskin altså, det er jo ikke håpløst å snakke om energi og energioverføring og sånt knyttet til kastemaskiner for eksempel.

BB

Men det gir seg jo ikke selv?

David

Nei det gjør ikke det, det gir seg ikke selv, og det kan være lett at det glipper. Innimellom. Men jeg tenker, jeg tenker litt sånn, og det må en etter hvert begynne å se i løpet av et 13-årig langt skoleløp, der de gjør det samme nesten nå i barneskole som i ungdomsskole som i videregående, og de fleste er etter hvert dritt lei. Det er jo derfor de ikke går videre med det, så jeg vil jo spissformulere meg litt og si at en 'happening' er i hvert fall ikke farlig, det er alt for lite 'happenings' på en måte i norsk skole, ikke sant? Men vi må prøve å, klart vi må prøve å kople faget til det. Altså, hvis 'happeningene' er knyttet til det at du sender opp varmluftsballonger, hvis 'happeningene' er knyttet til at du driver og jobber med mekanikk på en eller annen måte, eller med... Det er jo faglig innhold i det, altså i nesten alle oppgavene vi har hatt med å bygge tårn og sånt, faget ligger jo der! Men det er ikke så tydelig, altså, det gjør seg ikke selv å klare å vise teorien hele tiden, det krever litt erfaring på en måte å gjøre det, og det er ikke sikkert du får det til første gang du gjør prosjektet heller. Men jeg tror du blir flinkere etter hvert i å se at her kunne jeg fått til mer, og så gjør du det senere. Så jeg tror det er en sånn... Mer 'happening'. Jeg tror det er en 'happening' når vi sender opp disse fire varmluftsballongene ute her, det er et 'kick', altså elevene springer. Hvor mye lærer de om fysikken i det, altså... Men det ligger en mulighet til å gjøre det. De lærer ikke noe mer av fysikken ved at du på en måte står og snakker om det. Det er jeg i hvert fall helt sikker på.

[P14: 360 - 406]

David does not claim that pupils necessarily learn science, understood as generalised conceptual knowledge, by undertaking the above mentioned technology projects, which he denotes ‘happenings’. He admits the difficulties in making pupils learn the curricular subject content from them. They do, however represent what David calls “a potential for talking about things”, that is, they provide possible learning contexts that are motivating to the pupils. The challenge of teaching the *subject* is then to find ways of utilising this potential for pupils’ learning of subject content. Even if the approach may have weaknesses in the sense of pupils’ learning of subject content, David holds the conviction that they would nevertheless not learn more by a more traditional approach, which he describes as “stand there and talk about things”.

David confesses that his approach to science teaching is sometimes at odds with what is seen as appropriate in the educational community:

David

I sometimes interpret others, like on the technology seminar we attended, college educators who come in... where people are so concerned about... “they are ok, all those amusing activities, but where is the subject?”. Right? And then I think: Ok, that’s fine, but where is the *pupil*? Are we throwing out the baby with the bath water here? Are we so concerned about our subject so that we run over the pupil and miss the point completely?

BB

That we keep on with our subject, and the pupil -

David

- and then they are not interested! We need to make them interested first!

David

Men jeg kan godt oppfatte andre, sånn som på den teknologisamlinga vi var nede på, høgskolelærere som kommer inn... der folk er så opptatt av... ”det er vel og bra, disse oppgavene som er gode og fengende, men hvor er faget”, ikke sant? Og da tenker jeg, det er greit altså, men hvor er *eleven* da? Ikke sant, skal vi helle ut eleven med badevannet her, er vi så opptatt av faget vårt at vi overkjører eleven og bommer fullstendig?

BB

At vi står og holder på med vårt fag, og eleven -

David

- og så er de ikke interessert! Vi må jo få dem interessert først!

[P14: 340 - 352]

David advocates a view of teaching that is strongly pupil-centered, and indicates a tension between his concern for the pupil and what can perhaps be called a concern for the subject. However, David’s conception of technology teaching as a ‘problem-solving approach to Science’ can just as well be interpreted as ‘supporting the *subject*’ by providing pupils with learning possibilities represented by motivational ‘kicks’ as well as ‘happenings’ that function as potential learning contexts. These motivational factors are not only enhancing learning in David’s view – they are a prerequisite for learning to occur at all. This emphasis on the motivational effects of activities echoes what is found elsewhere, that teachers see motivation and

interest as the most important outcome of practical work in school science (Kind *et al.* 1999).

Frederic expresses a view of learning contexts in science teaching that has some similarities with David's view presented above. However, Frederic's concern is not primarily that the traditional approaches to school science fail to make pupils learn the content of the subject, but rather that the knowledge is bound by the context of the science lab itself. Below, he creates a picture of how the science knowledge remains in the cupboard together with the lab equipment after having undertaken practical work in school science:

Frederic

Usually when we do physics practicals, we acquire some lab equipment, some springs and blocks and so on, we do a practical and then we put everything back in the cupboard, and the knowledge stays in there. It is something one does in such a physics lab... - in that cupboard! [pointing to the cupboard in the room] It is not something we do otherwise. And that is in a way what we wish to assign to our projects, that the pupils take something home, so that they can show what they have worked with. Then they perhaps have to explain at home how it works. Then we are a step further.

Frederic

Vanligvis når vi driver med fysikk-øvelser så tar vi jo fram noe lab-utstyr, noe fjærvekter og klosser og sånt, så gjør vi en øvelse og så rydder vi og putter det inn i skapet igjen, og så blir kunnskapen der. Det er noe man gjør på en sånn fysikk-lab... - i skapet der! [peker på skapet i rommet] Det er ikke noe vi gjør ellers. Og det er på en måte det vi ønsker å gi våre prosjekter, at elevene tar med seg noe hjem, at de viser det de har holdt på med. Så må de kanskje forklare hjemme hvordan det virker. Da er vi kommet et steg videre.

[P7: 400 - 406]

Frederic's description of Science 'in the cupboard' might be interpreted as a metaphor pointing at two aspects of practical work in Science. One is the *relevance* of the equipment and procedures represented in practical work in Science ("It is not something we do otherwise"). Secondly, the metaphor may involve the idea of *situated knowledge* attained in the lab, it is associated with the equipment and procedures of the lab context, and does not transfer to other contexts. When doing technology projects, in contrast, the pupils have the opportunity to bring their products – and acquired knowledge – out of the context of the science lab. What Frederic also might be touching upon here, is that the products of science are conceptual knowledge, or more precisely 'inscriptions' of the material world (Latour & Woolgar 1979, Latour 1987), while the products of technology are material artefacts.

However, the way Frederic uses the idea of 'Science in the cupboard' appears to be mainly in a physical sense rather than as a metaphor for the lack of relevance of science teaching or the situatedness of science knowledge. This is exhibited when Frederic is reminded of the idea of 'Science in the cupboard' in a later interview and challenged to comment upon it:

BB

In the previous interview you talked about science teaching, and you said that when we do experiments in Science, some equipment is acquired from the cupboard, and then the knowledge stays in there when the equipment is put back! Can you say something more about it?

Frederic:

Yes, I can relate it to the mechanical toy also. They make some transformations, a camshaft and a crankshafts and try to learn those concepts. And they take it [the product] back home, so that if someone asks about “how does this thing work”, they might use those concepts once more. In opposition to if we had done it somehow in the science lab and put it back in the cupboard again.

BB

I det forrige intervjuet snakket om naturfaget, og så snakket du om at når vi gjorde forsøk i naturfag, så tar man fram noe utstyr fra skapet, og så ble kunnskapen der inne i skapet når man ryddet det inn igjen! Kan du si noe mer om det?

Frederic

Ja, jeg kan jo knytte det til den mekaniske leken og. Da lager jo de en del sånne overføringer, en kamaksel og en veivaksel og prøver å lære de begrepene. Og det får de jo med seg hjem, sånn at hvis noen skulle finne på å snakke om ”hvordan virker dette”, så vil de kanskje bruke de begrepene en gang til. I motsetning til om vi hadde lagd det i ett eller annet, på et naturfagrom og satt det inn igjen, i skapet.

[P10: 9 - 22]

Using the mechanical toy project described in the Fourth story as an example, Frederic responds to his own idea of ‘Science in the cupboard’ by stating that it is important that pupils bring their products home in a *physical* sense. He relates this to the possibilities these products provide for consolidating the *conceptual* knowledge, that is, the technological principles he has identified as learning objectives. Taking the product home may promote learning of these principles, as the pupils might be expected to, or want to, explain how it works to their family and friends. Hence, the material objects pupils create in technology sessions represent in themselves possibilities for learning of conceptual knowledge and thus for ‘supporting Science’, due to the fact that the pupils bring the objects with them in a physical sense.

Technology as application opportunities

Among the teachers in this study, technology teaching is also found to play the role of providing opportunities for pupils to *apply* knowledge already learnt in school science and other subjects. Gina provides us with an example. As a science teacher, she experiences that her pupils have problems in seeing the significance and relevance of school science – and in this case also mathematics – in their own lives:

Gina

(...) if you ask them, how they consider, if you have any need for Science and Mathematics, then most of them will say that Mathematics you have absolutely no need for, you do have a calculator, there is no need

Gina

(...) hvis du spør dem liksom, hvordan ser de for seg, om du har bruk for naturfag og matematikk, så vil de fleste si at matematikk har du i hvert fall ikke bruk for, du har jo kalkulator, du trenger ikke å forstå noe, du

for understanding anything, you don't need Mathematics. There are 10th graders saying that as well, they don't understand what you need Maths for! The same with Science: "No, that is something about atoms and stuff", and they are not able to see more than that. The subject is too limited perhaps, to see connections. You learn a bit chemistry, a bit physics, a bit biology, but you are not able to relate it to daily life perhaps. (...) It becomes such an isolated theory thing that the teacher talks about, Science and Maths, you don't have any need for that!

har ikke noe bruk for matte. Det er 10. klassinger som sier det og, skjønner ikke hva de har bruk for matte til! I det hele tatt. Samme med naturfag: "nei det er jo noe sånn om atomer og greier" og de klarer ikke å se mer enn det. Faget blir for spinkelt kanskje til at du ser sammenhenger. De lærer litt kjemi, litt fysikk, litt biologi, men klarer ikke å kople det til dagliglivet kanskje. (...) Det blir en sånn isolert teorigreie som læreren snakker om, det, naturfag og matte, du har ikke noe bruk for det!

[P13: 942 - 968]

The way Gina describes pupils' perception of Science and Mathematics signals that she does not question the actual significance and relevance of the content of the subjects. The problem she is addressing is rather the one of making pupils *see* the subjects' importance and relevance for their daily life. She also indicates that Science as a school subject is too limited for the pupils to see connections, which might suggest that some of the problem could have been solved by actually teaching pupils *more* chemistry, physics and biology. The problems Gina describes are raised again when she is about to start her teaching of technology as a separate elective unit at School G, and she expresses her expectations this way:

Gina

What is enjoyable with having such a group [in technology] now... the pupils, they have done Art and Crafts, right, and they have had some Science. Then we will see how much they manage to connect this, what can they accomplish?

BB

Yes... But have they done - what level is it?

Gina

This is grade 10. So they have done some physics, within Science, we have worked quite a bit on forces, so this will be an extension of what they have learnt there and, if we will go somewhat into the subject matter, then they have touched upon some issues, and concepts and principles there earlier. But this is a golden opportunity to use it for something!

Gina

Det som er artig med å ha en sånn gruppe [i teknologi] nå da så... elevene, de har jo vært på forminga, ikke sant, og de har jo hatt naturfag. Så får vi se hvor mye klarer de å koble det her da, hva kan de få til?

BB

Ja... Men har de hatt - hva slags klassesetning er det?

Gina

Det er 10. det her da. Så de har jo for så vidt hatt litt fysikk da, i naturfaget, krefter har vi jo jobbet ganske mye med, så det blir en utvidelse av det de har lært der og, hvis vi skal gå inn på det faglige noe særlig da, så har de jo vært borti en del ting, og begreper og prinsipper der fra før. Men det her er jo en gylden mulighet til å få brukt det til noen ting!

[P8: 226 - 240]

Gina launches technology as an area where pupils have the opportunity to *apply* and combine their knowledge from the subjects Science and Art and Crafts. In the

case of the science they have learnt, she describes technology sessions as “*a golden opportunity to use it for something*”. Hence, technology teaching provides *application opportunities* for science knowledge, and may thus ‘support Science’ in the sense that it gives pupils the chance to apply what they have learnt and hence exhibits for the pupils the relevance and significance of the subject matter. This interpretation is confirmed by how Gina comments explicitly on NITO’s aim of ‘supporting mathematics and the sciences’:

BB

They say it is to support mathematics and science (...). Does it do that?

BB

De sier at det skal støtte opp om matematikk og naturfaget (...). Gjør det det?

Gina

I don’t know what is meant by “support”, but there is something about seeing what, why those subjects are useful. Whether it makes more pupils choose Science and Mathematics [real-fag], I really don’t know, but at least perhaps the pupils get an opportunity to understand the significance of that kind of knowledge, that it is important, and that everybody needs to know it.

Gina

Jeg vet ikke hva som menes med ”støtte opp om” da, men det er jo noe med å se hva, hvorfor er de fagene nyttige. Om det får flere til å velge realfag, det vet jeg nå ikke men, i hvert fall kanskje at elevene får en mulighet til å forstå betydningen av den type kunnskap, at det er viktig og at alle har behov for å vite det.

[P13: 932 - 941]

She approaches the question of whether technology teaching associated with the TiS project ‘supports’ Science and Mathematics in schools in an utilitarian perspective, but not essentially in the meaning of enhancing recruitment or exhibiting career possibilities for pupils. On the contrary, she states that *everybody* needs some knowledge of these subjects, and that technology teaching may contribute to making pupils perceive the subjects as useful, relevant and significant.

Gina’s view of technology as an area where pupils apply knowledge matches the way the educational invention Design & Technology initially was presented as a school subject in England and Wales in the late 1980s. It was described as a curricular area where pupils “draw on knowledge and skills from a range of subjects but always involving science and mathematics” (see Barnett 1992). Gina does, however, signal a much closer connection between the content of the subjects and their application in technology teaching, by denoting technology as an *extension* of subjects where the knowledge being applied stems from. Below, she gives us an example of how technology can function as an extension of other subjects:

Gina

(...) If they have learnt some theory, electricity, electronics in Science, and worked with working drawings, or learnt to draw for example, in Art and Crafts, then it seems quite natural, then you can do a project, right, where you make working drawings and

Gina

(...) Hvis de har lært noe teori, strømlære, elektronikk, elektrisitet i naturfaget, og jobbet med arbeidstegninger, eller lært å tegne for eksempel, i kunst og håndverks-faget, så er det jo ganske nærliggende, da kan du gjøre ett prosjekt, ikke sant, hvor du både lager

draw circuits and on the whole combine it. You can do it, you have the opportunity to do it! But it is not as easy to be as free within one subject, Science, where you cannot do much else!

arbeidstegning og tegner kretser og i det hele tatt å kombinere det da. Du kan gjøre det da, du har mulighet til å gjøre det! Men det er ikke så lett å være så fri innenfor det ene faget, naturfag, der kan du ikke gjøre så mye annet!

[P8: 856 - 863]

To Gina, it is necessary for the ‘extension’ of the subject to take place outside the framework of the subject itself, due to the required combination with elements from other subjects. She indicates that Science as a school subject will not allow the inclusion of elements from other subjects in such a combination.

Other teachers also identify application opportunities for science knowledge in technology projects. Irene refers to a project she runs that involves simple electronics, and points to how this fits with learning objectives related to Science:

Irene

Electricity is a topic in Science, so I thought that when we were to learn about where the current comes from and so, it was nice to have the opportunity to apply the current for something, right? So then we could make an electrical circuit, and we could have a look. Plus and minus and those things, how we wire and the colours, black and red on the wires and short and long on the diode and all these concepts, try to include it. And the battery, those poles and so... It was convenient to create a thing, and then we included a component of design in a way.

Irene

Elektrisitet er jo et emne i natur- og miljøfag, så tenkte jeg at når vi nå skulle lære hvor strømmen kom fra og alt det der, så var det jo kjekt å kunne bruke den strømmen til noe og, ikke sant? Så da kunne vi jo lage en elektrisk krets, og så kunne vi se. Pluss og minus og de her tingene, hvordan vi kopler og fargene, sort og rød på ledningene og kort og lang på dioden og alle de her begrepene, prøve å få det litt inn. Og batteri, og pluss og minus, de her polene, altså... Da var det jo greit å lage en ting da, og da koplet vi det liksom på en sånn formgivingsbit på en måte.

[P16: 548 - 557]

Irene states that it would be “convenient to apply the current for something”. This is probably not meant in a physically sense, but rather related to using the electronics project as a context where pupils could apply and extend their knowledge of electrical circuits.

Summary: Technology as response to limitations of school science

Based on the Sixth story, Elna has been interpreted as utilising technology teaching as a vehicle for revitalising school science. It involves a broadening of the scope, content and aims of the subject to include technology, not primarily as applications, illustrations or motivation for the ‘real’ science content, but rather as a component of the subject in its own right. Elna expresses her rationale for this approach, and also her motivation for joining the TiS project, as related to a comprehension of traditional school science as not communicating with all pupils and as having an

‘ethos’ of being abstract and difficult. Hence, Elna’s use of technology projects within science teaching can be seen as a response to limitations and shortcomings she sees in the traditions of school science. This interpretation may also be applied to the other teachers’ approaches described in the foregoing. David’s view of technology as a ‘problem-solving approach to science teaching’ is motivated by how he experiences that school science as it is commonly taught does not make meaning for the pupils, due to lack of prior experiences and lack of motivation. Technology teaching represents a way of providing the experiences, motivation and learning opportunities that David sees as urgent for the teaching of Science. Gina expresses a concern for pupils seeing the relevance and applicability of school science, and refers to pupils who do not see what science knowledge could possibly be used for. Accordingly, she views technology as providing application opportunities that can demonstrate the relevance and applicability of science knowledge.

A high degree of internal consistence is found in how the teachers above perceive and experience limitations and shortcomings of school science and how they see and utilise the potential of technology teaching in schools. Their perception and realisation of technology teaching can hence be seen as a *response* to these limitations and shortcomings. In fact, this interpretation can also apply in the case of Eric, who in the Third story conceptualised technology as a domain of knowledge in its own right and independent of science. In the quotation below, he identifies limitations in the *purpose* of school science, and how he came to discover this through participation in NITO’s course in England:

Eric

[It was a] very strong experience... from England. Because I then looked back on what we, what I have been doing, what we are doing, in Science, here at the school. And we have always been proud of, maintain - I think - high standards; there are many good teachers at this school, in all subjects. And [I have] had such a rule for myself, every lesson in Science: a demonstration or two, or lab work or a small practical, some thing or another that is practical. Then I have considered, what they have usually been through during three years in this lower secondary school, that all demonstrations, all lab work, have had the purpose of supporting theory! That was a shocking experience, it was a deep one. One exception, and that was when we (...) made soap, made a piece of soap. With some lye and coconut fat and finally added some colour or some drops of perfume, and made a marbled and perfumed piece of

Eric

[Det var en] veldig sterk opplevelse... fra England. Fordi jeg så da tilbake på hva vi, hva jeg har drevet med, hva vi driver med, i naturfagene her på skolen. Og vi har alltid vært stolt over, holder et - tror jeg - bra nivå, det er mange dyktige lærere på denne skolen, i alle fag. Og [jeg har] hatt en sånn standard for meg selv, enhver time i naturfag: enten en demonstrasjon eller to, eller en elevøvelse eller en liten gjøring, et eller annet praktisk. Så har jeg da tenkt gjennom, hva de da har gjort gjennom et normalt løp, tre år i ungdomskolen her, at alle demonstrasjoner, alle elevøvelser, har hatt det sikte, å bygge opp under teori! Det var en sjokkopplevelse, den satt ganske dypt altså. Ett unntak, og det er når vi (...) kokte såpe, lagde et såpestykke. Med litt lut og kokosfett og til slutt satte til litt konditorfarge eller noen dråper med parfyme, og laget en marmorert og parfymert såpe. Og laget et lite såpestykke. Da var det

soap. Then it was a product, where we have simulated an industrial process; they can take it home and use it. And that emphasises another aspect with the thing with the sciences; that the purpose is to understand, that you should understand a working principle, but you should not be able to make it yourself. The goal is to understand, to support theory. The goal for us in technology, can be said simple in contrast, is to make products, it is to apply knowledge.

et produkt, hvor vi har simulert en industriprosess, de kan ta den med hjem og bruke den. Og det understreker også en annen side ved ... understreker den tingen med naturfagene, at siktemålet er å forstå, at du skal forstå en virkemåte, men du skal ikke kunne lage det selv. Målet er å forstå, bygge opp teori. Målet for oss i teknologi, kan da si enkelt i kontrast, det er å lage produkter, det er å anvende kunnskap.

[P6: 489 - 507]

Eric describes the practical work he has undertaken throughout many years as a science teacher, with the only exception of the making of a piece of soap, as aiming to 'support theory' in the sense of promoting pupils' understanding of generalised concepts and principles. This characterises limitations in the subject with regards to its *purpose*, as – in Eric's words – the purpose of practical work in Science is to enable you to understand, but not to make use of that understanding. His characterisation of school science shows some similarities with how Elna has described the subject in the Sixth story. They do, however, come to very different conclusions when it comes to meeting these limitations. To Elna, they motivate a change of Science as a subject towards technology, whereas Eric sees them as motivating technology as a separate subject in addition to Science. To stretch the meaning of 'supporting science' somewhat, Eric may be interpreted as seeing technology as 'supporting science' in the sense that it fills the role that science teaching can not.

Positioning technology with regards to school science

In the preceding sections, several ways of positioning technology with regards to school science can be identified. This section examines how the teachers' positions in this regard compare to the framework provided by Fensham and Gardner (1994). As described in Chapter 3, their framework classifies approaches to science and technology teaching as 'science before technology', 'technology before science', 'science and technology as independent' and 'science and technology in partnership'.

The Sixth story has shown how Elna uses technology teaching as a vehicle for revitalising science teaching by broadening the scope and content of school science to include technology projects. The technological content in her teaching is included in its own right and associated with its own learning objectives, and does not figure as merely applications of science knowledge. Elna's approach may thus be regarded as a '*Partnership approach*' to the teaching of science and technology.

The other categories in Fensham and Gardner's framework are also reflected among the teachers in this study. Gina's view of technology teaching as an arena for application of knowledge from Science may be seen as reflecting the '*Science before Technology*' approach. In Ann's technology teaching presented in the First story of this thesis, science knowledge relevant for the technology projects are addressed on a 'need to know' basis in various stages of the sessions, yet not motivated by any attempt to 'support Science'. Hence, Ann's approach may be interpreted as a '*Technology before Science*' position, not because of order (which in fact might be the opposite of what is indicated), but because the technology in focus determines what science will be taught in her sessions. Finally, the approach Fensham and Gardner denote '*Science and Technology as independent*' can be identified in Eric's approach presented in the Third story, where he places technology teaching outside school science in an organisational as well as in a conceptual sense.

Though the teachers above at first instance may appear to map nicely into Fensham and Gardner's framework, there are substantial differences between the assumptions underpinning their framework and the foundation on which the teachers' positioning is based. Fensham and Gardner's framework is heavily based on Gardner's (1994) four positions on a relationship between science and technology *per se*, that is, the view of technology as applied science, the demarcationist view, the materialist view and the interactionist view (see Chapter 2). A one-to-one correspondence is set up between each position and each of the four categories of teaching approaches. The explicit correspondence made conveys a message that approaches to the teaching of the interface of science and technology should be chosen on the basis of a consideration of their relationship as human endeavours in general. A subtler message that follows from this, and that also is noticeable in Fensham and Gardner's presentation, is that the 'Partnership approach' is the favourable one due to the political correctness of the interactionist view of science and technology.

The results from the present study indicate that the teachers often base their view of science and technology teaching on rather different considerations than the above. Only one of the teachers, Eric, is found to clearly articulate a link between how technology relates to science in an epistemic sense and how he positions technology teaching in relation to school science. In the Third story, he conceptualised technology as an independent domain of knowledge that to some extent may be seen as reflecting the demarcationist view (Gardner 1994), though he does acknowledge the contribution of science knowledge among other sources of knowledge in technological work. He places technology teaching accordingly as an independent subject outside Science. As presented in the Third story, Eric explains this by referring to what science is *not*:

Eric
(...) they must be able to put a bit in a drill machine, that is not a physics subject, all these practical skills, they need to know something about materials, materials' properties, flexibility, what kind of tools you can apply to plastic, you can apply to wood, you can apply to metal. What nuts and bolts are on the market, that makes it easier to arrive at a product... To handle all the equipment, those small machines we have, that is also technological knowledge, that does not belong in [school] Science.

Eric
(...)de må kunne sette i bor i en bormaskin, det er ikke noe fysikkemne, alle disse praktiske ferdighetene, de må kunne noe om materialer, materialers egenskaper, formbarhet, holdt på å si, hva slags redskap kan du behandle plast med, kan du behandle tre med, kan du behandle metall med. Hva som finnes på markedet av dingser og bolter, som gjør det lettere å komme til et produkt... Å håndtere all redskaper, disse små maskinene vi har, det er også teknologisk kunnskap, som ikke hører til naturfaget.

[P6: 528 - 535]

Eric conveys an essentialist view of school science embracing the disciplines from natural sciences. These disciplines do not cover the technical skills, knowledge of materials and appropriate and available tools to apply to these materials in making products. A conception of these epistemic features of science and technology guides Eric's placement of technology teaching outside school science.

The other teachers express a more pragmatic view, and their positioning of technology teaching with regards to school science appears to be based on pedagogical reasoning rather than consideration of what constitutes the appropriate view of the nature of science and technology as human endeavours and their relationship. The following interview sequence with Elna illustrates this point:

Elna
To me it is important that science, it makes the basis for development of technology. So that, you use technology without reflecting upon why it is there, that is, you are a user!

Elna
For meg så er det jo viktig at naturvitenskap, det legger jo basisen for utvikling av teknologi. Sånn at, du bruker jo teknologi uten å tenke gjennom hvorfor den er der, altså du er jo en bruker!

BB
Yes, most of the time we are users.

BB
Ja, stort sett så er vi jo det.

Elna
Yes.

Elna
Ja.

BB
Is it like that, that pupils need to become aware that there is science in it, or?

BB
Er det sånn at elevene trenger å bli klar over at det ligger naturvitenskap i det, eller?

Elna
I think it is important that they do not quit it! Think about that this is the reason for that we have achieved what we have done. I think of the things with IT, they are to a great extent

Elna
Jeg syns det er litt viktig at de ikke velger bort det! Tenker på at det er det som er grunnen til at vi har kommet så langt som vi har kommet nå. Jeg tenker på det med data,

consumers of IT, but they are not interested in what is behind it.

de er storbrukere av data, men de er ikke interessert i det som ligger bak.

[P15: 207 - 225]

Elna exhibits a view of science as an important basis for development of technology. However, this does not appear to be the determining reason for why she makes the close link between technology teaching and school science we have seen in the Sixth story. When she is asked whether the role of science in technological development is something pupils need to know about, she responds by stating that it is important that the pupils do not *quit* the subject. Thus, her argumentation is more about how she perceives the relation between *pupils* and the school subject than about any relationship between science and technology *per se*. This points back to Elna's aim of revitalising science teaching by means of technology projects, and suggests that this agenda is more influential on her positioning of technology teaching with regards to Science than her view of a science-technology relationship is.

An analysis of a science-technology relationship is even more peripheral as a basis from which the role of technology teaching can be deduced for some of the other teachers in this study. David's view of technology as a 'problem solving approach to Science' and Frederic's identification of technological objects as learning possibilities for conceptual knowledge must be seen as solely governed by pedagogical reasoning. This makes it difficult to place their approaches in categories according to Fensham and Gardner's framework. In general, the teachers' approaches are based on considerations on how the teaching of science as well as technology can best benefit the pupils in terms of personal development and learning outcomes within as well as in the periphery of what is customarily considered as the 'content' of the subject. This includes concerns for how the teaching context can be improved, how content knowledge can be presented in ways that are motivating and meaningful to the pupils, how knowledge can be made functional and useful to pupils, how potential learning contexts can be utilised and how school subjects like Science communicates its 'ethos' and its availability to pupils.

A relationship between science and technology? Teachers' perceptions as educationally situated

The previous sections have exhibited a span of positions in how the teachers see the role of technology teaching with regards to school science. It is indicated that these positions are based on a range of educational considerations, and not necessarily on a comprehension of the nature of science and technology *per se* and the relationship between these two areas of knowledge and activity.

This section addresses aspects of the above from a different angle, and examines teachers' view of the nature of the relationship between science and technology more specifically. The presentation is mainly based on teachers' reflections on one of the aims NITO has assigned to the TiS project, the one of 'promoting better understanding of the relationship between technology and science'. The analysis embraces two aspects. Firstly, it investigates how the teachers comprehend the nature of this relationship and whether they consider understanding of this relationship as a learning target for pupils. Secondly, it sheds more light on how teachers' view on a science – technology relationship is related to their positioning of technology teaching with regards to school science.

In the interviews, a question of what is inherent in NITO's aim of 'promoting better understanding of the relationship between technology and science' often caused a – I would say legitimate – confusion. More interesting, however, is that the confusion and the variety of responses are most often not due to problems of conceptualising a relationship between science and technology on a general level, but rather to identifying what the question is *about*.

One type of response is the one of equating 'science' with 'nature'. Below, Irene deals with this rather challenging question in an ad hoc manner, and includes a reflection on what 'natural science' means as a tool for her 'thinking aloud' about the question:

Irene
It is about, for example windmills, and now gas power plants and pollution, right, and... science...

Irene
Det handler jo om det her for eksempel med vindmøller og nå med gasskraftverk og forurensning, ikke sant, og... naturvitenskap...

BB
But windmills and gas power plants and pollution, is that, are we talking about science or technology really? Or is it both?

BB
Men vindmøller og gasskraftverk og forurensning, er det, snakker vi om naturvitenskap eller teknologi egentlig da? Eller er det begge deler?

Irene

Irene

It is certainly both. That is, what is [natural] science... Science about nature. Waves, pollution and oil, all that is certainly about it, technology and so. Yes, and how to get that oil up [from the sea]. How to use water power, how it works... Yes, you make power out of nature. That is technology.

BB

To utilise nature?

Irene

Yes. That technology, like magnetism, if we turn to what is in grade 5, with magnetism, how... iron ore for example and magnetism. No, I don't know. That one was too deep! [laughter]

Det er jo begge deler. Altså, hva er naturvitenskap... Vitenskapen om naturen. Altså bølger, forurensing og olje, alt handler jo om det, teknologi, altså. Ja, og hvordan få opp den der oljen. Hvordan bruke vannkraft, hvordan virker det... Ja, du lager jo kraft av naturen. Det er teknologi.

BB

At man utnytter naturen?

Irene

Ja. At teknologi, sånn som magnetisme, hvis vi går over til det som er i 5. klasse da, med magnetisme, hvordan... jernmalm for eksempel og magnetisme. Nei, jeg vet ikke. Det var for dypt! [latter].

[P16: 1034 - 1058]

To Irene, technology is related to natural science because natural science is 'science about nature', and technology is about utilising resources from nature. This way, technology teaching is related to science teaching simply because it is about nature. She hence appears to equate the concept of science with nature in itself, and any consideration of *knowledge* is not part of her argument above. Later in the interview, however, when Irene has had a few more seconds to reflect on the issue, she does include aspects of knowledge:

Irene

(...) If one thinks of the things about travelling to the moon and... What kind of technology is used when one makes those rockets and...

Irene

(...) Hvis man tenker på det her med å reise til månen og... Hvilken teknologi brukes når man lager de der rakettenes og...

BB

That technology becomes a prerequisite for science?

BB

At teknologien blir en forutsetning for naturvitenskapen?

Irene

Yes, for example. Or as a consequence of, "we need to find out something about the moon, how do we do that", and so... Science... And you need to, like she talked about, the one at the company Aker Maritime, those waves, right, out in the North Sea and... How can we make a platform that resists the high waves and how should it be connected to the sea bottom and how should the pipes go and... It certainly has to do with science! And then they need to use it as a basis when they are to develop the technology that is to cope with nature somehow! [laughter]

Irene

Ja, for eksempel. Eller som en følge av, "vi må finne ut noe om månen, altså, hvordan gjør vi det", og så... Naturvitenskap... Også må du, sånn som hun snakket om, hun der ute på Aker Maritime, de her bølgene, ikke sant, ute i Nordsjøen og... Hvordan skal vi lage en plattform som tåler de høye bølgene og hvordan skal den være festet i havbunnen og hvordan skal rørledningen gå og... Det har jo med naturvitenskap å gjøre! Og da må de jo bruke det som basis når de skal da utvikle teknologien som skal hamle opp med naturen på ett eller annet vis! [latter]

Irene mentions two concrete examples to illustrate a relationship between science and technology. The first example is the one of scientific exploration of the moon, and Irene points to technology as necessary for performing this exploration. When the interviewer suggests that in this example technology can be seen as a *prerequisite* for (the development of) science, Irene presents a slightly different picture than the one suggested, and denotes technology as a *consequence* of science. Though this suggests a view that science (in the mentioned example) precedes technology, it is not in the sense that technology follows from scientific *knowledge* as underpins the view of technology as ‘applied science’. Rather, she suggests that technology follows from *needs* generated by scientific activity (“We need to find out about the moon, how do we do that?”).

In her second example, Irene draws directly on a presentation she has recently attended at a company that produces equipment for oil industry. She now points to the important role of science in a knowledge perspective; scientific knowledge is an important basis for development of technology, understood as “coping with nature”. This is exemplified by the need for knowledge about the sea, waves and forces in order to fulfil the desire of transporting oil up from the bottom of the sea.

The above quotation acts as an example of the main impression from the interviews, that is, that a discussion of any relationship between science and technology *as such* and what this relationship possibly could imply for teaching, is not something they consider as being on the agenda in identifying the role of technology teaching in schools. The conclusions they arrive at, as Irene’s above, seem to be mainly artefacts of the interview itself.

Several teachers respond to the question of a relationship between science and technology in a yet different way than the above. Possibly as an effect of the question not being on the teachers’ agenda as suggested above, they often understand it in terms of Science and Technology as *school subjects*. Accordingly, they respond to the question by raising issues like the ones addressed in the previous section on the placement of technology *teaching* with regards to *school science*. One example is Ann:

BB

One is to “create a better understanding of the relationship between technology and science”. What kind of relationship is that, do you have any thoughts about that?

Ann

BB

Man skal ”skape bedre forståelse for sammenhengen mellom teknologi og naturvitenskap”. Hva er det slags sammenheng, har du noen tanker om det?

Ann

What I think is that... the things we have done in Technology are in fact things that stem from the curriculum for Science. It is a relationship between, you see it very easily that the topics that are taught in Science, might also be addressed in technology, in a way. So there is a relationship, a natural relationship.

Det jeg tenker er jo at... de tingene som vi har holdt på med i Teknologi egentlig er ting som har utspring i læreplanen i natur og miljø. Det er jo en sammenheng mellom, du ser jo veldig godt at de temaene som tas opp i natur og miljø, de kan du også ta opp i teknologi på en måte. Så det er jo en sammenheng der, en naturlig sammenheng.

[P11: 580 - 590]

Ann's response above is tightly situated in the educational context. She does not see the question as being about the nature of human activities denoted 'science' and 'technology' and their relationship, but understands it solely as a question of the organisation of the curriculum. In this context, she expresses a comprehension of 'relationship' between science and technology as simply an *overlap* of curricular content between the two subjects.

Frederic's response to the same question exhibits a similar influence from the educational context. He seems, however, to initially accept that the question is about a relationship between science and technology *outside* school. He shows some reluctance to dealing with the issue, and moves quickly into the educational context:

BB

But then they say [in the aims for the project]: "Create better understanding for the relationship between technology and science." How do you look upon the relationship between... what kind of relationship are we talking about?

Frederic

It is the physical laws, among other things.

BB

But the relationship between technology and science?

[silence]

BB

Is it like, how to use the physical laws for example in -

Frederic

In technology? A typical example of that is the siege machine we make, where you are to make a technological device that is to throw something, and then you may look at them and see why is this one effective and the

BB

Men så sier de [i målsettingene for prosjektet]: "Skape bedre forståelse for sammenhengen mellom teknologi og naturvitenskap." Hvordan ser du på sammenhengen mellom... hva slags sammenheng er det vi snakker om da?

Frederic

Det er jo de fysiske lovene da, blant annet.

BB

Men sammenhengen mellom teknologi og naturvitenskap?

[stille]

BB

Er det sånn, hvordan anvende de fysiske lovene for eksempel i -

Frederic

I teknologi? Et typisk eksempel på det er nok den kastemaskinen som vi lager, hvor du skal lage en teknologisk innretning som skal kaste noe, og da kan man gå inn og se på hvorfor den ene er effektiv og den andre ikke er det i

other not in terms of momentum of what force one uses and solidity and what forces apply on a bridge, for example. How one utilises force times distance in various tools, that's some of it... pliers...

BB

That we can identify...

Frederic

Yes, the physical principles in the objects, that we try to enlighten in a way the physical principles by looking at technological objects.

forhold til massefart og hvilken kraft man bruker og soliditet og hvilke krefter virker på en bro, for eksempel. Hvordan man utnytter kraft ganger arm i ulike redskaper er noe av det som... knipetang...

BB

At vi finner igjen...

Frederic

Ja, de fysiske prinsippene i gjenstandene, at vi prøver å belyse på en måte de fysiske prinsippene ved å se på teknologiske gjenstander.

[P10: 288 - 304]

Frederic suggests 'physical laws' as one mode of relationship between science and technology. He then proceeds by suggesting areas where one may use pupils' products or tools like pliers to visualise physical laws or principles. Frederic's response shows a clear connection to learning objectives he has identified for technology teaching (presented in the Fourth story), and also to technological products as learning opportunities as earlier described. This has nothing to do with how he understands the role of scientific knowledge – or possibly its lack of role – when those tools were developed; it is about identifying suitable learning contexts for the pupils.

A similar connection to teaching can be found in how Gina responds to the question of a relationship between technology and science:

BB

But if they are to learn about relationship between technology and science, I am not sure what is meant by that aim, but what could it be?

Gina

Well... the relationship between the subject, the subject science, the sciences... to understand that some knowledge from that area is required to work with technology, to give grounds for how you do things and... Yes, I don't know! I comprehend it as, to see that you need science and mathematics [realfag], or that kind of knowledge perhaps, to do other things!

BB

Men hvis de skulle lære om sammenheng mellom teknologi og naturvitenskap, jeg er ikke helt sikker på hva som menes i den målsettingen, men hva skulle det være?

Gina

Nei... sammenhengen mellom faget, faget naturfag da, naturfagene... skjønn at det må litt kunnskaper på det området til for å jobbe med teknologi, for å begrunne hvordan du gjør ting og... Ja, jeg vet ikke! Jeg forstår det sånn, se at du trenger realfag, eller realfaglig kunnskap kanskje for å få gjort andre ting!

[P13: 908 - 918]

Like Ann and Frederic above, Gina gives her answer above somewhat in terms of school subjects. However, she also expresses some consideration of a relationship in terms of the significance of scientific knowledge for technological work on a

more general level. The main message in the quotation is, however, the one of *exposing* and *acknowledging* this significance (“to see”, “to understand”). This matches the concern she has expressed earlier, that is, to let pupils experience the relevance of knowledge from school science (see pp. 229-231).

The above suggests that teachers’ view of a relationship between science and technology – or more precisely their *expressions* of such a relationship – may be influenced by their educational agenda, rather than that their teaching approaches are determined by a view of this relationship detached from the educational context.

In David’s case, it is found that the question of how technology is related to science is explicitly given a completely *different* meaning depending on whether the context is science *education* or science *per se*. In the quotation below, he reflects on modern technology and science in ways that can be recognised as a view of the two as forming a seamless web:

David

(...) it is clear that, technology has become a significant *part* of scientific research⁹, right, much scientific research is certainly dependent on technology. Just to think of space research or...

David

(...) det er klart, teknologi er jo en viktig del etter hvert *av* naturvitenskapen, ikke sant, mye naturvitenskap er jo helt avhengig av teknologi. Altså, du kan jo bare tenke romforskning eller...

BB

Yes, is it technology or scientific research?

BB

Ja, er det teknologi eller er det naturvitenskap liksom?

David

Yes, but I mean the scientific research in it is completely dependent on the technology you need to find out something. That is, just the telescope for example, or space ships or space - it is certainly technology you use to explore... So... I think it becomes, it is certainly... But of course, I guess one can discuss with the pupils and so also, the issues about... technology, what is technology...

David

Ja, men jeg mener den naturvitenskapen som ligger i det er jo helt avhengig av teknologien du trenger for å finne ut noe. Altså, bare teleskopet altså, for å være helt, eller romferje eller rom - det er jo teknologi du bruker for å utforske... Så... jeg syns det blir, det er jo... Men det er klart, det kan du sikkert diskutere med elever og sånn også, dette her med... teknologi, hva er teknologi...

(...)

But in school, at least I think very much in the sense of, in fact I have two approaches, that I try to have, to the teaching of Science. One is the scientific one, which I think of as research... But you use technology there also, even on school level, seen that way. A scale, for example, to weigh something is

(...)

Men i skolen så tenker i hvertfall jeg veldig sånn at, egentlig så har jeg to innfallsvinkler, prøver jeg å ha etter hvert, til det naturfaglige. Og det er det naturvitenskapelige, som jeg da tenker er forsker... Men du bruker jo teknologi der også, til og med på skolenivå, sånn sett da. Bare en vekt altså,

⁹ In this sequence, the notion ‘scientific research’ is used instead of ‘science’ in order to distinguish the concept clearly from ‘school science’.

certainly technology. But then, what I think of as technology, is when I work with practical problem solving tasks related to the making of things. Then you have in a way covered the subject, I feel. And then I in a way contrast them, but of course they are related, what you use to make the technology is also based on scientific research, so... To me this is, when you formulate goals like this, it often becomes, we always do like that, write down some appealing words, and the question is what the content of it is. I don't know, goals for the project, that one is not the most important one to me, connected to the project.

det å veie noe er jo teknologi altså. Men så, det som jeg tenker på som teknologi, det er når jeg jobber med praktiske problemløsende oppgaver knyttet til det å lage noe altså. Da har du på en måte dekket faget, føler jeg da. Og da setter jeg naturvitenskap... da setter jeg de opp imot hverandre, men det er klart, de henger jo... altså, det bygger jo på naturvitenskap det du bruker for å lage teknologien også, så... Så for meg så blir dette, når du setter opp sånne mål som det her, så blir det ofte, vi gjør jo alltid det, vi setter opp fine ord, så spørsmålet er hva er innholdet i det da. Jeg vet ikke, mål for prosjektet, om det der, det der er ikke det viktigste målet for meg, knyttet til det prosjektet.

[P14: 768 - 800]

It is noteworthy how David formulates a disparity between the discussion of scientific research and technology as a 'seamless web' on one hand and what underpins his comprehension of technology as an approach to science teaching on the other. Initially, he addresses how modern scientific research is strongly dependent on technology. He then claims that this is in fact the case in traditional school science also, as you use tools for example to measure the weight of something. Then comes a turning point in his argumentation, where a different comprehension of the meaning of technology in science teaching emerges. He now presents *two* possible approaches to science teaching. One is the 'scientific' one, which includes the above meaning of technology as *objects* to be used as tools in science teaching. The other is the teaching approach he identifies as 'technology', where the notion now is given the meaning of *activity*, that is, working with practical problem solving tasks related to the making of things. This shows that David holds parallel conceptions of what 'technology' means in science teaching, and that the one he refers to as 'technology' – as opposed to the 'scientific' one – is not based on any comprehension of the nature of science and technology. Rather, it is based on considerations of what kind of teaching will benefit the pupils.

In the interview sequence referred above, there is also a message from David that teaching pupils about the 'nature of science and technology' is not on David's agenda as a teacher. He states that one might discuss with the pupils what technology means, but the tone in this utterance indicates that he sees it as a rather peripheral idea to do so. He confirms this impression in the final lines of the sequence, where he moves back to the theme of NITO's aims for the project and states that this aim ('promote better understanding of the relationship between science and technology') is not the most important to him. Further, he states:

David

David

I think that lower secondary pupils really to a high degree have some problems with seeing connections at all. We might work with it, we might talk about it, but they are still very concrete in what they are doing. If they build a buggy, then they build this buggy, they are not very interested in placing it into a broader perspective really.

Jeg tror at ungdomsskoleelever egentlig i ganske stor grad har litt problemer med det å se sammenhenger i det hele tatt altså. Vi kan jobbe med det, vi kan snakke om det, men de er fortsatt veldig konkrete på hva de holder på med altså. Hvis de bygger en bil så bygger de den bilen, de har ikke så veldig lyst å sette den inn i en stor sammenheng de altså.

[P14: 733 - 737]

David indicates that making pupils ‘see connections’ beyond the concrete level is not even realistic on the level of lower secondary school. He asserts that when pupils make a buggy, their focus will be on the buggy and they are not interested in, or capable of, placing it in a broader perspective.

From the above, the conclusion can be drawn that though the teachers (yet to a varying degree) possess an conception of the complex nature of technology and its relationship with science, this conception is not in general decisive for how they look upon technology as an *educational* subject. The latter may be based on quite different considerations related to pupils and the teaching context. This confirms what is earlier suggested by Jarvis and Rennie (1996), that teachers hold an ‘*educational view*’ distinctive from their view of technology outside the school context. Jarvis and Rennie denote this phenomenon a “*confusion* between everyday and educational interpretations of technology” (p. 51, my italics). A more appropriate interpretation than a ‘confusion’ might be that it signifies that when creating technology as a new subject the teachers’ focus is – as prescribed by Lewis (1999) – upon the children rather than the technology.

Summary and concluding remarks

This chapter has explored how teachers participating in the TiS project relate technology teaching associated with the TiS project with regards to Science as a school subject, how they see technology as ‘supporting Science’ and how they reflect upon the relationship between science and technology.

It has been shown that many of the teachers participating in the TiS project *associate* technology with science, reflecting the stronger link to science and science teaching conveyed by the TiS project than what is the case with Design & Technology that forms a basis for conceptualisation of technology teaching in the project. The teachers do however, comprehend the relationship between technology and science in different ways, and we find differences in how a link to science comes to expression in their realisation of technology teaching.

For science teachers, the realisation of the TiS project has been interpreted as responses to limitations and weaknesses they have experienced in how school science is taught in schools. Though they may share this starting point, it does, however, lead to various ways of positioning technology with regards to Science, and all the four positions formulated by Fensham and Gardner (1994) can be identified among the teachers in this study. The findings reported from other studies and referred in the introduction of this thesis (Chapter 1), that science teachers tend to perceive technology as solely 'applied science' and to teach technology accordingly is not confirmed in the present study. In cases where a close link to science is found in how teachers express their perceptions of technology teaching, this is not based on an 'applied science' view of technology. It rather derives from a need for making pupils aware of the *relevance* of science in contemporary technology and for making knowledge from school science and the subject itself motivating, functional, accessible and meaningful to the pupils.

More generally, it is shown that their views on the role of technology in relation to school science to a high degree are educationally situated. This means that they are based on considerations of pupils' motivation, learning outcomes and their experience of meaning and relevance, as well as a need for identifying suitable learning contexts rather than on a consideration of what constitutes an appropriate view of the relationship between science and technology *per se*. An analysis of such a relationship appears as peripheral to the teachers, as learning target for the pupils as well as a determinant factor for how technology teaching should be shaped with regards to a relationship with science teaching. Rather, their expressions of a relationship between science and technology appear to be influenced by the educational context the teachers operate within.

CHAPTER 12

RECONSTRUCTING EDUCATION

The forgoing chapters have indicated that the teachers participating in the TiS project creates technology teaching that supports their own aims for teaching, and that their educational beliefs are fundamental for how they interpret and realise technology as a subject of teaching. It is also shown that teachers utilise technology teaching associated with the TiS project in fulfilling needs they see for *changing* aspects of teaching. For example, technology teaching is utilised as a means for ‘Making school more practical’ and for ‘Revitalising science teaching’. This chapter presents results and interpretations illustrating that some of the teachers utilise the possibilities provided through the TiS project in pursuing a yet more reconstructive agenda for educational change. This agenda will be conceptualised as ‘*Fighting the grammar of schooling*’ – a notion partly borrowed from Tyack and Tobin (1994). It will be shown how some teachers make technology teaching associated with the TiS project form part of this broader agenda.

Data giving rise to the above interpretation will partly be presented by means of the Seventh and final story of this thesis. This story gives an account of how Gina creates technology as a subject fundamentally *different* from other school subjects, and how she reflects upon technology teaching at various stages of the process of realising technology teaching associated with the project. The story will also contribute to a later discussion on the anticipated connection between teachers’ subject background and how they focus their technology teaching.

SEVENTH STORY. TECHNOLOGY AS ‘DIFFERENT’

Gina represents a somewhat atypical teacher in terms of her educational background. Her educational level is above the average among teachers in lower secondary schools in Norway, and her specialisation in physics and computer science is also unusual at this level. This background is reflected in how Gina expresses her motivation for joining the TiS project:

Gina
It seemed exciting, two weeks in
England, technology, ok, it probably
suits me!

Gina
Det så spennende ut, to uker i
England, teknologi, ok, det passer
sikkert for meg!

BB
Why did you think it would suit you?

BB
Hvorfor tenkte du at det passet for deg?

Gina
As a physicist, I thought like that. Technology sounds exciting, get it into school, that sounds ok with me!

Gina
Som fysiker, så tenkte jeg det. Teknologi høres spennende ut, få det inn i skolen, det høstes ok ut!

[P8: 493 - 501]

Gina directly refers to her background in physics as pertinent for joining the project. This relates to what she initially thought the course and the project would be about, that is, what she calls the 'technical part' of technology:

BB
But what you thought in advance, that as a physicist technology is in a way -

BB
Men det du tenkte på forhånd, at som fysiker så er teknologi liksom -

Gina
I thought more about the technical part, for example mechanics, but also towards information technology. I just got some associations that it was in the background, I have that as a subject also.

Gina
Da tenkte jeg mer på den tekniske biten, for eksempel mekanikk, men også mot informasjonsteknologi. det bare ringte noen bjeller at kanskje det var i bakgrunnen, jeg har jo det som fag også.

BB
You thought it was IT?

BB
Du tenkte at det var IT?

Gina
Yes, because the ways we usually use that word makes us think in that direction. Electronic gadgets, that is technology. I didn't think about it to be so much more!

Gina
Ja, for sånn som vi bruker det ordet til vanlig så tenker vi som regel i den retningen da. Elektroniske duppe- dingser, det er teknologi. Tenkte ikke så mye over at det var så mye annet!

[P8: 526 - 540]

Gina expected the TiS course she was going to attend to be about mechanics, electronics and maybe computers, as these topics are those she would usually associate with the notion 'technology'. However, her view changed when she became acquainted with the TiS project and attended the course in York. She realised that the course, and in fact technology as such, is much more than electronic gadgets.

Participation in the TiS project and on the course in York has – according to herself – broadened Gina's view of technology and

technology teaching. However, she still talks about technology teaching somewhat in terms of physics. In the phase of planning the technology unit she is to teach at School G, she reflects on what she wants to include in it this way:

Gina

One needs to choose one thing. So, then I thought that mechanics was quite tangible, because it might be easier to get started regarding materials we have to buy and... yes, easier, available.

Gina

Så en må ta en ting da. Og da tenkte jeg at mekanikk var ganske håndgripelig, for at der kanskje er det lettere å komme i gang i form av materialer vi må kjøpe inn og... ja, enklere, tilgjengelig.

BB

What do you think of as mechanics?

BB

Hva tenker du på som mekanikk?

Gina

I think of... the other part, not current, not electronics, because the pupils have not worked much with that, and we would need to buy a lot of new equipment to start with that. That was what I thought, basic principles in mechanics, somewhat toward engineer thinking. How they can build things that move, what must they think of, physics among other things.

Gina

Jeg tenker... altså den andre biten, ikke strøm, ikke elektronikk, for det har ikke elevene jobbet noe mye med fra før, og vi må kjøpe inn veldig mye nytt for å begynne med det. Det er det jeg tenkte, mekaniske grunnprinsipper og litt mot ingeniør-tenking da. Hvordan skal de bygge ting som kan røre seg, hva må de tenke på, fysikk blant annet da.

[P8: 123 - 135]

When creating a new subject, Gina sees it as necessary to focus on a few themes, mainly due to the equipment and materials the teaching will require. Above, she explains that she finds mechanics a convenient choice, and the quotation also indicates that she sees the definition of the content of technology teaching as a choice between mechanics on one side and electronics on the other, two areas that are related to physics. She also upholds that the pupils, when building things that move, will have to think about physics. This fits with how Gina earlier has expressed technology as ‘supporting science’ in that it provides application opportunities and how she characterised technology as “a golden opportunity to use it [science] for something” (p. 230).

At School G, technology teaching associated with the TiS project is organised as an elective unit for pupils in grade 10, taught two subsequent lessons once a week within ‘School’s and Pupils’ Options’ (SEV). The unit on technology is denoted ‘Technology and Design’ (‘teknologi og design’), and Gina shares the responsibility for developing and teaching this unit with her colleague Gerhard. They have planned

the technology unit together, but they teach separate parts of it and are rarely present in each others sessions.

The schedule for the technology sessions is not strongly defined when Gina and Gerhard start the unit with their pupils. One reason is that the unit is new, and the teachers need to gain some further experiences before they plan the entire unit. Gina also maintains, with reference to the fact that the unit is part of SEV, that pupils should have influence on defining its content:

Gina

We suppose we will participate in some of the practical things the pupils do and feel our way. That is, what is special about the way we do it is that it is SEV, School and pupil's option, so it is in no way supposed to be the kind of subject with homework and the traditional things. It is to be practical, or something different, something else that the pupils like to do. So it will be very much up to the pupils here.

Gina

Vi regner med at vi og deltar i litt av det praktiske som elevene gjør og føler oss litt fram. Det er jo, det som er spesielt med måten vi gjør det på er jo at det er SEV, altså Skolens og Elevenes Valg, så det skal jo ikke på noen måte være et sånn der fag med lekser og sånn tradisjonelt. Det skal jo være praktisk, eller noe annerledes, noe annet som elevene liker å gjøre. Så det blir mye opp til elevene og her da.

[P8: 11 - 16]

In Gina's view, technology teaching as part of SEV implies that it should be 'different' from the regular school subjects. The concept of 'pupil's option' hence applies not only in whether they chose the unit or not, but also in shaping the content of the unit itself.

Gina's teaching of the technology unit reflects this view. The sessions are characterised by a relaxed atmosphere and high degree of freedom for the pupils. The starting point of the activities pupils undertake is mainly defined by the teacher, but the pupils have strong influences on the development of the sessions, for example how much time is used on the various activities and what they choose to make out of them.

A range of activities is offered to the pupils in the technology unit. The first activity Gina presents to her class is the 'classic' one of making bridges out of paper tubes. Gina then proceeds with letting pupils design and make boxes from cardboard. Gina introduces the activity with an account of the need for storing things, and the pupils are encouraged to think about the function of the box when designing, for example how many rooms are needed to fulfil the purpose, what should their dimensions be and so on. In the subsequent sessions Gina teaches the pupils how to make three-dimensional drawings from

a grid system which she learnt to use at one of the seminars for the teachers participating in the TiS project. The pupils also construct siege machines, and work with LegoDacta. The LegoDacta sets were, however, perceived as being trivial – and hence boring – by Gina as well as by the pupils. Further, the pupils also got the opportunity to mould with plastics, by borrowing equipment from a neighbouring school also taking part in the TiS project. In the last part of the unit a series of sessions is used for taking apart old computers and printers that were discarded from the school, with the initial idea of creating new artefacts from their components.

Gina introduces the activity with the old computers in an environmental perspective. It is initiated by a discussion of the possibilities for recycling scraps and household materials. She shows the pupils earrings and trinkets she has made herself from the interior of a Walkman. Although she encourages the pupils to use a range of different scrap and materials in the project, almost all the pupils appear to engage with the electronic devices Gina has brought to the classroom.

The pupils apparently enjoyed the investigation of the inside of the electronic devices, but hardly any new artefacts resulted from the project. Gina is not bothered by the fact that the teaching project turned out in a different way than she had intended:

Gina

They were very eager, so they were allowed to keep on with this for the remaining sessions. They found it extremely enjoyable to pick out and screw and sort and just sit and speculate about small parts, what is this and...

Gina

De var veldig ivrige, så de fikk holde på resten av timene med det der da, de synes det var fryktelig morsomt å plukke og skru og sortere og bare sitte og spekulere på små dingser, hva det var for noe og...

BB

But was this your intention with it...?

BB

Men var det det som var din tanke med det...?

Gina

No, actually it was supposed to be a project on recycling. Where they could use completely different materials and objects to work on if they wished, out and investigate a bit. But when the machines had entered the room, they were so focused on them, that there were nobody thinking in other directions at all. So, even if we tried to stimulate some of them,

Gina

Nei, egentlig skulle det være et prosjekt i gjenbruk. Hvor de kunne egentlig velge helt andre materialer og gjenstander å jobbe med hvis de ville det, ut og undersøke litt. Men når først de maskinene kom inn i klasserommet, så var de så fokusert på det, at det var ingen som tenkte i andre baner i det hele tatt. Så, selv om vi

maybe do other things than fumbling with those machines, they preferred to do that.

prøvde å stimulere enkelte, kanskje gjøre noe annet enn å skru på maskinene, så ville de heller gjøre det altså.

[P13: 96 - 109]

Gina appreciates the pupils' eagerness in turning the activities in their own direction. The fact that there are no specific learning objectives in terms of an intended outcome of specified knowledge attached to the project facilitates this approach.

The 'golden opportunity to use science knowledge for something' Gina initially launched as a motive for going into technology teaching seems to have slipped away in her teaching as well as in how she reflects upon it afterwards. She now emphasises other values technology teaching offers pupils and everyday school life. Some of these values are placed in direct contrast to ordinary school subjects, and she refers explicitly to Science in this regard:

Gina

In this subject [Technology] you need to be creative, you need to put things together in new ways in order to create things. That is part of the subject! To arrive at new ideas, and you cannot do that if you only have theory, then you need to tell them how to do things and then you don't really stimulate innovation, creativity...

(...)

The technology subject, to compare it with Science, where it is the teacher who must be in charge and do all the planning, there is not much room to follow ideas pupils come up with, you need to keep to the plan you have made.

BB

You have so much to cover?

Gina

You have so very much to cover, and you cannot always let pupils go their own ways and have some work with one thing and others with something else. You need to keep to a plan, you have many pupils to attend to and

Gina

I det faget her [teknologi] så må du være kreativ, du må sette sammen ting på en ny måte for å lage ting. Det er jo litt av faget det! Komme på nye ideer, og det kan du ikke hvis du bare har teori, så må jo du på en måte fortelle dem hvordan de skal gjøre ting og da stimulererdu ikke akkurat den her nytenkinga, kreativiteten...

(...)

Teknologifaget, sammenlikne det med naturfag da, så er det jo læreren som må styre og planlegge hele tiden, det er ikke mye rom for å ta opp ideer der som elevene kommer med, du er nødt til å følge den planen du har lagt.

BB

Du har så mye du skal gjennom?

Gina

Du har veldig mye du skal gjennom, og du kan ikke slippe løs elevene sånn at noen jobber med en ting og noen jobber med en annen ting alltid da. Du må nå følge en plan da, du har jo mange elever du skal ta deg av og de

they are to go through a certain amount of subject matter.

skal gjennom en viss mengde stoff. [P8: 806 - 836]

Gina points to *creativity* as a main characteristic of technology as a subject, and she puts creativity in direct contrast to ‘theory’. It is shown earlier in this thesis that teachers often use the rather subtle concept ‘theory’ to denote a type of classroom organisation associated with reading, writing and listening. In the above quotation, Gina also relates it to another feature of school teaching, that is, that you need to cover a certain amount of subject matter prescribed by the formal curriculum. In Gina’s view, this feature of traditional school subjects acts in opposition to the development of pupils’ creativity in several respects: It requires that it is the teacher – not the pupils – who decides on the agenda of pupils’ activities and who needs to “tell them how to do things”. It requires the teacher to keep to the plan made in order to cover the curriculum rather than chasing pupils’ initiatives and ideas. Finally, it requires that pupils undertake more or less *identical* activities, as they are bound to the *same* curriculum.

The interview sequence below reveals further aspects that prevent the fulfilment of Gina’s educational beliefs in the teaching of ordinary school subjects:

Gina

You are more bound in other subjects, I feel. Because of the curriculum, that the pupils are to know about this and know about that, and you are in turn governed partly by the local school community, things are done in so and so ways, you cannot just decide to do things differently, you need to do it in co-operation with the other teachers. It is very free here because it is new, there is no standard for how to do it, you don’t have any curriculum, you... yes, you can do it that way! But also that it is an elective, where pupils could come afterwards and require that they should have covered so and so and learnt so and so. And it is very enjoyable to work that way also, it really is. But ideally you should have been as creative within all subjects, but you cannot just...

Gina

Du er mye mer styrt i andre fag, føler jeg. På grunn av lærerplanen, at elevene skal ha kjennskap til ditt og ha kjennskap til datt og du er styrt delvis av miljøet på skolen igjen, at ting gjøres sånn og sånn, du kan ikke komme her og gjøre noe helt annerledes, du må jo gjøre det i samarbeid med de andre lærerne. Det blir veldig fritt her fordi det er nytt, det er ikke noen mal for hvordan det skal gjøres, du har ikke noen læreplan, du... ja, du kan jo gjøre det på den måten! Men også det at det var et valgfag, hvor elevene ikke kunne komme etterpå og kreve at de skulle vært innom det og det og lært det og det. Og det er veldig morsomt å jobbe på den måten og, det er det. Men ideelt sett skulle en ha vært like kreativ innenfor alle fag, men du kan ikke ta...

BB

You don't have the capacity, that is one thing. But like you say, you can not suddenly do something completely different in one class when the other classes don't -

Gina

- No, and, it is fixed in advance, you make the plans in the beginning of the term, you are to make a plan to give to the parents, you are to cooperate with other teachers and classes. There is so much to be planned in advance that you cannot change very much as you go along. Here [in the technology unit] we have been forced to do that all along the way, to solve things more or less as they arise. You haven't done it before, you don't know. It might be, when you have taught this subject for some years in school, that you end up not being creative in the same ways, you do the same things and... [laughter], and the pupils know what will meet them when they come to a session also! There is something there, if they know somebody, have siblings who have had the subject before, then they come and ask already the first session, "are we to make plastic soon?", right. So the fact that pupils don't know anything in advance makes you more free in how to present things.

BB

Du har ikke kapasitet, det er nå det ene. Men sånn som du sier at du kan ikke plutselig gjøre noe helt annet i en klasse når de andre klassene ikke -

Gina

- Nei, også, det er jo planlagt på forhånd, du planlegger jo i starten av skoleåret, du skal lage en fagplan som foreldre skal ha, du skal samarbeide med andre lærere og klasser. Det skal planlegges så mye på forhånd at du kan ikke ta så veldig mye ting å gjøre annerledes underveis. Her [i teknologi-faget] har vi blitt tvunget til å gjøre det hele veien, å ta ting mer eller mindre på sparket. Du har ikke prøvd det før, du vet ikke. Det kan jo være, når du har hatt det faget her i noen år på skolen at du ikke blir kreativ på samme måten lenger, du gjør de samme oppleggene og... [latter], og elevene vet hva de har i vente når de kommer til time og! Det er noe med det og, hvis de kjenner noen, har søsken som har hatt faget før, så kommer de og spør allerede første timen, "skal vi lage plastikk snart?", ikke sant. Så det at elevene ikke vet noe på forhånd og gjør at du kan være mye friere i måten du presenterer ting på.

[P13: 1135 - 1163]

Gina addresses several factors that govern the teaching of school subjects, and how her realisation of the technology unit to a much lower degree than her teaching of ordinary subjects is directed by these factors. She first points to the *formal curriculum* as a controlling mechanism for teaching and then to the *school community* as constraining for realising her ideal intentions in teaching. The school community acts as a constraining factor in an *organisational* sense because one has to synchronise plans for all the classes in cooperation with the other teachers. The school community also represents *cultural barriers* for an innovative teacher. Even if changes were possible from an administrative perspective, you are not 'allowed' to do things differently due to conservative social forces. A customary school policy is to keep *parents* informed about their children's

education by delivering lesson and activity plans in the beginning of terms. Gina describes this requirement as a constraint because it makes the agenda of the teaching fixed and predetermined. She also points to *pupils* functioning as control mechanisms, as they would – in case she deviated from the prescribed curriculum is between the lines – confront her with the discrepancy. Pupils also have a preserving function for the teaching in the sense that they may be familiar with the content of a school subject through information from older friends and siblings, and thus meet the subject with certain expectations. Finally, Gina points to the *innovative teacher* as a conservative force in herself; having developed and taught the new subject in creative ways for some years, the creativity may fade and the innovation might turn into a subject just as predictable as the others.

An important aspect of teaching in lower secondary school is the one of formal assessment. Gina is strongly concerned about the restrictions formal assessment and grading set on teaching. She teaches Science in grade 10, the final year of compulsory school, and the focus on examinations and pupils' final grades is strong. The pupils are highly concerned about their grades, and Gina herself has to put effort into acquiring the basis of grading their work. She describes how this affects the teaching of science in her grade 10 class:

Gina

It is strongly defined, they are to be given an average mark, they are to be given term grades, they should know their present level at every time and you need to have a dialogue with them about it and how they can improve and... So there is much focus on grades, and it is difficult to break away from what they do in the lessons also. Because the pupils are so concerned about it, at least in the lessons, that they come and ask "how is my present level, what if I do so and so well there, what must I do to make it better?". So, the motivation is the grade in many cases, rather than the subject.

Gina

Det er jo veldig definert, de skal jo ha standpunkt-karakterer, de skal ha terminkarakterer, de skal vite hvordan de ligger an til enhver tid og du skal ha en dialog med dem om det og hvordan de kan forbedre seg og... Så det blir mye fokus på karakterer, og det er vanskelig å løsrive det fra det de gjør i timene og. For det at elevene er såpass opptatt av det, i hvert fall i timene, at de kommer og spør "hvordan ligger jeg an nå, hvordan ligger jeg an nå, hva hvis jeg gjør det så og så bra der, hva må jeg gjøre der for å få bedre?". Så motivasjonen er karakter i mange tilfeller, isteden for faget.

[P13: 318 - 327]

Gina points to pupils' motivation as being related to grades rather than to the subject in itself, and also that lesson time is used for discussing grades and possibilities for improvement with pupils. In the technology unit, however, this influential element is absent and Gina describes this as *liberating*:

Gina

What is so liberating here [in technology lessons], is that there is no grading, that there is no assessment in that way at all, we work freely! So I don't know, it is possible to achieve a lot within the subjects also, with these kinds of projects. But if it is only for getting a grade, as pupils try to, then I think it sometimes could be difficult to motivate them.

Gina

Det som er befriende her [i teknologitimer], er at det ikke er karakterer, at det ikke er noen vurdering på den måten i det hele tatt, jobber fritt! Så jeg vet ikke, det går an å få til mye innenfor fagene og, med sånne typer prosjekter. Men hvis det hele skal være for å få en karakter liksom, som elevene prøver da, så tror jeg kanskje at du i perioder får vanskeligheter med å motivere dem.

[P13: 1135 - 1163]

The absence of grading makes Gina and her pupils work more freely in technology than in other subjects. She indicates that the introduction of grading in this subject would work counteractive to pupils' motivation for the subject. Seen in relation to what she said about the effect of grading in Science teaching, it appears that grading provides pupils with an external motivation, but that this motivation does not add to but rather expels or counteracts their internal motivation for the subject.

The organisation of technology teaching within SEV allows Gina the freedom she appreciates in her teaching. This subject is not bound by the factors that she has identified as governing ordinary subjects in the curriculum, and thus appears as essentially different from these subjects. When discussing technology teaching in the interviews, Gina often stresses that this represents the approach chosen at School G, and that a formation of technology on a more regular basis in schools needs to be based on other considerations than simply allowing the subject to be *different* from other subjects. However, when she is asked what technology as a school subject should contain if it was a specified component in the curriculum for all pupils, she again turns to the constraining factors she has mentioned above:

BB

But if one, it is somewhat exceptional when you were to create a subject, an option, that should be different from ordinary school, but if we should have technology, or technology and design, as a subject for all pupils, like some of the participants in TiS work towards, what do you think about that, what should it contain?

BB

Men hvis man, det ble jo litt spesielt når dere skulle lage et fag, eller en valgmulighet, som skulle være annerledes enn vanlig skole, men hvis man skulle ha teknologi, eller teknologi og formgivning, som et fag for alle elever, sånn som noen av de som jobber i prosjektet TiS jobber for, hva tenker du om det, hva det skulle inneholde?

[silence]

Would it need to be different from how you run it here?

Gina

I don't know, I perhaps think that it becomes somewhat different if it is a subject that is compulsory, they don't have a choice, that it would maybe be too much of it, that it will come theory, textbooks there as well and, tests, grades, the whole works associated with other subjects.

[stille]

Ville det måtte bli annerledes enn sånn som dere kjører det her?

Gina

Jeg vet ikke, jeg tror kanskje det blir litt annerledes i om med at det er et fag som alle må ha, de har ikke noe valg, at det blir kanskje for mye av det, at det kommer til å komme teori, lærebøker der og, prøver, karakterer, hele pakka man forbinder med andre fag.

[P13: 232 - 247]

It appears that what technology as an ordinary subject could possibly contain is less important to Gina than the prospect of what she indicates as inescapable; if technology is defined as a specific subject in the curriculum, it will adopt the aspects associated with other subjects, such as a predefined curriculum, 'theory', textbooks, tests and grading.

Fighting 'the grammar of schooling'

The Seventh story has exhibited how Gina looks upon technology as she runs it as an elective unit as a subject that is essentially 'different' from other school subjects, and how its way of being different in itself legitimates the subject as part of pupils' education. She points to a range of *external determinants* (Lindblad 1994) of teaching the traditional subjects in the curriculum, including expectations from colleagues, parents and pupils and organisational as well as cultural barriers in the school community. The benefit of technology teaching the way it is realised at School G is, according to Gina, that it gives an opportunity to *escape* from the determinants that strongly govern how other subjects are, and can be, taught. This opportunity is, however, not a feature of technology teaching as such. Rather, it arises from technology being a *new* subject that has not settled in the curriculum, in the traditions carried by a school subject, in the pupils' expectations and in the habits of the teachers, that is, what Lindblad (1994) has denoted the *inner logic* of teaching.

Establishing technology as a compulsory subject might lead to the adoption of the same inner logic and essential aspects that govern the teaching of the other subjects in the curriculum. In the final quotation in the Seventh story, Gina described these aspects as "theory, textbooks, tests, grades *and the whole works* associated with

other subjects”. This formulation, and her overall argument through the story, suggest that it is not the single factors in themselves (e.g. textbooks, grades) that represent hindrances for teaching the way she wish for in her work. Eliminating single factors like textbooks or grading would not solve the problem, as these factors rather function as indicators of a more general paradigm – “the whole works” – that determine what is done in schools and how it is done.

The ‘whole works’ Gina is referring to can be recognised as what Tyack and Tobin (1994) have denoted ‘the grammar of schooling’, that is, the regular structures and rules that organize the work of instruction. Like with the grammar of speech, the rules inherent in the grammar of schooling are often taken for granted and do not have to be consciously understood in order to operate smoothly.

Tyack and Tobin present the historical origin of some of the grammatical rules of education often taken for granted today (e.g. age graded classes and standardised time units used in instruction) and analyse why some initiatives have been successful in changing the overall grammar of schooling while many others do not withstand the test of time. They explain the persistence of the grammar of schooling in three main perspectives. Firstly, it may be understood in political terms of relative power of groups that press for either change or stability. Secondly, a functionalist approach focuses on how the grammar of schooling over time becomes congruent with general social changes or institutional needs within schools. Finally, the persistence of the grammar of schooling may be understood as a result of a cultural construction of shared beliefs about the characters of ‘real school’. These beliefs are culturally transmitted to new generations of pupils and in turn teachers simply by the fact that they go to school. In this perspective, cultural beliefs about what a ‘real school’ represents is the dominant factor in what shapes school.

Gina’s realisation of technology teaching related to the TiS project and her reflections upon it may be understood as a fight against aspects of the grammar of schooling. In the Seventh story she has conceptualised many aspects of this grammar and how they are counteractive to the fulfilment of her educational beliefs and desires. The persistence and all-pervading nature of the grammar of schooling makes an attempt to change it impractical or impossible on an individual basis. However, technology run as a new elective subject at the school witin SEV is excepted from strict requirements of a formal curriculum and assessment, traditions of the subject and expectations from pupils, co-operation with colleagues and the need for synchronising classes. The subject is created as a free space where Gina and her pupils can escape from the cultural and organisational rules inherent in the grammar of schooling. This way, Gina may be interpreted as utilising the opportunities provided by the TiS project in an attempt to reconstruct education in the

direction of her educational beliefs, which entail departing from aspects of the grammar of schooling.

In interview sequences presented in Chapter 11 as well as in the beginning of the Seventh story, Gina appeared to see technology teaching as closely related to science teaching. She pointed to her own background in physics when explaining her motivation for joining the TiS project, and she expressed a view on technology teaching as an arena of application opportunities for science knowledge – as she said – it is “a golden opportunity to *use* science knowledge for something”. However, the Seventh story has exhibited that the links made to science in Gina’s technology teaching are few. Instead, she now conceptualises technology as a subject that is fundamentally *different* from other subjects and especially from school science. One might ask: What happened to the golden opportunities she launched?

The two positions Gina seems to be taking can be seen as being in conflict. One may interpret Gina as seeing technology teaching as a way of making pupils experience science knowledge as relevant and useful, but that this concern is overruled by a more comprehensive belief in that pupils need something *different* than the traditional school subjects. The connection between her two positions can, however, be given other interpretations. One is that Gina may in fact see pupils as ‘applying’ their science knowledge in the technology sessions – despite the fact that this knowledge is not explicitly brought to light neither by pupils nor by the teacher. A third – and perhaps the more feasible – interpretation is that her concern for making school science relevant and useful to pupils *and* her conception of technology teaching as ‘different’ from other subjects both are expressions of a dissatisfaction with the overall culture, or the grammar, of schooling. The ‘grammar of *school science*’ implies a focus on conceptual knowledge in a decontextualised shape, where applications and relevance is peripheral. This forms part of a more general grammar of schooling, materialised through textbooks, teacher-led activities, formal assessment and conformity. Due to the cultural and institutional persistence of the ‘grammar’ of established school subjects, Gina’s fight against the grammar of schooling is effectual only *outside* the framework of these subjects, that is, in her realisation of technology as a *new* subject.

We will now turn to one of the other teachers, David, who appears to fight against the grammar of schooling along similar lines as Gina. David and his colleagues at School D are experimenting with new methods of organisation and teaching, and the school has applied to the government for being exempt from the national regulations for compulsory education (see Appendix 1). One important aspect of

the changes attempted at School D is the allocation of teachers' working time. David explains how *grading* traditionally takes up a substantial part of a teacher's time and energy and what underpins this priority:

David

What we have indeed seen again and again over the years is that we use a lot of time on grading work. And we sit at home with these heaps, we have up to 50-60 pupils in class, even if we are lucky and only have 40 now, it is rather, when you sit there and are to give a written assessment, then you are to give... (...), you write comments, feedback on things that could be done better and so, and finally you set a grade. My personal feeling is that pupils just look: "3, ok", they look at their grade – period. They are not even interested in the work they have done on the assignment, because they are finished with it, they have done it, so they don't bother look at it again to see what they could have done better or...

(...)

So we want to do less grading. Because, one of the reasons for giving that many tests, that much grading, is in fact, even if it should not be like that, that we need to provide evidence for the final marks, right. We need to justify the fiver we set.

David

Det vi har sett egentlig opp igjen og opp igjen i årevis at vi bruker masse tid på rettarbeid. Og vi sitter hjemme med disse her bunkene, vi har jo opp i 50-60 elever i klassen, selv om vi er heldige og har bare 40 nå, så er det ganske sånn, når du sitter der og du skal gi skriftlig vurdering, du skal gi... (...), du skriver kommentarer, tilbakemelding på ting som kan gjøres bedre og sånn, og til slutt så setter du en karakter. Jeg har nesten utelukkende en følelse av at elevene ser "3, å-ja", de ser karakteren sin – ferdig med det. Da er det uinteressant hva som er gjort med den oppgaven, for de er ferdig med den, de har gjort den de, så de gidder ikke ta igjen den og begynne å se på hva de kunne gjort bedre eller...

(...)

Så vi tenker sånn at vi skal rette mindre, vi. Fordi at, en av grunnene til at vi gir så mye prøve, gir så mye retting, er jo faktisk, selv om det ikke burde være sånn, at vi skal dokumentere de karakterene vi gir til slutt, ikke sant. Vi må legitimere den femmeren som vi gir.

[P3: 377 - 396]

David indicates that the purpose of all the assessment work with feedback to pupils ideally is that it will be useful to their further learning. However, the pupils tend to notice the grade, ignore the 'helpful' comments and show no interest in re-entering the work they feel they are finished with. However, David also argues that the real purpose of the assessment work is not to assist the pupil in further learning, but rather to justify the grade given. In order to make the teachers' working time and effort more useful to the pupil, School D wants to re-allocate time from grading work towards work directly related to individual pupils:

David

So we want to try to rearrange some of the time we use for grading to be there together with the pupils. And it is somewhat... that's why we have requested a bit... we have applied for dispensation from these things with working hour regulations. Not all teachers are happy with us thinking like that, because it involves removing some of the time we sit

David

Så vi har lyst til å prøve å omdisponere litt av den tida vi bruker til retting til å være ute sammen med elevene. Og det er litt sånn... derfor har vi søkt litt sånn... fra det her med arbeidstidsbestemmelsene også har vi søkt sånn dispensasjon da. Det er noe med at det er ikke alle lærere som er glade for at vi tenker sånn, for det er noe med at da tar vi vekk litt

sheltered in the office and then we go into class. And we take out one pupil, and we talk about what is done instead. Because we believe that we achieve much more with regards to that pupil, and developed him further.

av den tida der vi sitter skjermet på kontoret og så går vi ned i klassa. Og så tar vi ut en elev, og så snakker vi om det som er gjort isteden for. For da tror vi at vi oppnår mye mer i forhold til den eleven, og får utviklet ham bedre altså.

[P3: 396 - 403]

David is convinced that the school will achieve more by using the assessment time for communicating with the individual pupil. However, he signals a resistance from other teachers towards this change. They may in fact see the time they are allowed to do office work instead of engaging with pupils as a *desirable* aspect of the grammar of schooling.

The changes School D attempts involve a flexible curriculum. Their idea is to divide the curriculum into modules where the pupils, after having completed a few basic ones, are allowed to choose which topics or subjects they want to pursue, and to what level. This way, the combination and level of modules the pupil has undertaken will exhibit the pupil's competence in the absence of grades. This model leads inevitably to a situation where pupils leave school with very different versions of compulsory education, and may also open up for pupils to create an easy way through school. This is contrary to what many think of as 'real school', that is, another aspect of the grammar of schooling:

David

For some reason we have this idea that all pupils are to go through everything, and that is wrong. In our opinion that is wrong, we need to dare to take the risk that some get through in such a system. Of course some will do that. But we must try to capture them back in, try to find other ways of capturing them back in.

David

På en eller annen måte så har vi en sånn mening om at alle sammen skal igjennom alt, og det er feil. Vi mener det er feil, vi må tørre å ha is i magen til å ta sjansen på at noen da sniker seg unna i et sånt system. Selvfølgelig er det noen som gjør det. Men da får vi prøve å hanke inn dem, prøve å finne andre måter å hanke inn dem på.

[P3: 578 - 582]

This system creates possibilities for cultivating the pupil, a category of aims for technology teaching presented in Chapter 9, in a more comprehensive way than our schools normally allow. The pupils will have the chance to develop themselves in directions according to their own agenda, which in turn means that they will eliminate components of the curriculum that they usually do not succeed in. With this high degree of freedom, one might see dangers regarding pupils with special needs, for example pupils with reading and writing difficulties. David is not worried about these dangers. On the contrary, he describes the 'grammatical rules' that force pupils to spend more time on what they do not accomplish as more dangerous:

David

Traditionally in special needs, they have, those pupils who are bad at writing, they are drilled in writing, they lose and lose, because we in a sense say as a society that they need to learn it, they certainly need to learn to write. And think that the surrounding society places focus on what they are not good at, and then we are to initiate programmes in order to improve the skills they are lacking. And then these special needs pupils sit in situations of losing again and again. And then it appears that they are in fact good at something else; why on earth are they not allowed to cultivate what they are good at, because that is where they have their future, that is where they have their opportunities, right?

David

Tradisjonelt i spes-ped, så har de, disse her elevene som er dårlige til å skrive, de blir drillet på skriving, de taper og taper og taper og taper, fordi at vi liksom sier som samfunn at de må lære det, de må jo lære å skrive. Og så tenker en at, samfunnet rundt setter fokus på det de ikke kan, og så skal vi prøve å sette i verk tiltak for å på en måte ruste dem opp på det de ikke kan. Og så sitter de her spes-ped-elevene i tapsituasjon igjen og igjen og igjen. Og så viser det seg at de er jo faktisk flinke på noe helt annet; hvorfor i all verden får de ikke lov til å dyrke det de er flinke på, det er jo der de har framtida si, det er der de har mulighetene sine, ikke sant?

[P3: 552 - 561]

The idea that all pupils need to end up with identical knowledge leads to a need for filling 'slots' in pupils' knowledge. David describes this by introducing another metaphor – the concept of the 'teacher spinal'. Like grammar used as a metaphor in this chapter, David's metaphor reflects the fact that the rules in action are not always conscious, yet they have a large impact on work in schools. David describes how the idea of 'filling slots' is part of the 'teacher spinal' and how this idea influences the communication he has with the primary schools from which School D get their pupils:

David

What are we really doing in schools? We do have, the entire teacher spinal is about, in a way, where does this pupil have slots I need to fill, right? That is a ridiculous way of thinking! (...) It is quite hilarious, when I go out to the primary schools here to inquire what do these pupils accomplish really, we are to get some information on our pupils in advance, in fact you do not have to do that, but it can be convenient to have some information if you use it right, I think. I think it was after the sixth, seventh pupil that they realised that I was more interested in what this pupil is good at than where the pupil has problems. I really had to ask, what is it that this pupil accomplishes, and what is that they... I did have to ask about this, for all the first ones before, I think I talked about five or six of them, before they started to talk about what they were good at first.

David

Hva er det egentlig vi holder på med i skolen? Jo, vi har jo, hele lærerspinalen vår går jo på en måte på, hvor er det denne eleven har huller som jeg skal fylle igjen, ikke sant? Det er jo en håpløs tankegang! (...) Det er ganske morsomt altså, når jeg drar ut til barneskolene her for å høre hva er det de elevene her kan for noe egentlig, der vi skal høre litt om elevene våre på forhånd, det er jo det som er at du trenger ikke gjøre det, men det kan være greit å ha litt kunnskap hvis du bare bruker den rett tenker jeg. Jeg tror det var først etter sjetten, sjuende eleven at de oppfattet at jeg var mer interessert i hva eleven var flink til enn hvor eleven hadde problemer. Altså, for jeg måtte spørre, hva er det den eleven kan, og hva er det de... Det måtte jeg altså spørre, på alle de første før, jeg tror jeg snakket om fem eller seks stykker jeg, før de begynte å snakke om det de var flinke til først.

[P13: 1174 - 1190]

While the information David gets about pupils from primary schools tends to be focused on the pupils' shortcomings and failures, David is more interested in knowing what they are good at, that is, where they have their potential for development and success.

The cultural beliefs on what school is about are not only located in the spinal of the teachers. The pupils who enter lower secondary school arrive with a clear opinion on what 'real school' is. The most important outcome from primary school may be that the pupils have learnt how to apply the grammar of schooling:

<p>David When we get these pupils, they already have a clear opinion about school, what school is. School is books, and to copy what we read in that book on to a piece of paper. (...) Because there is a question here, and there is a word that says ... EU, then I need to search the book until I find EU, and when I find EU I write what is written around EU, right.</p>	<p>David Når vi får de elevene her, så har de en veldig klar oppfatning av skole, hva skole er for noe. Skole er bøker, og det å kopiere det vi leser i den boka der over på et ark. (...) For det står et spørsmål her, og der er det et ord som sier... EU, da må jeg lete i boka til jeg finner EU, og når jeg finner EU så skriver jeg det som står rundt EU, ikke sant.</p>
--	--

[P3: 626 - 632]

This idea of reproducing information from textbooks represents the one David sees as the most important challenge for schools. He calls this 'the fight against reproduction':

<p>David The fight against reproduction. In my opinion that is one of, if something is important in the future, it is really to fight against reproduction. We must move away from, but our pupils do that now and then also, in the very moment they fall into such a quantitative way of thinking again, it becomes, and they are used to it through six years, or seven years at school, that it is about copying.</p>	<p>David Kampen mot reproduksjonen. Jeg mener den er en av de, er det noe som er viktig framover, så er det å kjempe mot reproduksjonen altså. Vi må bort fra, men det gjør elevene våre også innimellom altså så, i det øyeblikket de havner over i en sånn kvanitativ tenkning igjen, så blir det sånn at, og de er helt innarbeidet i det gjennom seks år, eller sju år på skolen, at det handler om å kopiere.</p>
---	--

[P14: 1211 - 1215]

The 'fight against reproduction', the wish for individualism in education and the desire to let pupils work on their own agenda are combined with the curricular requirements of 'real school' in the teaching model developed at School D. Teaching is built up in modular units, where introductory instruction is meant to function as 'tools' for the pupils. These 'tools' contain the basic knowledge and skills pupils need in order to undertake a following individual project where they are to give individual expressions to their products. The notion of 'tools' is used in a wide sense, and can be technical as well as conceptual. For example, David's pupils in grade 8 have been working with a film program, and given the task of making an

animated movie on the particulate nature of matter. The introductory part of this project, that is, the introduction of 'tools', consisted of a short instruction unit on the film equipment and also a teaching sequence about matter as particles. In their work with creating the film, the pupils have to further develop their skills in using the film equipment and their conceptual understanding of the particulate nature of matter.

How does technology teaching related to the TiS project fit in David's and his school's scheme for reconstructing education and fighting the grammar of schooling? Technology teaching understood as practical teaching projects within or across school subjects matches several of the perspectives David has presented in the above. First and foremost, as described in the conceptualisation of the aim 'fostering the pupil's agenda' in Chapter 9, technology represents one option for pupils when identifying their agenda. Practical technology gives pupils who fail within the frames set up by the traditional grammar of schooling opportunities to engage with fields of activities in which they succeed and in which they have their future. David's emphasis on individualism is attended to by technology teaching in two regards. Firstly by representing a *possible agenda* for pupils as described above, and secondly by providing possibilities for individualism *within* technology teaching in itself as technology projects where pupils design and create artefacts facilitates individual solutions and expressions. The subject Design & Technology that has influenced the TiS project also includes the idea of a 'task-action capability' (Black & Harrison 1985). This idea is noticeable in how David describes his impression of the subject, and he relates it to the concept of 'tools':

David

What I found alright with how they do it, the impression I got, was that I think they have a very good way of arranging the subject. These things with tools, that is equivalent to how we think ourselves, to teach them how to use tools, and then allow students and pupils to work out their own projects, elective tasks by and by. I think that was a very good structure, which I also recognised from here, but which I think they had cultivated very nicely over there and perhaps come further with.

(...)

The structure I think was very systematic.

And when we arrived at the school we visited, it appeared that they used exactly the same approach, that is, the first thing they were to make was that cover of a filofax or something like that, and that was in order to learn to use a bore machine, work a bit with plastic and... And they had such a research project of some

David

Det jeg synes var alright med det sånn som de driver det, det inntrykket jeg fikk, var at jeg synes de hadde en veldig fin måte å legge opp faget på. Dette her med verktøy, altså de, og det er jo sånn som vi også tenker, dette her med å gi verktøyopplæring, for deretter å la studenter og elever få lov til å løse egne prosjekter, selv-valgte oppgaver etter hvert. Det synes jeg var en veldig fin struktur, som jeg kjente igjen herifra for så vidt, men som jeg synes de hadde dyrket veldig fint der borte og kanskje kommet lenger på.

(...)

Strukturen på det var veldig systematisk synes jeg. Og når vi da kom til skolen vi besøkte, så viste det seg at de brukte akkurat samme formen, altså det første de skulle lage var vel den her framsiden på en Filofax eller noe sånt, og det var for å lære å bruke bormaskin, jobbe litt med plast og... Og så hadde de vel

kind, where they were to learn research. And when they were to learn drawing, they had a project, that is, it had a content. And that's how we try to think here also, when we teach the pupils, just a simple example such as word processing, then they write a poem. Right, it is about giving them some creative tasks which, where they need to use the tool. And where they actually need to learn how to use the tool in order to express what you want.

et sånt research-prosjekt av et eller annet slag, der de skulle lære seg research. Og når de skulle lære seg å lage sånne tegninger, så hadde de også et prosjekt, altså det hadde et innhold. Og det er sånn vi prøver å tenke her også, når vi skal lære elevene, bare bruke et så banalt eksempel som tekstbehandling, så skriver de dikt. Ikke sant, det er noe med at du gir dem noen kreative oppgaver som, hvor de må bruke verktøyet. Og de må faktisk lære seg å bruke verktøyet for å få uttrykt det du vil.

[P13: 25 - 64]

What David associates with the subject he experienced at the course in York and at the school they visited, is how teaching projects systematically involve 'tools' to be learnt in order to arrive at an individual product, and also how the subject is open to individualisation of pupils' work. He makes an explicit parallel to how they work at School D, by using an example of teaching pupils word-processing as a tool for expressing yourself through a poem. Thus the aspects David focuses on when describing Design & Technology as a subject are those matching his own educational preferences.

When we compare David's perspectives presented above to those given by Gina in the Seventh story, we find many similarities in how they conceptualise the grammar of schooling and how they attempt to change aspects of this grammar in their own work. There are, however, important differences in what role technology teaching associated with the TiS project plays in pursuing this agenda. These differences can be interpreted as a result of differences in institutional and cultural settings at their respective schools. The settings at School G do not facilitate fundamental changes in the direction of Gina's educational beliefs on a general level. They do, however, allow Gina to make her realisation of the TiS project contest the grammar of schooling through a *supplementary* unit that deviates from ordinary school subjects. David, on the contrary, acts in institutional and cultural settings that allow and support a more comprehensive fight against the grammar of schooling in all subjects and in all aspects of his work. To him, technology teaching does not represent any deviation from ordinary practice, but is one of many means of fulfilling his educational beliefs and agenda for change. In both cases, however, technology teaching associated with the TiS project is utilised as a tool by the teachers in reconstructing aspects of teaching and in their fight against the grammar of schooling.

CHAPTER 13

FINAL DISCUSSION AND CONCLUSIONS

The study reported in this thesis has investigated the introduction of technology as a new subject of teaching in Norwegian schools, and how ideas from Design & Technology inherent in the TiS project have transformed into a Norwegian school context under various influences. The analysis and presentation of interview data, classroom observations and tape-recorded classroom teaching have exhibited various aspects of the issue. The focus has partly been on individual teachers, and aspects of how they create technology as a subject in their schools have been presented by means of seven 'stories' throughout the thesis. Between the stories, the presentation has included cross-case comparisons and analysis of the cases as a group.

This final chapter of the thesis discusses the two questions raised in the introduction (Chapter 1) on the basis of results from the study and their interpretations presented in the preceding chapters. This is followed by a discussion of the nature of teachers' interaction with the TiS project, and the thesis concludes with an account of possible implications for curriculum development and research.

Teachers' perception and realisation of technology as a subject of teaching

The preceding chapters have described aspects of how the teachers in this study comprehend the nature of technology as a subject of teaching, and how they realise technology teaching associated with the TiS project in their schools. These aspects include the aims teachers possess for technology teaching, how they frame technology as a subject and relate it to science and other subjects in the curriculum as well as interpretations of how, in some cases, technology teaching forms part of an agenda for educational change on a fundamental level. In the following, some key characteristics of the teachers' perceptions and realisation of technology teaching arising from the analysis as a whole will be summarised and discussed.

What is technology teaching *for*?

It has been shown in this thesis that the teachers participating in the TiS project have adopted many of the activities provided through the project in their realisation of technology as a subject of teaching in their schools. However, as illustrated

through the First and Second story in this thesis, the teaching they create based on these activities can be substantially dissimilar. This motivated an exploration of the various *aims* the teachers possess for their technology teaching. These aims have been conceptualised within categories derived from the empirical data themselves in Chapter 9, and complemented throughout the subsequent chapters. They can be summarised as follows:

Pointing pupils to technology reflects the individual aspect of the economic argument for technology education. It involves *exposing the joy of technology* in order to motivate pupils for technological work and *opening doors to technological careers* by means of providing pupils with relevant experiences of what technological work implies.

Making school more practical embraces several distinct concerns. Technology teaching is seen as *improving the teaching context* in that it offers activities that deviate from typical school activities such as reading, listening and writing. Secondly, it acts as a way of *building experiences*, which is seen as valuable in itself but also as a means for establishing a basis of experiences on which pupils' learning of content knowledge in for example Science can be built. Finally, technology is seen as a body of mainly *practical knowledge*, to which pupils should be introduced as part of their general education.

Familiarising pupils with technological surroundings presents a picture of pupils as members of a technological society. In this picture, technology teaching is seen as building pupils' awareness of these surroundings, that is, *extending their horizon of registration*. Further, technology teaching acts to *humanise technology* in that pupils are made aware of technological products as human products, the existence of a technological development and specific human beings that have been important in this development. Affective aims of technology teaching are represented by *building pupils' confidence in engaging with technology*. This involves supporting pupils' self-confidence and curiosity in engaging with technology on an everyday basis, and has utilitarian connotations. Further, teachers also express aims of equipping pupils with *knowledge about industry and production* in the society in which they live and with attitudes of *environmental awareness* as critical consumers. Technology teaching is also found to aim at an *understanding of everyday technology* in terms of how technological objects and systems physically work. Finally, the aim of *broadening the technology concept* identified in Chapter 10 can be subsumed under this category of 'Familiarising pupils with technological surroundings'. The aim represents a desire to broaden pupils' usually more narrow view of what technology entails towards a comprehension of technology as any process from raw material to a product.

Cultivating the pupil addresses the potential of technology teaching in cultivating the pupil as a human being. It embraces *nurturing the pupil's pride and self-esteem as a creator* and *fostering the pupil's agenda*. Further, technology teaching is seen as valuable in *maintaining general educational goals*, such as making pupils learn co-operation skills, helpfulness and skills in planning and organising their work. It is also seen as contributing to social equity by providing pupils of lower academic ability with an arena where they can succeed.

Revitalising science teaching involves the inclusion of technology in science teaching in order to make this subject more useful, enjoyable and meaningful to pupils. This entails a broadening of the scope of school science and an altering of the subject's 'ethos' from a merely academic subject towards a subject that is more practical and oriented towards utility.

Fighting the grammar of schooling represents attempts to alter characteristic aspects of conventional school teaching, and it is shown that technology teaching associated with the TiS project plays an important role for some teachers in pursuing this agenda for change. Technology teaching fits this agenda as it provides an opportunity to deviate from elements of the conventional 'grammar of schooling', such as a predefined subject matter to be learnt, pupils' lack of power in defining the agenda and a strong focus on reproduction and assessment.

The aims in the above categories do to some extent correspond with those formulated for the TiS project. For example, NITO's emphasis on science in their conceptualisation of the project is reflected in 'Revitalising science teaching'. However, the teachers' aims for their technology teaching appear to exceed those formulated by NITO, and they also appear to differ from what can be associated with the subject Design & Technology. Rather than adopting the full rationale of the project policy or Design & Technology as a subject, it appears that the teachers utilise specific aspects of ideas and resources provided through the project in pursuing their *own* agenda for their work with pupils. The characteristics of this agenda will be further discussed in the following sections.

What is technology teaching about?

What characterises the teachers' aims for technology teaching on the whole and the way they are put into practice? The question may be considered in terms of the picture of *technology* they convey and thus what it means to 'teach technology'.

As shown in Chapter 2, technology is a multifaceted concept and carries several distinct but related meanings. Among the four broad meanings of technology

conceptualised by Mitcham (1994), that is, technology as object, activity, knowledge and volition respectively, the conceptions of technology as *object* and *activity* appear to be most prevalent among the teachers. Further, it seems that the teachers apply a criterion of physical movement associated with the human-made artefact itself in defining what can be considered as technological objects and activities. It is, however, also found that some teachers hold a broader conception of technology, as shown in the Fifth story.

A view of technology as *knowledge* also appears to be held by some teachers in this study, though it is often vaguely expressed. Most articulated in this regard is Frederic's formulation of technological principles as intended learning outcomes of his technology teaching in the Fourth story and particularly Eric's conceptualisation of a knowledge base of technology presented in the Third story. Both Frederic's and Eric's expressions of technology as knowledge reflects mainly the technical aspect (Pacey 1983) of technology. Cultural, societal and organisational aspects are less attended to.

Chapter 3 presented some features, denoted '*fundamentals*', of what a school subject represents, including Schwab's conception of the 'structure of a discipline'. The presentation included a brief review of the current discussion and conceptual problems related to defining technology as a discipline and hence also technology as a school subject. The teachers in the present study, however, pay little attention to these 'fundamentals' in creating technology as a subject in their schools. With the exceptions indicated above, a general impression across cases is that the teachers appear to place a minor emphasis on identifying technology as a subject on *epistemic* grounds, that is, based on a consideration of the type of knowledge and skills technology as such represents. For example, it was shown in Chapter 11 that the teachers' positioning of technology teaching with regards to school science is educationally situated rather than based on considerations of a relationship between science and technology outside the school context. This stands out against the assumptions underpinning Fensham and Gardner's (1994) framework for ways in which science and technology are related in the curriculum.

Though Chapter 10 revealed that the teachers to some extent define technology as a subject on the basis of what other subjects are *not*, it has been shown that technology teaching is often comprehended as an *interdisciplinary* approach to the teaching of contents of other subjects. Rather than viewing technology as an essentially new subject, teachers associate it with project work as a working method prescribed in the curriculum L97 (see Chapter 5). Accordingly, technology teaching is often realised as interdisciplinary projects in the schools participating in the TiS project. Thus the teachers' framing (Bernstein 1971) of technology as a 'subject' is weak, as they do not conceptualise strong boundaries between what

‘may be taught’ and what ‘may not be taught’ in technology teaching understood as interdisciplinary projects.

Some teachers refer to technology as a *process*, yet not in the sense it was presented in the introduction of Design & Technology as a subject in England and Wales, that is, as a generic design process that can be taught, learnt and assessed. Instead, some teachers describe technology as a process in terms of an active way of working with subject matter from various areas. Correspondingly, some of them describe Design & Technology in fact as simply a different *combination* of subject elements and it has been upheld that what this subject represents is in principle already covered by L97. Technology specified as a subject or as cross-curricular project work is nonetheless seen as a new and advantageous approach, as it combines these elements in meaningful contexts for the pupils. This comprehension relates technology teaching to many subjects in the curriculum, but it is also shown that the teachers link technology and technology teaching particularly to Science. Technology teaching is seen as providing learning opportunities and application opportunities for science content knowledge, as a motivational tool or as a way of revitalising science teaching as described in the Sixth story.

“We teach children – not subjects!”

Though the study has revealed various views of what technology means among the teachers, the most striking feature of how they perceive and realise technology teaching is, however, not how they contemplate *technology* but how they contemplate the *pupil*. In accordance with what has been proposed by Lewis (1999), the teachers’ emphasis is on how pupils can benefit from technology teaching in various ways rather than on how teaching should convey an appropriate picture of technology *per se*. This orientation is prevailing in all the teachers’ approaches to technology teaching, and echoes from Rousseau and progressive movements in education can be heard, particularly within the aims classified as ‘Cultivating the pupil’. In essence, the teachers express a fundamental attention to what can be understood as *care* for their pupils.

Noddings (1992) has criticised the rationale for liberal education as she claims that it draws on a narrow set of human capacities. Rather than organising education around instruction within academic disciplines, she proposes that education should be organised around domains of *care*. These include caring for self, caring for intimate others, caring for associates and distant others, for non-human life, for the human-made environment in terms of objects and instruments and finally caring for ideas. In her view, curricula and school practice are too heavily based on what she calls a ‘single purpose view’, where human capacities are solely comprehended

as academic abilities and care for *ideas*. She claims that purposes reflecting other human capacities and other domains of care are undermined and should to a higher degree be attended to in schools and educational policy.

The teachers' thinking as it has come to expression in this thesis can be seen as residing in care as a rationale for teaching as described by Noddings. Care for self and others and for the human-made environment appears to form a fundamental basis for the teachers' creation of technology as a subject of teaching. Less emphasis is placed on identifying technology as a subject or conceptualising epistemic features of technology, which may explain why explicit learning objectives in terms of knowledge and skills have sometimes been hard to identify in this study. This may also account for the fact that 'typologies' found in literature on technology education have not been fully functional for capturing the teachers' various expressions of the rationale for their technology teaching. Those typologies, and writings on technology teaching more generally, may reflect an academic orientation which emphasises the epistemic features of the subject. This orientation differs from the one expressed by many of the teachers in this study, who rather base technology teaching on considerations of what benefits the pupils as humans.

Further, the results of the present study indicate that the teachers' focus on the pupil in their creation of technology as a subject is dominated by a 'here-and-now' perspective and related to pupils 'lived-in' experience (Eisner & Vallance 1974) rather than being directed towards a future goal. Reflecting the ideas of Dewey (see Imsen 1997), the teachers see school life as valuable in itself rather than as an instrument for future life. They emphasise how technology teaching can improve the everyday teaching context, give varied and meaningful experiences and enhance pupils' motivation and interest for school in itself. This feature of teachers' thinking parallels what has been observed elsewhere, that factors associated with the teaching context and pupils' interest are crucial for teachers planning processes (e.g. Clark & Yinger 1987). However, the teachers in the present study appears to conceive the teaching context and pupils' interest as a *target* for their actions rather than as *factors* guiding their actions.

The above does not mean that there is no component of knowledge present in the teachers' technology teaching. It has been shown earlier that technology in itself is perceived as knowledge by teachers and that this perception is reflected in their teaching. The study has revealed differences in how, and to what degree, teachers formulate learning outcomes in terms of knowledge and skills, but also that a distinction between 'subject-centered' and 'pupil-centered' teachers can not be made on the basis of the data. As discussed in Chapter 9, the difference between the

teachers is rather to be found in the *role* they assign to this knowledge component in fulfilling their aims, which all have a fundamental focus on the pupil.

The teachers' 'here-and-now' perspective may also account for the peripheral role assigned to issues related to societal aspects and democratic control of technology. These issues, prevailing in the discourse related to technological literacy (see e.g. Lewis & Gagel 1992), are not emphasised in how the teachers in this study conceptualise and realise technology teaching. It is hard to deny the relevance of societal aspects of technology for adult citizens. For pupils, however, they might not be chief targets for interest and motivation. Not only are societal aspects of technology to a minor degree attended to by the teachers; some also indicate that teaching associated with these aspects of technology might be *counteractive* to the aims they possess for their technology teaching. Such indications can be traced in how Eric distinguished between education *in* technology and education *about* technology in the Third story, where he claimed that elements of practical-technological character are missing in Norwegian schools. Further, Elna has argued in the Sixth story that school science has developed too much towards social studies, and the story shows how she has utilised technology teaching associated with the TiS project in pursuing her aim of revitalising science teaching in the sense of making this subject more useful and less academic. Her position appears to be shared by both David and Gina (pp. 127-128), who have placed technology teaching in direct opposition to the use of textbooks. Rather than being a sign of a narrow view of technology held by the teachers, the minor emphasis on societal aspects is likely to be due to a disparity between the *type of teaching* associated with societal aspects of technology and the ones deemed appropriate for fulfilling the aims the teachers possess. The teaching one would easily associate with societal aspects is likely to involve the use of textbooks and discursive approaches to technology teaching, that is, what Frederic has pinpointed as 'reading, listening and writing' (p. 124). This type of teaching could be counteractive to the teachers' own agenda inherent in the aims of Making school more practical, Cultivating the pupil and Revitalising science teaching as well as some teachers' attempts to alter the 'grammar of schooling'. The teachers' bias towards the *technical* aspect of technology, involving cultural and societal aspects being less attended to, may hence be interpreted as related to teaching methods rather than to a view of what technology as such represents. It thus reflects a fundamental focus on the pupil in a 'here-and-now' perspective.

Following Bernstein (1971) and how he relates the concepts of framing and classification to the power of those involved in the pedagogical relationship (see Chapter 3), we may relate the teachers' expressions of their focus on the pupil,

their aims for for technology teaching and their weak framing of technology as a subject to the teachers' *power ideology*. It has been shown in this thesis that the teachers place little emphasis on conceptualising technology as a discipline or as an independent subject, leading to a *weak framing* of the subject. Bernstein (ibid.) maintains that weak framing is associated with a decreased *power* for the teacher over the pupil, and thus a strengthening of the pupil's power in the pedagogical relationship. Such a strengthening of the pupil's power in deciding 'what may be taught' is evident in the aims the teachers in this study express for technology teaching. The aim conceptualised as *fostering the pupil's agenda* (Chapter 9) and the rationale underpinning how teachers are *fighting the grammar of schooling* (Chapter 12) entail precisely such an empowering of the pupil. It thus appears that the teachers' perceptions and realisation of technology as a subject of teaching has been shaped by an ideological stance involving a desire to create teaching that is less authoritative and that supports the pupils in making their own decisions.

In sum, the teachers' focus on the pupils and the teaching context and the sometimes vague expressions of the 'subject content' of technology education can be captured by the aphorism "*We teach children – not subjects!*" (see Scheffler 1960), though the opposition it suggests can be (and is) easily questioned. For the teachers in this study, the aphorism signifies the consideration of pupils and their needs as a starting point in the creation of technology as a subject, and the more peripheral role assigned to a systematic conceptualisation of the subject's content and structure in this regard.

Rehabilitating the practical pupil

One aspect of care as a foundation for the teachers' realisation of technology teaching is the deep concern they show for how it may benefit pupils who do not succeed in academic subjects but are more practically oriented. They see technology teaching as providing those pupils with opportunities to work within areas where they succeed, and to explore their potential and develop their abilities in practical directions. Eric has pointed to the absence of these opportunities in compulsory education in Norway as "a great injustice built into our compulsory school" (p. 121). However, several teachers appear to have justice for pupils also on a social level in mind, and they point to how technology teaching may contribute to social equity among the pupils. This is evident in how Benny gave pupils a high degree of freedom in shaping their projects in the Second story in order to let all pupils succeed. He emphasised that technology teaching gives pupils who struggle with other subjects an opportunity to demonstrate their knowledge and skills in practical areas. Correspondingly, Irene asserted that technology teaching provided a new arena for low ability pupils (p. 167), where they could

experience being a greater resource and being in charge to a greater extent than in conventional teaching contexts. Further, it appears that the social equity the teachers seek can not be fully attained by offering the type of pupils in question specific practical units that can replace academic subjects. On the contrary, teachers have pointed to such units as ‘negative choices’ (Eric p. 132) and as being labelled as a place for the less able (Jim p. 122), thus leading to a further stigmatisation. The presence of all pupils appears to be a prerequisite for technology teaching to function as improving the social status of the practically oriented pupils, besides – of course – the benefits all pupils may actually gain from technology teaching.

The ideological position the teachers have expressed in their concern for the less academic-minded pupils shows some parallels to the idea of a ‘rehabilitation of the practical’ (Layton 1984) that formed part of the foundation for the establishment of technology as a compulsory subject in England and Wales. ‘Rehabilitation of the practical’ was associated with a desire to rise the status of technology-related *work* and counteract the drift of able pupils away from industrial areas seen as a keystone in the nations’ economy. As shown above, the Norwegian teachers’ perspectives as they have emerged in this study appear to include a somewhat different rationale, which perhaps can be described as a ‘*social rehabilitation of the practical pupil*’.

Transferring a subject?

Through participation in the TiS project the teachers have become acquainted with ideas inherent in Design & Technology taught as a compulsory subject in England and Wales. What aspects of this subject are adopted in how the participating teachers create technology as a subject of teaching in their schools?

The key idea of pupils’ designing and making artefacts embedded in Design & Technology has largely been adopted by all teachers, but they are found to comprehend and realise this idea in various ways. To some, such as Ann in the First story and Frederic in the Fourth story, it entails giving pupils the opportunity to create high quality products under the guidance of their teacher. Others, such as Benny in the Second story, emphasise pupils’ creative experimentation with materials in realising their own ideas where the quality of the final product is given less prominence. Others again see the pupils’ creating of artefacts as an introduction to what it means to work as a technologist, as conveyed by Eric in the Third story. To some of the teachers, the idea of letting the pupils create has a deeper meaning than merely development of objects in the material world. This is manifested in the notion ‘the pupil as a creator’ introduced within the category of aims for technology teaching denoted ‘Cultivating the pupil’. It involves building pupils’ pride and self-esteem towards themselves as active creators who have a

potential for expressing themselves by creating. For the teachers in this study this is, however, to little degree underpinned by the idea of commercialism embedded in the subject Design & Technology in England and Wales; that pupils should learn to create *marketable* products.

Pupils are often given high degrees of freedom in shaping the activity and also in defining what the activity is *about*. However, the technology teaching observed and the teachers' description of it rarely communicate a view of the pupil as a modern inventor in the sense that they 'identify needs and opportunities', investigate the market for their inventions, strategies for large scale production and the employment of visual communication in order to 'sell' their ideas and inventions. This picture is, on the contrary, conveyed by curricula and implementation of Design & Technology as a subject in England and Wales (see Chapter 3). The focus on 'selling ideas' in this subject is manifested through the extensive use of drawing techniques for visual communication and 'folios' with pupils' drawings and design briefs, seen as an important aspect of the subject by a majority of teachers in England and Wales (Mittell & Penny 1997). The visual appearances of these folios and the English pupils' drawing skills have impressed the Norwegian teachers, but attempts to copy this approach are rare. To the extent that drawings are used, they are meant to function as technical working drawings or – as formulated by Eric in the Third story – as "a way of thinking" (p. 134).

The teachers in this study have adopted the use of materials and tools associated with modern industry in their teaching, primarily represented by activities involving electronics and moulding with plastics. They also include knowledge about mechanisms, structures, material and components in their technology teaching, which can be recognised from the specification of Knowledge and understanding in the curriculum for Design & Technology in England and Wales (see Table 2, p. 36). However, though an aim of familiarising pupils with industry and production has emerged from the empirical data, the teachers are not observed to address key aspects of modern industry, such as techniques for mass production and strategies for marketing, in relation to the technological products made by the *pupils* in their teaching. The category of aims denoted '*Familiarising pupils with technological surroundings*' includes making pupils – as members of a technological society – aware of how things we use in everyday life are technically produced and in fact also that they *are* produced. The aims in this category point towards involvement with technology in ones surroundings on an everyday basis rather than a view of pupils as active participants in development and production processes. This makes for example the aim denoted 'understanding everyday technology' in fact having more in common with 'The science of common things' as a movement in science education in 19th century Britain (see Layton 1973) than with the image

conveyed by contemporary Design & Technology. This transformed comprehension of technology teaching may explain why several teachers are doubtful about assigning food technology under the headline of technology teaching. They may associate food products with cooking in the home rather than seeing them as a result of a process involving development and communication of ideas, considerations of the market, arrangement of production lines and marketing. Strategies for communicating and promoting ideas for products are rarely an issue in the teachers' technology sessions or in how they reflect upon the subject. The few references made to the promotion of ideas or products are related to a view of pupils as *critical consumers* rather than industrial inventors, and can be interpreted as a wish to *protect* pupils against *others'* attempts to promote commercial products.

In general, the teachers' utilitarian perspectives, which appear to be integrated in several of their aims for technology teaching, are not mainly directed towards industry and modern production, but rather towards household in a broad sense of the notion. The activities they arrange for their pupils involve creating products for their own use rather than for (hypothetical) marketing. The teachers' rationale for these activities is often described in terms of understanding principles of products in everyday use and developing skills and attitudes in engaging with technology on an everyday basis rather for industrial innovation. The Norwegian teachers' creation of technology as a subject of teaching hence appears to be a less commercial-flavoured enterprise than the 'original' Design & Technology. The Fifth story presents an exception in this regard. Benny thoroughly investigated Kinder Eggs together with his pupils with the intention of building their understanding of technology as a process from raw material to a product, and thus that a product such as chocolate is to be considered as technological. The aspects of technological production he addressed in this session, such as marketing, costs of materials, packaging, consideration of the consumer and so on were, however, not central in how his *pupils* undertook their projects in the subsequent sessions (see Second story). On the contrary, these sessions were interpreted as aiming at giving pupils opportunities to experiment freely with their creativity and available materials.

The above shows how certain aspects of Design & Technology have been adopted by teachers participating in the TiS project in their realisation of technology as a subject of teaching. It is also evident that other aspects have been modified or left out. In sum, the present study has shown that educational ideas 'transferred' from Design & Technology have been significantly reworked when realised in a Norwegian school context.

Influences on the realisation of ideas from Design & Technology in Norwegian schools

What have been important influences on how ideas from Design & Technology have transformed into Norwegian schools participating in the TiS project? The following sections will discuss the significance and nature of influence from aspects of the TiS project itself and from the framework for compulsory education set up by the curriculum L97. The impact of the teachers' subject background will then be considered in light of earlier research in the field. Finally, the cultural shaping of technology teaching associated with the project will be discussed.

Influences from the project policy and implementation

Through participation in the TiS project, teachers have been introduced to ideas inherent in Design & Technology as a subject in England and Wales. How have different aspects of the project itself influenced the realisation of these ideas in Norwegian schools? The following will consider the influence of the official project policy, its underlying intentions and aspects of project implementation in terms of teacher training and resources provided.

The official project policy for TiS is expressed in terms of the project's aims presented in Chapter 6. These aims are not very specific in character, and it appears from the present study that they have not been the main basis for how the participating teachers create technology as a subject of teaching. On the contrary, interviews have exposed that the aims have hardly been read, and to an even lesser extent discussed or reflected upon, by the teachers participating in the project. Many teachers have, however, indirectly grasped the messages communicated by some of the aims, that is, that technology teaching should enhance pupils' motivation for science and mathematics.

As a general impression across the cases, the teachers appear to make a stronger link between technology and science, at least in the school context, than what is the case in Design & Technology as a subject in England and Wales. Chapter 11 has exhibited various ways in which the teachers position technology with regards to school science, and it was suggested that several of their approaches could be interpreted as a response to limitations they experience in school science. The close link made to science teaching, at least on a conceptual level, can be an effect of how the TiS project is conceptualised and communicated by NITO, given that Design & Technology as a subject in England and Wales is not at all characterised by any strong link to Science (Barlex & Pitt 2000). The relatively strong connection to science made by the Norwegian teachers can, however, also be due to different connotations of the English word 'technology' and its equivalent in

Norwegian, as was briefly discussed earlier in this thesis (Chapter 2 p. 6 and Chapter 5 p. 69).

In Chapter 6, it was claimed that NITO's underlying agenda for initiating and running the project is to enhance recruitment to engineering. Chapter 9 revealed that this agenda has been well communicated to the teachers, yet not all teachers share their priorities. Jim, for example, has asserted that pupils should rather be encouraged to choose technical vocational occupations (pp. 121-122).

How is the teachers' realisation of technology teaching related to the TiS project influenced by this underlying intention of enhanced recruitment? The intention is found to be comprehended and operationalised by the teachers as teaching that pupils find *enjoyable* and that provides them with *experiences* of what technological work means. Interestingly, these two qualities of technology teaching correspond with the teachers' agenda in other regards, conceptualised as the aims *improving the teaching context* and *building experiences* respectively. This might indicate that the influence of the underlying agenda of the TiS project is fortified because it merges with teachers' aims and desires in other regards. They might have adopted the stance of emphasising recruitment purposes simply because its implications for teaching are similar to those providing for their concerns in the educational context.

The course the teachers have attended as part of their participation in the TiS project, as well as seminars related to the project, are found to have a highly detectable effect on the realisation of technology teaching in the Norwegian schools. This impact is found to be mainly in terms of specific *activities* around which the teachers structure their teaching. These activities have not essentially functioned as examples or illustrations of how educational ideas in Design & Technology can be realised, they have rather been directly adopted by teachers to a degree that suggested that these activities themselves *define* the TiS project and technology teaching associated with it. This observation motivated the interpretation of the TiS project as an *activity account* discussed in Chapter 8.

The idea underpinning 'activity account' as a metaphor, that is, the use of activities in the meaning of curriculum material as a tool to reach specific goals set for teaching, is not new. Nor is the observation that educational aims and objectives are not intrinsic features of curriculum material themselves. Among others, Powell and Anderson (2002) have pointed to both of these aspects of curriculum material and their use, and to the fact that the behaviour and beliefs of the teacher are a critical factor in how the material is put into action. However, their perspective is

slightly different from the one adopted in the conceptualisation of an ‘activity account’ in this thesis. Powell and Anderson describe the influence of curriculum material in educational reforms in terms of two extreme ends of a continuum; a so-called ‘positive action’ denoting teaching practice that is consistent with the reform’s intentions at one end, and at the other end a transformation of curriculum material into what they describe as “a stagnant expression of reform where the teacher chooses to ignore the reform initiatives manifest in the materials” (p. 112). In a corresponding manner, Mittell and Penny (1997) have stated that “seeing an activity as important is not the same as using that activity appropriately” (p. 285). Such descriptions appear to miss out on the dimension of the teachers’ *own* intentions with their teaching based on the material provided. The present study has revealed a multiplicity of positions along this dimension, and that teachers – who may or may not *ignore* the intentions ‘manifest in the material’ – utilise activities provided in creating teaching, in this case on technology, that fulfil intentions the teachers see as important and the aims they themselves possess for their teaching. From the results and analysis presented in this thesis it is evident that the TiS project has had a profound impact by providing teachers with tools in this regard.

Influences from the curriculum L97

Though the TiS project represents an attempt to introduce aspects of a new subject in Norwegian schools, the participating teachers are governed by the framework set up by the formal curriculum for compulsory education when realising technology teaching associated with the project. How has this framework influenced the shaping of technology teaching in Norwegian schools?

The audit undertaken in Chapter 5 has shown that the formal curriculum provides opportunities for technology teaching in some version of the notion in several specified subjects, as well as within ‘School’s and Pupils’ Options’ (SEV), as project work or as thematic teaching across the curriculum. These opportunities have been utilised in several ways in the schools involved in the TiS project. It is worth noting, however, that the teachers seldom – if at all – refer to the subject specifications in order to identify the opportunities they provide for technology teaching. This applies even in cases where teachers assert that technology teaching is an interdisciplinary approach to the coverage of content specified in several subjects in the curriculum. As was exemplified by Frederic in Chapter 10 (pp. 203-204), the teachers rather refer to the *general* part of the curriculum in this regard, which provides the ideological foundation on which compulsory education is to be based and the principles and guidelines that are to govern compulsory school. This finding is coherent with research reported by Kallestad (2000), who found that Norwegian teachers rank general educational goals as high as or higher than goals related to achievements in school subjects. Furthermore, the aims for technology

teaching derived from the empirical data in this thesis show clear parallels to essential ideas presented in the general parts of the curriculum and reviewed in Chapter 5. The teachers' focus on development of pupils' creativity and self expression reflects the *Creative human being* described in the Core Curriculum. The portrayal of the *Environmental-aware human being*, which conveys a desire to sustain critical consumerism, can also be recognised among the teachers' aims for technology teaching. Further, essential aspects of the curriculum's Principles and Guidelines, such as transfer of control from the teacher to the pupil, experience-based learning, play as a way of learning and individual adaptation of teaching appear to be integral in how the teachers have conceptualised and realised technology teaching associated with the TiS project.

No conclusion can, however, be drawn on whether the above is an indication of a high *influence* of the general part of the formal curriculum as such, or whether it is rather a sign of a strong *consistence* between the philosophy expressed in the curriculum document and the shared educational culture of which the teachers are members. Possible influences of this shared culture on the realisation of technology teaching in Norwegian schools will be the theme in a later section.

A different, and as significant, connection between the curriculum and the teachers' approaches to technology teaching has also been detected in the present study. This connection regards the *problems* the teachers have pointed to with regards to their realisation of the curriculum L97. Though the teachers appear to appreciate the curriculum's emphasis on project work and interdisciplinary approaches, they have announced difficulties in finding ways of including meaningful substance in this kind of teaching, pinpointed by David with the expression "much inter and little discipline" (p. 205). Similar problems have been identified by Broadhead (2001) in a study of the implementation of L97. In a survey among Norwegian teachers, she found that the two biggest challenges teachers experienced in this implementation process were to acquire sufficient relevant resources for theme/project work and to use thematic and project work. The analysis in Chapter 10 indicated that technology teaching associated with the TiS project is looked upon as a possible *solution* to these problems by some teachers, and even as a *catalyst* in fulfilling the formal curriculum's requirements (Irene, p. 207). This way, the curriculum L97 can be seen as having influenced the realisation of technology teaching in the sense that it provides the teachers not only with *opportunities*, but in fact also with *needs* for technology teaching to fulfil. These experienced needs appear to have contributed significantly to the shaping of technology as a subject of teaching in Norwegian schools.

From the high degree of consistence between the educational rationale of L97 and the teachers' creation of technology as a subject of teaching presented above, it might be concluded that the teachers participating in the TiS project have not essentially realised a technology subject imported from England and Wales. They can more aptly be seen as having realised the intentions in the *Norwegian* curriculum by means of technology teaching. This finding accentuates the importance of considering the specific educational context at hand when attempting to understand or commence educational change in schools.

Teachers' subject background as significant?

The teachers participating in the TiS project hold different educational backgrounds and may hence be affiliated with different disciplines and school subjects. What is the significance of the differences in educational background for the teachers' interpretation and realisation of technology as a new subject in schools? Are they biased towards their own subjects and their subculture (Jones 1999) in how they interpret the content of technology as a subject and in how they focus their teaching of technology? Indications in this direction were reviewed in Chapter 1. They are, however, not supported by the findings in the present study. The teachers' educational backgrounds, summarised in Appendix 1, are in many cases multifaceted. However, a broad categorisation of teachers with the purpose of investigating how educational background and subject affiliation have influenced their realisation of technology as a subject of teaching can still be made. One category contains teachers with their background mainly in the natural sciences, some on a relatively high academic level. This category consists of Eric, Frederic and Gina. Elna can also be placed in this category, yet her background also contains a significant component of Art and Crafts. David, with his multifaceted background, also refers to himself primarily as a science teacher and can be placed in this group. A group of teachers with their background mainly in Art and Crafts contains Ann, Gerhard, Hanna and Jim. The remaining teachers are generalist teachers or have their subject specialisation within yet different areas, in Frida and Irene's cases for example, in the humanities.

No clear patterns can be detected when considering the results of the present study in light of these categories of teachers. The differences between them are mainly to be found in how the teachers relate technology to science and science teaching on a *conceptual* level. The teachers in the 'science group', Eric, Frederic, Gina, Elna and David, tend to be slightly more *explicit* than the others in their conceptualisation of how technology relates to science. However, the view of technology as 'applied science' claimed elsewhere to be widely held by science teachers (van den Berg 1986, Rennie 1987, Tairab 2001), is far from dominant among science teachers in the present study. On the contrary, the Third story has shown how Eric

conceptualises technology as a school subject in terms of its *contrasts* to science. Compared to the others, the science teachers do, however, express more articulated views on how technology teaching in various ways may benefit, complement and even revitalise the teaching of school science. The latter may simply be an effect of the fact that science is a subject those teachers *teach*, and that the issue was not to the same degree addressed in interviews with teachers who are less involved in science teaching. Differences can also be found in how the teachers describe their motivation for joining the TiS project. As described in Chapter 11, the project's link to science acted as a motivation for science teachers while those without background in science tended to see this link as an obstacle.

While the teachers' subject background may have influenced how they relate technology to science and school science on a conceptual level, this pattern disappears when we enter the classrooms. Observations of their technology teaching show no sign of bias towards the teachers' own subjects. The situation is rather closer to the opposite. The teacher who is found to include most science content knowledge and its applications in her technology teaching is Ann, a teacher with her background in Art and Crafts and who also signalled an alienated attitude towards science as a subject (see First story). Gina, on the contrary, holds a strong background in physics, but hardly any subject matter from science was addressed in her teaching of technology (see Seventh story). Her initial motive of letting pupils 'use science knowledge for something' appears to be conquered by her concerns on a more fundamental level than those arising from her subject affiliation and wish to promote her subjects among the pupils.

Between the extremes represented by these two teachers, the teachers' emphasis on science, technical skills and aesthetic design has been varying, yet none of them appeared to be biased towards what can be identified as their 'own' subject. If this finding is to be explained in terms of the teachers' subject backgrounds, it must be seen as an effect of teachers conceiving the new subject as something that ought to be *different* from the subjects they normally teach, rather than that teachers interpret technology teaching in terms of their own subjects' subcultures as suggested by Jones (1999).

The above finding, as well as the actual difficulties in assigning some of the teachers to categories related to school subjects, may be a consequence of the relatively low standing of *subjects* as fundamental entities in Norwegian schools compared to the situation in many other countries. In a study of secondary schools in the US, Siskin (1994) found that different subject departments represent very different environments for teaching and that departments are more important carriers of a culture of teaching than is the school as a whole. Along this line one

could expect an influence of specific subject departments and their culture in the conceptualisation and realisation of technology as a new subject. Such an influence can not be detected in the present study, especially because any equivalent to 'departments' is hard to identify in Norwegian schools. On the other hand, this relative *absence* of a rigorous subject structure in Norwegian schools can in fact be interpreted as having significantly influenced the transfer of educational ideas on technology teaching from England and Wales, where the standing of *subjects* and *subject department* appears to be stronger. While considerable effort was put into *defining* technology as a subject in England and Wales (see e.g. Layton 1995), the transfer to a Norwegian school context has rather led to an emphasis on its potential for *cross-curricular* approaches to teaching (though the very different *scale* to which technology is introduced in schools should be taken into account). The teachers' realisation of technology as cross-curricular teaching is often given an explicit justification based on a view of technology teaching as a way of covering the contents of 'other' subjects with clear reference to project work as specified in the formal curriculum L97. However, it appears that the teachers conceive integration more in the direction of how Venville *et al.* (2002) have conceptualised integration as an ideological stance conflicting the one rooted in knowledge organised as academic disciplines. Their view of and realisation of technology as interdisciplinary teaching can also be seen as an expression of *care* rather than subjects as a structuring foundation for teaching as earlier discussed.

The view of school subjects as rather flexible entities can be illustrated by how Frida described it as *constraining* to limit technology to one subject area (p. 199), and by the pragmatic view Ann signalled when reflecting on the knowledge component of her technology teaching: "*If it is physics or something else, that doesn't really bother me much!*" (p. 110). In general, the Norwegian teachers' views and practice in relating technology teaching to science and other subjects in the curriculum do not mirror the lack of communication and co-ordination between Science and Design & Technology in English schools that have been verified by Barlex and Pitt (2000). It thus appears that the lack of rigour in identifying what and who belongs to a school subject has neutralised the impact teachers' background and subject affiliation might otherwise have on the realisation of technology as a new subject of teaching in Norwegian schools.

Cultural influences

How has the transfer of educational ideas inherent in Design & Technology into Norwegian schools been affected by cultural factors? The question addresses a subtle issue. In addition to the fact that *influences* can only be indirectly detected, it also involves problems in identifying what the essential features of the '*culture*'

which is anticipated to have an influence actually are. This section nonetheless presents an attempt to identify how the realisation of technology teaching associated with the TiS project reflects characteristic features of Norwegian culture. Some of these characteristics may well represent cultural *myths* rather than reality. But myths may in fact be at least as influential as ‘reality’, whose meaning in addition is far from clear when speaking of cultural aspects of a community.

Gundem (1993) provides a helpful starting point, as she gives an account of what is *specific* to the Norwegian educational situation in an international perspective, and how this reflects historical, political and geographical aspects of culture more generally. These characteristics can be summarised as follows:

- close connection between the Lutheran state church system and the educational system
- low degree of urbanisation combined with major differences between rural and urban areas
- a struggle for national and cultural independence, in which education has been seen a means for the building of a cultural identity and a national awareness
- deliberate emphasis on utilitarian knowledge rather than classicism in schools
- emphasis on equity, justice and democratic values

Several of these characteristics can be recognised in how the teachers in this study express their rationale for technology teaching. The emphasis on equity and justice reflects what is often seen as a characteristic aspect of the Norwegian society more generally, namely that its population is highly homogeneous and virtually class-less (though this claim has also been questioned, see e.g. Kramer 1984). The ideology of equity is highly evident in what was earlier interpreted as teachers’ attempts at a ‘social rehabilitation of the practical pupil’, that is, that technology teaching can provide for a more *equal* status between pupils with abilities in academic and practical direction respectively. It also reflects related issues, that is, the prevailing idea of unification of pupils in what is referred to as ‘one school for all’ as well as the emphasis given to children’s social competence and self-worth in Scandinavian schools (see Telhaug 1994 or Lillemyr 2002). Finally, the teachers’ intended ‘*empowering of the pupil*’ that follows from weak framing of technology as a subject discussed in a previous section, can be seen as reflecting the emphasis on justice and democratic values pointed out as characteristic to Norwegian educational thinking above.

The emphasis on *utilitarian* knowledge which Gudem (ibid.) points to as another characteristic can largely be seen in how the teachers have formulated aims for technology teaching, at times combined with other concerns. This perspective is in fact also found to apply to *science* teaching, as Elna's desire to revitalise science teaching presented in the Sixth story involved making school science more *useful* by means of technology teaching. As earlier noted, the teachers' utilitarian perspective on technology teaching is often directed towards what can be seen as household in a broad sense. In addition, they quite often see this household in a *retrospective* perspective, leading to a touch of *yesterday's* technology in the teachers' aim denoted 'understanding everyday technology' described in Chapter 9. For example, both Irene and Benny have pointed out that children today do not see their parents *repair* or maintain things in the household to the extent they used to in earlier times (pp. 150-151). In addition, David and Gina have addressed a change with regards to pupils' experiences; they do not get experiences with 'tinkering' and manipulating physical objects as young people used to in earlier times (pp. 128-129). This lack of practical experiences related to daily life is thus presented as one motive for the inclusion of technology teaching in schools. Irene has located this change not only along a time dimension but also along a geographic dimension, as she suggests that people living in rural settings are more clever at technology than those living in cities, since they are surrounded by more things in need of repair (p. 152). More directly, both Ann and Elna have addressed the ability to 'repair things' in the household as a potential outcome of technology teaching, though this aim has been interpreted as directed towards attitudes rather than specific skills. Ann asserted that technology teaching thus may make pupils more confident in engaging with everyday technology, and counteract the tendency of constantly calling upon experts (p. 141).

How come a school subject aiming at counteracting the 'decline of the industrial spirit' (Medway 1992) is now largely described as being about repairing utensils in a traditional household? The observed phenomenon can be understood in light of what the German writer Enzenberger (1984) has described as a beloved *anachronism* in the Norwegian mentality. He describes Norwegians as persistently keeping to pre-modern ways of living, and with a peculiar eagerness to restore old modest buildings and other testimonies of the past – often those associated with the poor and oppressed – by means of traditional techniques. Combined with strong affection for new technology, this anachronism has turned the country into what Enzenberger encapsulates as "*Europe's largest folk museum and simultaneously an enormous future laboratory*" (ibid., p. 96, my translation).

Though Enzenberger's description of Norway as the largest folk museum in Europe may be a bit exaggerated, it does indeed capture essential features of Norwegian culture. Kramer (1984) points to how Norwegian ethnical identity is based on an image of the "weather-beaten farmer" (p. 94), and how this self-image has acted as a unifying and mobilising force in the struggle for independence from foreign colonists. The image has some bearing on reality given the country's relatively late industrialisation and an economy that as late as early 20th century was based on two sectors: self-contained small-scale farming and export of raw material.

This feature of the Norwegian collective self-image may account for the teachers' frequent reference to a motive of maintaining or repairing things in everyday life in their conceptualisation of ideas from Design & Technology. The significance of a cultural 'repair paradigm' in how teachers interpret these ideas can be further illustrated by the instance earlier referred to as the 'egg clock experience' (p. 142): When Ann dropped a kitchen clock onto the floor and discovered that it was not working her reaction was to open the clock, investigate it and see if she could *repair* it. An archetypal response in a Design & Technology scheme would rather be to 'identify needs and opportunities' and invent a profitable device that could prevent kitchen clocks from breaking (or rather to present this challenge to the class). Interestingly, Ann describes how the action she made would not have occurred to her earlier, but was an effect of her participation on the TiS course in *England*. The course she attended may, however, be interpreted as having *activated* a latent culture rather than having introduced Ann to a new one.

Though 'repairing things' has not to any considerable degree been a specific and explicit theme in the technology teaching observed in the present study, the idea appears to form part of the teachers' rationale for the subject. This is especially evident in how teachers have expressed aims conceptualised within the category 'Familiarising pupils with technological surroundings'. Cultural influences may also account for the fact that few teachers put considerable emphasis on aspects that can be related to modern industrial technology in the activities they arrange for their pupils. As has earlier been pointed to, the purpose of the activities rather appear to be the making of artefacts for their *own* use and with intentions such as making pupils more confident in engaging with technology in everyday life.

In sum, while Design & Technology as a subject in England and Wales may be seen as reflecting the ideal of an innovative industrial designer, its transformed version in a Norwegian context indirectly conveys an ideal of the self-reliant pre-industrial farmer. This exhibits the significance of the surrounding culture for how new educational ideas are interpreted, reshaped and realised in schools.

Teachers' interaction with ideas

The transformation of ideas from Design & Technology into Norwegian schools under the influences described above can be seen as a result of teachers' *interaction* with the TiS project and with the ideas on technology education conveyed by this project. In the following, this interaction will be interpreted in terms of Barnes' (1992) conception of 'teachers' professional frames' presented in Chapter 4. The present study has revealed diverse aspects of conceptions, beliefs and desires that can be seen as forming part of the teachers' initial frames prior to their engagement with the TiS project. These are represented by conceptions of what 'technology' means as well as beliefs about pupils, education and themselves as teachers as well as desires on what they want to achieve in their work.

How do these initial frames influence the teachers' creation of technology as a subject of teaching, and how are their frames influenced by the ideas presented to them through their participation in the TiS project? Based on the data and their interpretation presented in this thesis, I suggest four *modes of interaction* by which the teachers have created technology as a subject of teaching based on the TiS project. These modes are not to be seen as mutual exclusive categories in which individual teachers or their actions can be placed; they rather refer to phenomena that are more or less prevailing in the interpretations of each teacher's actions and concerns in various regards.

The first mode is *assimilative* in nature, and involves that new ideas are adopted and interpreted in terms of the teachers' existing frames. This assimilation is observed in how the teachers interpret technology teaching in terms of the ideas of project work and thematic structuring of content familiar from the Norwegian curriculum L97 rather than as a new subject that adds to the curriculum. Their interpretation of the rationale of technology teaching within the earlier described 'repair paradigm' based on a collective self-image of a self-contained pre-industrial farmer is another expression of the assimilative mode of interaction with ideas. Teachers' use of specific activities in their teaching may also be seen as assimilative. Teaching activities offered teachers from the 'activity account' associated with the TiS project may be assimilated into and thus broaden their repertoires of teaching activities, without altering their frames or essential features of their teaching. Benny's buggy project presented in the Second story may be interpreted in these terms. His emphasis on pupils' experimentation with materials, their creativity and active learning through independent engagement with a broadly formulated task appears to be an important component of his professional frames as a teacher. The activity that involved the building of a buggy run by an inflated balloon is thus interpreted within this frame, and assimilated into Benny's repertoire of activities he uses in his teaching.

A second mode of interaction can be identified in how aspects of ideas are *selectively* adopted. It has been shown that teachers' have eliminated certain aspects of the technology subject they have become acquainted with in their choice of teaching activities, for example activities based on food products and those where there is no movement associated with the product. In these examples, the teachers' frames on what 'technology' means appear to have acted as a filter for whether activities from the activity account provided are adopted or eliminated respectively. This selectivity does not apply to specific activities only, but also to aspects of the subject as a whole. As earlier indicated, cultural influences may have led the teachers to emphasise aspects of technology teaching that can be associated with utilitarian purposes in the household, while aspects related to industrial production are partly rejected. Selectivity is also found to arise from teachers' experienced *needs* in school teaching. Thus the teachers have selectively adopted aspects of technology teaching that fulfil these needs, for example aspects that assist them in making school more practical with regards to the teaching context or meeting the various limitations teachers see in Science as a subject.

The third mode of interaction is the *supplementary* one, where the teacher's frames are broadened as a consequence of their engagement with new ideas. The present study has shown how some teachers have – according to themselves – broadened their conception of technology *per se* as a result their participation in the TiS project. For example, Gina confessed in the Seventh story that her conception of technology had been extended to include more than computers and electronic gadgets or – more precisely – supplemented by an alternative comprehension of technology used in contexts related to the TiS project, giving rise to a double conception of technology.

The opportunities provided by moulding with plastic that are found to be highly appreciated by the teachers can also be seen as having supplemented teachers' frames. They represent a supplement not only in terms of new materials and techniques pupils may use, but also because they illuminate aspects of how modern technological products are manufactured and thus a supplementary *aim* for technology teaching. One may speculate whether the awareness of how plastic objects in everyday use are manufactured, addressed by several teachers as an intended outcome of technology teaching, is not also an awareness they *themselves* have gathered through the TiS project.

Involvement in the TiS project may also be seen as having supplemented some teachers' frames with regards to their '*conception of self*' (Elbaz 1983). In a study of teachers' practical knowledge, Elbaz described teachers' conception of self in

terms of their view of their abilities in teaching ('self as resource'), their attitude towards pupils and colleagues ('self in relation to others') and perceptions of their own personality as humans ('self as individual'). A further category, '*self in relation to subject matter*', might be added to those suggested by Elbaz. The present study shows that interaction with the TiS project has had an effect on how some of the teachers conceive the relation between themselves and aspects of technology as a subject of teaching. Irene has described how her self-image came to include a view of being competent in technology as a result of her engagement with the TiS project (p. 101). Similarly, Ann, signalled in the First story an initially alienated relation to subjects such as physics ("Physics has been some kind of a non-subject to me") and that she "had never been one who used to fumble with technology and stuff" (p. 142). The message is not primarily that she had looked upon herself as unsuccessful in these areas, nor that she *was* unsuccessful in any sense, but rather that she had not associated these areas with the image of herself. Her involvement in the TiS project has supplemented Ann's professional frames by making her to a larger degree *include* these areas in her conception of self in relation to subject matter.

Finally, a *re-constructive* mode of interaction can be identified. This mode implies that teachers utilise the ideas presented to them as *tools* in pursuing their desires for change. The ideas are thus actively and deliberately re-constructed to support these desires. This re-constructive engagement with ideas is most evident in how Gina and David use technology teaching as a vehicle for 'changing the grammar of schooling' (Chapter 12), but can also be recognised in Elna's attempt to revitalise science teaching described in Chapter 11.

The four modes of interaction identified above show that the teachers engage with new ideas in a highly dynamic manner. The interaction entails a transformation of ideas by means of teachers' adoption, reshaping and deliberate use of aspects of the ideas with varying degree of transformation. It is also shown that new ideas and experiences in turn can alter teachers' professional frames by providing new repertoires for teaching and by extending and modifying their conceptions of subject matter as well as their conception of self.

An important drive in this interaction process is shown to be the teachers' *purposes* for education on a fundamental level, including how they experience a need for change in their work with pupils. The TiS project has here been important in providing teachers with tools to fulfil their aims, which appear to be an essential component of the teachers' initial professional frames rather than being introduced to them through the TiS project.

Implications of the study

The empirical study presented in this thesis has investigated in some detail how teachers participating in the TiS project on technology teaching in Norway perceive and realise technology as a new subject of teaching. It has shown how cultural factors and the ideology underpinning the national curriculum L97 have contributed to a transformation of ideas from Design & Technology into Norwegian schools, through a mediation with the teachers' professional frames.

The scope of the study has been to build an understanding of aspects of the specific situation set up by the transfer of curricular ideas on technology teaching by means of the TiS project. The results of the study nevertheless raise some issues with relevance to other situations and contexts, and some implications of the study beyond its own framework may hence be suggested. The sections to follow discuss implications for curriculum development with special focus on the further development of technology as a subject of teaching in Norwegian schools. Possible implications for educational research are then discussed, and some issues for further research are indicated.

Implications for curriculum development and implementation

It is shown in this study that the teachers' engagement with ideas on technology education has been a highly interactive process and that this interaction has several modes. Though the TiS project does not involve a formal curriculum in terms of specifications of content and learning objectives, it nevertheless represents a curriculum of *ideas* and *intentions*. The results of the study may hence have relevance to curriculum development and implementation in a broader sense.

The study has demonstrated that teachers are not short of educational aims for their actions. On the contrary, they have announced a need for curriculum material and concrete ideas for teaching by which those aims can be realised. The TiS project has been an example of an initiative that has provided teachers with such material. The approach is contrary to the idea underpinning for example the curriculum for compulsory education in Norway, where the goals for teaching are specified and the development of means for reaching these goals is seen as the teacher's responsibility. Following this line of argumentation, the teachers' need for an 'activity account' should be acknowledged and emphasis should be put on developing adequate teaching materials for teachers rather than on specifying detailed goals for education.

More specifically, what implications do the results of the present study have for the further development of technology teaching in Norwegian schools? As the study is descriptive rather than normative in nature, it does not itself provide answers to this

question. However, I will propose that the teachers' perspectives and viewpoints presented in this thesis should be taken into account in the further conceptualisation and development of technology as a an area of teaching in compulsory schools. The foundation for this proposal is twofold. Firstly, the teachers should be listened to simply because they – as has been pointed out – are highly influential on how educational ideas are put into practice. Secondly, the teachers' perceptions and realisation of technology teaching as they have emerged in this study provide aspects of technology teaching and its potential contribution to general education that only to a minor degree have been attended to in national and international discourse on technology education. The teachers' perspectives are situated in the specific Norwegian school context and based on comprehensive experience and knowledge about this context and about pupils. They thus represent an important source for increasing our understanding of the potential of technology teaching in schools, and to further its development in compulsory schools in Norway. In addition to impulses gathered from outside, the development of technology as a curricular area should draw on the teachers' viewpoints on and accumulated experiences with technology teaching in the specific Norwegian context, in order to ensure a development adequate for realisation in this context.

One important aspect of the teachers' message conveyed in this thesis regards technology as a specified subject versus technology as interdisciplinary teaching across the curriculum. On one hand, teachers have pointed to the value of technology teaching as meaningful projects across the curriculum released from the rigidity of conventional school subjects. On the other hand, they signal a danger that technology teaching this way will be disregarded due to practical and institutional circumstances, and that the opportunities provided by the curriculum L97 with regards to technology as cross-curricular teaching may not this way be fully utilised. How should this challenge be met? It is important that the further discussion and conceptualisation of technology as a curricular area in Norwegian schools draw on the teachers' experiences gained from realising technology teaching associated with the TiS project in their schools. It is also important to consider ideas for technology teaching based on *other* approaches than the one represented by Design & Technology, such as those presented as possible 'gateways' to technology education in Chapter 3. Teachers should be exposed to these approaches in ways that facilitate a constructive interaction, as has been the case with the TiS project. This way, technology as a subject of teaching in Norwegian schools may develop its identity based on various sources of ideas as well as reshaping of those ideas in ways adapted to the specific Norwegian school context.

Finally, important questions related to the view of teachers as ‘curriculum creators’ arise from the study. The investigation of teachers’ perceptions of technology teaching has revealed that there are certain commonalities in how the teachers have transformed and realised ideas from Design & Technology in their schools. These have been mainly ascribed to features of the TiS project itself and to aspects of a shared educational culture and the Norwegian culture more generally. However, there are also substantial differences between how individual teachers have approached technology as a subject of teaching. This is illustrated by the fact that ‘identical’ activities have been used as a means to create technology teaching with substantially different content and purpose and hence presumably different outcomes with regards to pupils’ gain from the teaching. Should this be considered a problem? Is consensus (which can be read standardisation) on the purpose of teaching in specific areas a prerequisite for quality in schools? Or does it rather – as Eisner (1994) has indicated – represent an obstruction for quality because it constrains teachers’ creativity? How far should the freedom of teachers as *professional* curriculum creators extend seen in a policy perspective? These questions – in essence political – are pertinent in curriculum development and educational policy, and relate to the brief discussion on teachers’ professionalism undertaken in Chapter 4. They do, however, also raise new questions for *research*, which will be addressed in the section to follow.

Implications for research

Several implications for research can be drawn from the results of the present study, and some involve suggestions for further research. One component of the present study has been the conceptualisation of teachers’ aims for technology teaching. Though we have seen an increasing attention towards *teachers* in educational research, their *aims* for teaching have not been judged to be particularly significant in themselves, but rather “a foil for other issues” (Donnelly 1999, p. 18). The present study suggests that teachers’ aims are an important component of their professional frames and thus highly influential on how curricular ideas are put into practice in schools. Further research needs, however, to be undertaken in order to build a more comprehensive understanding of the significance of teachers’ aims on a more general level. The TiS project differs from ordinary subject curricula and many educational reforms in its flexible nature and the absence of very concrete specifications of what pupils should learn or in other senses gain from technology teaching. Whether the highly interactive nature of teachers’ engagement with ideas that has been reported in the empirical part of this thesis also applies to situations where the intended curriculum is expressed in more explicit terms in a formal curriculum remains to be seen, and suggests an important arena for research.

In this thesis I have claimed – based on results of the empirical study – that ideas from Design & Technology have been significantly transformed on their way through the TiS project into Norwegian *classrooms*. I have also indicated that parts of this transformation are due to influences from the shared culture of which the teachers studied are members. The latter claim could need some further exploration. The present study has not taken into account the possible transformation of ideas from Design & Technology on the level of intentions and policy into English and Welsh classrooms, except by drawing on indications given in a few published studies in the field and on less structured personal experiences. Some aspects of what I have identified as cultural influences might thus as well be an effect of more general ‘teacherly’ concerns transcending cultural differences. A complete understanding of cultural influences on the transfer of educational ideas would hence require a *comparative* approach, which could elicit more clearly how different cultural frameworks lead to different interpretations of educational ideas.

The cultural influence on ideas indicated in the present study also has relevance to research more generally. The findings reinforce the importance of taking cultural differences into account in educational research, especially in studies with an international perspective. The present study has elicited that not only factors such as school systems, formal curricula and ways of teaching are different in culturally different school contexts; the overall *aims* for teaching may in fact be very dissimilar. This has particular relevance to measures of the ‘success’ of a school system or comparisons of pupils’ ‘achievement’. Critical questions in this regard are: Success according to *whom*? Achievement by *what criteria*?

The conclusion of the present study has highlighted the importance of teachers’ professional frames in the realisation of curricular ideas. Any needs for *altering* teachers’ frames or strategies by which such an alteration can be accomplished have not been addressed. The issue is, however, likely to be of interest in policy implementations and consequently relevant to educational research. Attempts to enact changes in schools will require acknowledgement of the importance of teachers’ professional frames, an awareness of that they are deeply rooted in the surrounding culture and an understanding of the dynamic nature of teachers’ interaction with new ideas. In order to further the understanding of this interactive process and how teachers’ professional frames can be altered, it is necessary to take into account the totality of the teachers’ frames, including their educational aims, their concern for the teaching context, their conception of subject matter and their conception of self. The modes of interaction identified in this thesis might be a point of departure in this regard.

EPILOGUE

*It went well! It actually did.
So I feel I have grown a bit with the challenge
– that I have learnt quite a bit by jumping into it in a way.
But it was somewhat, it was in a sense a bit frightening.*

*Det gikk bra! Det gjorde jo det.
Så jeg føler jeg har vokst litt med den utfordringen
– at jeg har lært en del gjennom å hive meg ut i det liksom.
Men det var litt sånn, det var litt skremmende på en måte.*

Ann

REFERENCES

- ABELSON, R. (1979). Differences between belief system and knowledge systems. *Cognitive Science*, 3, 355-366.
- AIKENHEAD, G. (1997). STL and STS: common ground or divergiant scenarios? In UNESCO: *Innovations in science and technology education*, Vol. VI (ed.: E. Jenkins). Paris: UNESCO.
- AIKENHEAD, G. (2003). STS education: a rose by any other name. In R. Cross (ed.): *A Vision for Science Education. Responding to the work of Peter Fensham*. London and New York: Routledge Falmer.
- ALLSOP, T. & WOOLNOUGH, B. (1990). The relationship of technology to science in English schools. *Journal of Curriculum Studies*, 22 (2), 127-136.
- ALTERS, B. J. (1997). Whose Nature of Science? *Journal of Research in Science Teaching*, 34 (1), 39-55.
- ANDERSEN, H. W. & SØRENSEN, K. H. (1992). *Frankensteins Dilemma: en bok om teknologi, miljø og verdier*. Oslo: Ad Notam Gyldendal.
- ANDERSSON, B., BACH, F. & ZETTERQVIST, A. (1997). *Nationell utvärering 95 - Åk 9. Teknikämnet i omvandling? Na-spektrum, Studier av Naturvetenskapen i Skolan Nr 20*. Mölndal: Göteborgs universitet.
- ANGELL, C. (UNDATED). *Teknologi i Skolen. Rapport med oppsummering av elevers svar på et spørreskjema*. Oslo: University of Oslo.
- APPLE, M. W. & JUNGCK, S. (1992). You Don't Have to Be a Teacher to Teach This Unit: Teaching, Technology and Control in the Classroom. In A. Hargreaves & M. G. Fullan (eds.): *Understanding teacher development*. New York: Teacher College Press.
- AUBUSSON, P. & WEBB, C. (1992). Teacher Beliefs about Learning and Teaching in Primary Science and Technology. *Research in Science Education*, 22, 20-29.
- BARLEX, D. & PITT, J. (2000). *Interaction: The relationship between science and design and technology in the secondary school curriculum*. London: Engineering Council.
- BARNES, B. (1982). The Science-Technology Relationship: A model and a Query. *Social Studies of Science*, 12, 166-72.
- BARNES, D. (1992). The Significance of Teachers' Frames for Teaching. In T. Russell & H. Munby (eds.): *Teachers and Teaching: From Classrooms to Reflection*. London: The Falmer Press.

REFERENCES

- BARNES, D., JOHNSON, G., JORDAN, S., LAYTON, D., MEDWAY, P. & YEOMANS, D. (1987). *The TVEI Curriculum 14 – 16. An Interim Report Based on Case Studies in Twelve Schools. TVEI report no 3*. Leeds: University of Leeds.
- BARNETT, M. (1992). Technology, Within the National Curriculum and Elsewhere. In J. Beynon & H. Mackay (eds.): *Technological Literacy and the Curriculum*. London: The Falmer Press.
- BARNETT, M. (1995). Literacy, Technology and 'Technological Literacy'. *International Journal of Technology and Design Education*, 5, 119-137.
- BASALLA, G. (1988). *The Evolution of Technology*. Cambridge: Cambridge University Press.
- BEIJAARD, D., VERLOOP, B. N. & VERMUNT, J. D. (2000). Teachers' perceptions of professional identity: an exploratory study from a personal knowledge perspective. *Teaching and Teacher Education*, 16, 749-764.
- BENCZE, J. L. (2001). 'Technoscience' Education: Empowering Citizens Against the Tyranny of School Science. *International Journal of Technology and Design Education*, 11 (1) , 273-298.
- BERNSTEIN, B. (1971). On the Classification and Framing of Educational Knowledge. In M. F. D. Young (ed.): *Knowledge and Control. New Directions for the Sociology of Education*. London: Collier MacMillan.
- BERNSTEIN, B. (2000). *Pedagogy, symbolic control and identity: Theory, research, critique*. Lanham: Rowman & Littlefield Publishers.
- BIJKER, W. E. (1987). The Social Construction of Bakelite: Toward a Theory of Invention, In W. E. Bijker, T. P. Hughes & T. Pinch (eds.): *The Social Construction of Technological Systems*. Cambridge, Massachusetts: The MIT Press.
- BIJKER, W. E., HUGHES, T. P. & PINCH, T. (EDS.) (1987). *The Social Construction of Technological Systems*. Cambridge, Massachusetts: The MIT Press.
- BLACK, P. & ATKIN, M. (1996). *Changing the Subject. Innovations in science, mathematics and technology education*. London: OECD / Routledge.
- BLACK, P. & HARRISON, G. (1985). *In Place of Confusion. Technology and Science in the School Curriculum*. London: Nuffield Chelsea Curriculum Trust and the National Centre for School Technology, Trent Polytechnic.
- BLACK, P. & HARRISON, G. (1994). Technological capability. In F. Banks (ed.): *Teaching Technology*. London: Routledge.
- BLACK, P. (1995). 1987 to 1995 - The Struggle to Formulate a National Curriculum for Science in England and Wales. *Studies in Science Education*, 26, 159-188.

- BLOOM, B. S. (1956). *Taxonomy of Educational Goals. Handbook 1: Cognitive Domain*. New York: Longmans, Green & Co.
- BRISÅ, S. (1997). Hva vet skoleelevene om teknologi? (Kronikk). *Aftenposten* 16. oktober.
- BROADHEAD, P. (2001). Curriculum Change in Norway: thematic approaches, active learning and pupil cooperation - from curriculum design to classroom implementation. *Scandinavian Journal of Educational Research*, 45 (1), 10-36.
- BROWN, S. & MCINTYRE, D. (1993). *Making Sense of Teaching*. Buckingham: Open University Press.
- BRUNER, J. (1960). *The Process of Education*. New York: Vintage.
- BUNGUM, B. (2003). Teknologi - naturvitenskapens uekte barn? In D. Jorde & B. Bungum (eds.): *Naturfagdidaktikk. Perspektiver, forskning, utvikling*. Oslo: Gyldendal Akademisk.
- CAJAS, F. (2001). The Science/Technology Interaction: Implications for Science Literacy. *Journal of Research in Science Teaching*, 38 (7), 715-729.
- CARTER, K. (1992). Creating Cases for the Development of Teacher Knowledge. In T. Russell & H. Munby (eds.): *Teachers and Teaching: From Classrooms to Reflection*. London: The Falmer Press.
- CHAPMAN, B. (1991). The overselling of science education in the eighties. *School Science Review*, 72 (260), 47-63.
- CHIDGEY, J. (1994). A critique of the design process. In F. Banks (ed.): *Teaching Technology*. London: Routledge.
- CHILDRESS, V. W. (1996). Does Integrating Technology, Science, and Mathematics Improve Technological Problem Solving? A Quasi-experiment. *Journal of Technology Education*, 8 (1), 16-26.
- CLANDININ, D. J. & CONNELLY, F. M. (1995). *Teachers' Professional Knowledge Landscapes*. New York and London: Teachers College Press.
- CLARK, C. M. & YINGER, R. J. (1987). Teacher Planning. In J. Calderhead (ed.): *Exploring Teachers' Thinking*. London: Cassell Educational Limited.
- CLARKSON, C., MARCH, J. & PALMER, J. (2002). *GCSE Textiles Technology for OCR*. Oxford: Heinemann Educational Publishers.
- CONNELLY, F. M., CLANDININ, D. J. & HE, M. F. (1997). Teachers' personal practical knowledge on the professional knowledge landscape. *Teaching and Teacher Education*, 13, 665-674.

REFERENCES

- COOPER, P. W. (1993). Field Relations and the Problem of Authenticity in Researching Participants' Perceptions of Teaching and Learning in Classrooms. *British Educational Research Journal*, 19 (4), 323-338.
- CRONIN-JONES, L. L. (1991). Science Teacher Beliefs and their Influence on Curriculum Implementation: Two Case Studies. *Journal of Research in Science Teaching*, 28 (3), 235-250.
- CROSS, A, NAUGHTON, J. & WALKER, D, (1986). Design method and scientific method. In A. Cross & B. McCormick (eds.). *Technology in Schools*. Milton Keynes: Open University Press.
- CUSTER, R. L. (1995). Examining the Dimensions of Technology. *International Journal of Technology and Design Education*, 5, 219-244.
- DAVIES, D. & ROGERS, M. (2000). Pre-service Primary Teachers' Planning for Science and Technology Activities: influences and constraints. *Research in Science and Technology Education*, 18 (2), 215-225.
- DAY, C., FERNANDEZ, A., HAUGE, T. E. & MØLLER, J. (EDS.) (2000). *The Life and Work of Teachers. International Perspectives in Changing Times*. London and New York: Falmer Press.
- DE VRIES, M. J. (1994). Technology education in Western Europe. In UNESCO: *Innovations in science and technology education*, Vol. V (ed.: D. Layton). Paris: UNESCO.
- DE VRIES, M. J. (1996). Technology Education: Beyond the "Technology is Applied Science" Paradigm. *Journal of Technology Education*, 8 (1), 7-15.
- DEBOER, G. (2000). Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *Journal of Research in Science Teaching*, 37 (6), 582-601.
- DENZIN, N. K. (1978). *The research act: A theoretical introduction to sociological methods*. New York: McGraw-Hill.
- DES/WO (1990). (Department for Education and Skills / Welsh Office) *Technology in the National Curriculum*. London: Her Majesty's Stationary Office.
- DFE/WO (1995). (Department for Education / Welsh Office) *Design and Technology in the National Curriculum*. London: Her Majesty's Stationary Office.
- DFEE/QCA (1999). (Department for Education and Employment / Qualifications and Curriculum Authority) *Design and Technology. The National Curriculum for England*. London: Her Majesty's Stationary Office.
- DFES/QCA (2000). (Department for Education and Skills / Qualifications and Curriculum Authority) *Design and Technology. The National Curriculum*. London: Her Majesty's Stationary Office. Available online: <http://www.nc.uk.net/home.html>

- DONNELLY, J. (1992). Technology in the School Curriculum: A critical Bibliography. *Studies in Science Education* 20, 123-156.
- DONNELLY, J. (1999). Interpreting differences: the educational aims of teachers of science and history, and their implications. *Journal of Curriculum Studies*, 31 (1), 17-41.
- DONNELLY, J. (2001a). Contested terrain or unified project? 'The nature of science' in the National Curriculum for England and Wales. *International Journal of Science Education*, 23 (2), 181 – 195.
- DONNELLY, J. F. (2001b). School Science teaching as a profession: Past, present and future. *School Science Review*, 82 (300), 31 - 39.
- DONNELLY, J. F. & JENKINS, E. (1992). *GCSE Technology: Some Precursors and Issues*. Occasional Publication No 4, Education for Capability Research Group. Leeds: University of Leeds, School of Education.
- DONNELLY, J. F. & JENKINS, E. W. (2001). *Science Education: Policy, Professionalism and Change*. London: Paul Chapman Publishing Ltd.
- DRIVER, R. (1983). *The Pupil as Scientist?* Milton Keynes, Philadelphia: Open University Press.
- DRIVER, R., LEACH J., MILLAR, R. & SCOTT, P. (1995). *Young People's Images of Science*. Buckingham: Open University Press.
- EGGEN, A. B. & KNAIN, E. (2003). Naturfaget til eleven eller eleven til naturfaget? Naturfaget i grunnskolen utfra et naturfagdannende eller allmenndannende perspektiv. In D. Jorde & B. Bungum (eds.): *Naturfagdidaktikk. Perspektiver, forskning, utvikling*. Oslo: Gyldendal Akademisk Forlag.
- EGGLESTON, J. (1996). *Teaching Design and Technology*. Buchingham, Philadelphia: Open University Press.
- EISNER, E. W. & VALLANCE, E. (1974). Five Conceptions of Curriculum: Their Roots and Implications for Curriculum Planning. In E. W. Eisner & E. Vallance (eds.): *Conflicting conceptions of curriculum*. Berkely, CA: McCutchan.
- EISNER, E. W. (1994). *The educational imagination. On the design and evaluation of school programs*. New York: Macmillan College Publ. Co.
- ELBAZ, F. (1983). *Teacher Thinking: A Study of Practical Knowledge*. London: Croom Helm.
- ELLUL, J. (1979). *The Technological Society*. New Yourk: Alfred A. Knopf.
- ENCYCLOPÆDIA BRITANNICA, online: <http://www.britannica.com>

REFERENCES

- ENZENBERGER, H. M. (1984). *Norsk utakt*. Oslo: Universitetsforlaget. Translated by L. Tømte from German original: "Norwegische Anachronismen", 1984.
- FANG, Z. (1996). A review of research on teacher beliefs and practices. *Educational Research*, 38 (1), 47-65.
- FEENBERG, A. (1991). *Critical theory of technology*. New York: Oxford University Press.
- FENSHAM, P. (1988). Approaches to the teaching of STS in science education. *International Journal of Science Education*, 10 (4), 346-356.
- FENSHAM, P. J. & GARDNER, P. L. (1994). Technology education and science education: a new relationship? In UNESCO: *Innovations in science and technology education*, Vol. V (ed.: D. Layton), Paris: UNESCO.
- FERREYRA, R. (1997). Technological literacy: an intermediate perspective. In UNESCO: *Innovations in science and technology education*, Vol. VI (ed.: E. Jenkins), Paris: UNESCO.
- FORES, M. L. & REY, L. (1979). Technik: the relevance of a missing concept, *Higher Education Review*, 11 (2), 43-56. Reprinted in A. Cross & B. McCormick (eds.) (1986). *Technology in Schools*. Milton Keynes: Open University Press.
- GALLAGHER, J. (1991). Prospective and practising secondary school science teachers' knowledge and beliefs about the philosophy of science. *Science Education*, 75, 121-133.
- GARDNER, P. (1994). Representations of the Relationship between Science and Technology in the Curriculum. *Studies in Science Education*, 24, 1-28.
- GESS-NEWSOME, J. & LEDERMAN, N. G. (ED.) (1999). *Examining Pedagogical Content Knowledge. The Construct and its Implications for Science Education*. Dordrecht: Kluwer Academic Publishers.
- GILBERT, J. F. (1992). The interface between science education and technology education. *International Journal of Science Education*, 14 (5), 563-578.
- GLASER, B. G. & STRAUSS, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Chicago: Aldine.
- GOODLAD, J. I. (1979). *Curriculum Inquiry. The Study of Curriculum Practice*. New York: McGraw-Hill.
- GOODSON, I. & DOWBIGGIN, I. R. (1994). Vocational Education and School Reform: The Case of the London (Canada) Technical School, 1900 - 1930. In I. Goodson: *Studying Curriculum: cases and methods*. Buckingham: Open University Press.

- GOODSON, I. (2000). Professional Knowledge and the Teacher's Life and Work. In C. Day, A. Fernandez, T. E. Hauge & J. Møller (eds.): *The Life and Work of Teachers. International Perspectives in Changing Times*. London and New York: Falmer Press.
- GRIFFITHS, A. K. & HEATH, N. P. (1996). High School Students' Views about Technology. *Research in Science and Technology Education*, 14 (2), 153-162.
- GUNDEM, B. B. (1993). *Mot en ny skolevirkelighet? Læreplanen i et sentraliserings- og desentraliseringsperspektiv*. Oslo: Ad Notam Gyldendal.
- HANEY, J. J., CZERNIAK, C. M. & LUMPE, A. T. (1996). Teacher Belief and Intentions Regarding the Implementation of Science Education Reform Strands. *Journal of Research in Science Teaching*, 33 (9), 971-993.
- HANSEN, K. H. & OLSON, J. (1996). How Teachers Construe Curriculum Integration: The Science, Technology, Society (STS) Movement as Bildung. *Journal of Curriculum Studies*, 28 (6), 669-682.
- HANSEN, R. & FROELICH, M. (1994). Defining Technology and Technological Education: A Crisis, or Cause for Celebration? *International Journal of Technology and Design Education*, 4, 179-207.
- HANSEN, R. (1997). The value of a Utilitarian Curriculum: The Case of Technology Education. *International Journal of Technology and Design Education*, 7, 111-119.
- HARGREAVES, A. & EVANS, R. (1997). *Beyond Educational Reform. Bringing Teachers Back In*. Buckingham, Philadelphia: Open University Press.
- HARGREAVES, A. & FULLAN, M.G. (EDS.) (1992). *Understanding teacher development*. New York: Teacher College Press.
- HARGREAVES, A. (1994). *Changing teachers, changing times: teachers' work and culture in the postmodern age*. London: Cassell.
- HARGREAVES, A. (2000). Four Ages of Professionalism and Professional Learning. *Teachers and Teaching: History and Practice*, 6 (2), 151-182.
- HARGREAVES, A., EARL, L., MOORE, S. & MANNING, S. (2001). *Learning to Change. Teaching Beyond Subjects and Standards*. San Francisco: Jossey-Bass.
- HEIDEGGER, M. (1994). The Question Concerning Technology. In D. Farrell Krell (ed.): *Martin Heidegger. Basic Writings, from Being and Time (1927) to The Task of Thinking (1963)*. London: Routledge, Kegan and Paul. (Original work published 1954.)

REFERENCES

- HELSEBY, G. (2000). Multiple Truths and Contested Realities: The Changing Faces of Teacher Professionalism in England. In C. Day, A. Fernandez, T. E. Hauge & J. Møller (eds.): *The Life and Work of Teachers. International Perspectives in Changing Times*. London and New York: Falmer Press.
- HENDLEY, D. & LYLE, S. (1996). Pupils' Perceptions of Design and Technology: a case study of pupils in South Wales. *Research in Science & Technological Education*, 14 (2), 141-151.
- HEPBURN, G. & GASKELL, P. J. (1998). Teaching a New Science and Technology Course: A Sociocultural Perspective. *Journal of Research in Science Teaching*, 35 (7), 777-789.
- HERSCHBACH, D. R. (1992). Technology and Efficiency: Competencies as Content. *Journal of Technology Education*, 3 (2), 15-25.
- HERSCHBACH, D. R. (1995). Technology as knowledge: Implications for instruction. *Journal of Technology Education*, 17 (1), 31-42.
- HODSON, D. (1996). Laboratory work as scientific method: three decades of confusion and distortion. *Journal of Curriculum Studies*, 28 (2), 115-135.
- HODSON, D. (1998). Is this really what scientists do? Seeking more authentic science in and beyond the school laboratory. In J. Wellington (ed.): *Practical Work in School Science. Which way now?* London: Routledge.
- HÖRNER, W. (1985). 'Technik' and 'technology': some consequences of terminological differences for educational policy making. *Oxford Review of Education*, 11, 317-324.
- HORSFJORD, V. (1982). *Naturfag i forandring. En oversikt over de bærende ideer i den internasjonale reformbevegelsen i naturfagundervisningen*. Report no. 8 in the Research project 'Faglig kunnskap og individuell og sosial relevans'. Trondheim: NAVF.
- HOYLE, E. & JOHN, P. (1995). *Professional Knowledge and Professional Practice*. London: Cassell.
- HUGHES, T. P. (1986). The seamless web: technology, science, etcetera, etcetera, *Social Studies of Science* 16, 281-92.
- HURD, P. D. (1998). Scientific literacy: new minds for a changing world. *Science Education* 82 (3), 407-416.
- IMSEN, G. (1997). *Lærerens verden: Innføring i generell didaktikk*. Oslo: Tano Aschehoug.
- ITEA (1996). *Technology for all Americans: A Rationale and Structure for the Study of Technology*. Virginia: International Technology Education Association.

- ITEA (2000). *Technology for All Americans: A Rationale and Structure for the Study of Technology*. Virginia: International Technology Education Association.
- JARVIS, T. & RENNIE, L. J. (1996). Perceptions about Technology Held by Primary Teachers in England. *Research in Science and Technology Education*, 14 (1), 43-54.
- JENKINS, E. W. (1992). School science education: towards a reconstruction. *Journal of Curriculum Studies*, 24 (3), 229-246.
- JENKINS, E. W. (1997a). Scientific and Technological Literacy for Citizenship: What can we learn from research and other evidence? In S. Sjøberg & E. Kallerud (eds.): *Science, Technology and Citizenship. The Public Understanding of Science and Technology in Science Education and Research Policy*. Oslo: NIFU.
- JENKINS, E. W. (1997b). Scientific and technological literacy: meanings and rationales. In UNESCO: *Innovations in science and technology education*, Vol. VI (ed.: E. Jenkins), Paris: UNESCO.
- JENKINS, E. W. (1999). Practical work in School Science - some questions to be answered. In J. Leach & A. C. Paulsen (eds.): *Practical Work in Science Education: Recent research studies*. Dordrecht: Kluwer.
- JOHN, P. D. (1991). A qualitative study of British Student Teachers' Lesson Planning Perspectives. *Journal of Education for Teaching*, 7 (3), 301-320.
- JOHNSEY, R. (1995). The Design Process - Does it Exist? A critical Review of Published models for the Design Process in England and Wales. *International Journal of Technology and Design Education*, 5, 199-217.
- JOHNSON, S. D. (1992). A Framework for Technology Education Curricula Which Emphasizes Intellectual Processes. *Journal of Technology Education*, 3 (2), 26-36.
- JONES, A. & CARR, M. (1992). Teachers' Perceptions of Technology Education: Implications for Curriculum Innovation. *Research in Science Education*, 22, 230-239.
- JONES, A. (1999). Teachers' Subject Subcultures and Curriculum Innovation: The example of Technology Education. In J. Loughran (ed.): *Researching Teaching. Methodologies and Practices for Understanding Pedagogy*. London: Falmer Press.
- JØRGENSEN, S. (2000). Personal communication with senior engineer Sissel Jørgensen, University of Oslo.
- KAGAN, D. M. & TIPPINS, D. J. (1991). How Teachers' Classroom Cases Express Their Pedagogical Beliefs. *Journal of Teacher Education*, 42 (4), 281-291.
- KALLESTAD, J. H. (2000). Teacher Emphases on General Educational Goals: an approach to teacher socialisation in Norwegian schools? *Scandinavian Journal of Educational Research*, 44 (2), 193-205.

REFERENCES

- KIMBELL, R. (1997). *Assessing Technology: International trends in curriculum and assessment*. Buckingham: Open University Press.
- KIMBELL, R., STABLES, K. & GREEN, R. (1996). *Understanding Practice in Design and Technology*. Buckingham: Open University Press.
- KIND, P. M. , KJÆRNSLI, M., LIE, S. & TURMO, A. (1999). *Hva i all verden gjør elevene i realfag? Praktiske oppgaver i matematikk og naturfag*. Oslo: ILS, University of Oslo.
- KLETTE, K. (2000). Working-Time Blues: How Norwegian Teachers Experience Restructuring in Education. In C. Day, A. Fernandez, T. E. Hauge & J. Møller (eds.): *The Life and Work of Teachers. International Perspectives in Changing Times*. London and New York: Falmer Press.
- KNAIN, E. (1999). *Naturfagets tause stemme. Diskursanalyse av lærebøker for Natur- og miljøfag i et allmenndannelsesperspektiv*. Dissertation for the degree of dr. scient., Faculty of Mathematics and Natural Sciences. Oslo: University of Oslo.
- KOLSTØ, S. D. (2001). Scientific literacy for citizenship: tools for dealing with the science dimension of controversial socioscientific issues. *Science Education*, 23 (9), 877-901.
- KORITZINSKY, T. (2000). *Pedagogikk og politikk i L97. Læreplanens innhold og beslutningsprosessen*. Oslo: Universitetsforlaget.
- KRAMER, J. (1984). Norsk identitet - et produkt av underutvikling og stammetilhørighet. In A. M. Klausen, (ed.): *Den norske væremåten*. Trondheim: J. W. Cappelens forlag.
- KRANZBERG, M. & PURSELL, C. W. (1967). The Importance of Technology in Human Affairs. In M. Kranzberg & C. W. Pursell (eds.): *Technology in Western civilization*. Vol 1. New York: Oxford University Press.
- KRUSE, S. & DRAGSTED, S. (2000). *Living in different real worlds*. Lecture given at The 5th European Science Education Summerschool (ESERA), Gilleleje, September 6th - 13th 2000.
- KUD (1987). (Royal Ministry of Church and Education) *Mønsterplan for grunnskolen*. Oslo: KUD / Aschehoug.
- KUF (1993). (Royal Ministry of Church, Education and Research) *Core Curriculum for Compulsory School, Upper Secondary School and Adult Education*. Oslo: KUF.
- KUF (1994a). (Royal Ministry of Church, Education and Research) *Reform '94: Videregående opplæring*. Oslo: KUF.

- KUF (1994b). (Royal Ministry of Church, Education and Research) *Naturfagutredningen, Rapport nr 1. Naturfag i grunnskole og lærerutdanning: sammendrag: funn, anbefalinger og tiltak*. Oslo: KUF.
- KUF (1996). (Royal Ministry of Church, Education and Research) *Læreplanverket for den 10-årige grunnskolen (The Curriculum for the 10-year compulsory school in Norway)*. Oslo: KUF / Nasjonalt læremiddelsenter.
Available online, in Norwegian: <http://skolenettet3.ls.no/dok/sn/L97/>
In English: http://skolenettet3.ls.no/L97_eng/Curriculum/
- KUHN, T. S. (1962). *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
- KUNNSKAPSFORLAGET (1998). *Engelsk blå ordbok. Engelsk - norsk / norsk - engelsk*. Oslo: Kunnskapsforlaget.
- KVALE, S. (1996). *InterViews. An Introduction to Qualitative Research Interviewing*. Thousand Oaks, California: Sage Publications.
- KVALE, S. (1997). *Det kvalitative forskningsintervju*. Oslo: Ad Notam Gyldendal.
- LATOUR, B. & WOOLGAR, S. (1979). *Laboratory Life. the Social Construction of Scientific Facts*. Vol. 80, Sage Library of Social Research. Beverly Hills and London: Sage Publications.
- LATOUR, B. (1987). *Science in action: How to follow scientists and engineers through society*. Milton Keynes: Open University Press.
- LAYTON, D. (1973). *Science for the People: The origins of the school science curriculum in England*. London: George Allen & Unwin.
- LAYTON, D. (1988). Revaluing the T in STS. *International Journal of Science Education*, 10 (4), 367-378.
- LAYTON, D. (1991). Science Education and Praxis: The Relationship of School Science to Practical Action. *Studies in Science Education*, 19, 43-79.
- LAYTON, D. (1993). *Technology's Challenge to Science Education. Cathedral, Quarry or Company Store?* Buckingham: Open University Press.
- LAYTON, D. (1994). A school subject in the making? The search for fundamentals. In UNESCO: *Innovations in science and technology education*, Vol. V (ed.: D. Layton). Paris: UNESCO.
- LAYTON, D. (1995). Constructing and Reconstructing School Technology in England and Wales. *International Journal of Technology and Design Education*, 5, 89-118.
- LAYTON, D. (ED.) (1984). *The Alternative Road. The Rehabilitation of the Practical*. Leeds: CSSME, University of Leeds.

REFERENCES

- LAYTON, E. (1977). Conditions of technological development. In I. Spiegel-Rösing & D. de Solla Price (eds.): *Science, technology and society: a cross-disciplinary perspective*. The International Council for Science Policy Studies. London: SAGE Publications.
- LEVINSON, R., MURPHY, P. & MCCORMICK, R. (1997). Science and Technology Concepts in a Design and Technology Project: a pilot study. *Research in Science & Technological Education*, 15 (2), 235-255.
- LEWIS, T. & GAGEL, C. (1992). Technological literacy: a critical analysis. *Journal of Curriculum Studies*, 24 (2), 117-138.
- LEWIS, T. (1991). Introducing technology into school curricula. *Journal of Curriculum Studies*, 23 (2), 141-154.
- LEWIS, T. (1995). From manual training to technology education: the continuing struggle to establish a school subject in the USA. *Journal of Curriculum Studies*, 27 (6), 621-645.
- LEWIS, T. (1999). Content or Process as Approaches to Technology Curriculum: Does It Matter Come Monday Morning? *Journal of Technology Education*, 11 (1), 45-59.
- LIDDAMENT, T. (1994). Technological literacy: the construction of meaning. *Design Studies*, 15 (2), 198-214.
- LILLEMUR, O. F. (2002). 'Reform 97' in Norway. A new perspective on motivation and learning? *Nordisk Pedagogik*, 22, 38-52.
- LINDBLAD, S. (1990). From technology to craft: On teachers' experimental adoption of technology as a new subject in the Swedish primary school. *Journal of Curriculum Studies*, 22 (2), 165-175.
- LINDBLAD, S. (1994). *Lärarna - samhället och skolans utveckling: utforskningar och analyser av lärarledd verksamhet*. Stockholm: HLS Förlag.
- LOCHHEAD, J. & YAGER, R. E. (1996). Is Science Sinking in a Sea of Knowledge? In R. E. Yager (ed.): *Science / Technology / Society As Reform In Science Education*. Albany, New York: State University of New York Press.
- LORTIE, D. (1975). *Schoolteacher: A sociological study*. Chicago: University of Chicago Press.
- LOVDATA (1997). *Forskrift for Grunnskolen*. Oslo: Cappelen Akademisk Forlag.
- LUMPE, A. T., HANEY, J. J. & CZERNIAK, C. M. (2000). Assessing Teachers' Belief about Their Science Teaching Context. *Journal of Research in Science Teaching*, 37 (3), 275-292.

- MATTSSON, G. (2002). *Teknik i Ting och Tanke. Skolämnet teknik i lärarutbildning och skola*. Licentiatavhandling ved Institutionen för pedagogik och didaktik, IPD-rapport nr 2002 : 01. Göteborg: Göteborgs universitet.
- MAYR, O.: (1976). The science-technology relationship as a historiographic problem. *Technology and Culture*, 17, 663-73.
- MCCARTHY, A. C. & MOSS, D. (1990). Pupils' Perceptions of Technology in the Secondary School Curriculum: a case study. *Educational Studies*, 16 (3), 207-216.
- MCCOMAS, W. F. (ED.) (1998). *The nature of science in science education: rationales and strategies*. Dordrecht, London: Kluwer Academic Publishers.
- MCCORMICK, R. (1992). The Evolution of Current Practice of Technology Education - Part I. *Journal of Epsilon Pi Tau*, 18 (2), 19-28.
- MCCORMICK, R. (1994). The coming of technology education in England and Wales. In F. Banks (ed.): *Teaching Technology*. London: Routledge.
- MCCULLOCH, G. (1997). Teachers and the National Curriculum in England and Wales: Socio-historical Frameworks. In G. Helsby & G. McCulloch (eds.): *Teachers and the National Curriculum*. London: Cassell.
- MCCULLOCH, G. (2000). The Politics of the Secret Garden: Teachers and the School Curriculum in England and Wales. In C. Day, A. Fernandez, T. E. Hauge & J. Møller (eds.): *The Life and Work of Teachers. International Perspectives in Changing Times*. London and New York: Falmer Press.
- MCCULLOCH, G., JENKINS, E. & LAYTON, D. (1985). *Technological Revolution? The politics of school science & technology in England & Wales since 1945*. London and Philadelphia: The Falmer Press.
- MCRORBIE, C. J., GINNS, I. S. & STEIN, S. J. (2000). Preservice Primary Teachers' Thinking About Technology and Technology Education. *International Journal of Technology and Design Education*, 10 (1), 81-101.
- MEDWAY, P. (1989). Issues in the Theory and Practice of Technology Education. *Studies in Science Education*, 16, 1-24.
- MEDWAY, P. (1992). Constructions of Technology: Reflections on a New Subject. In J. Beynon & H. Mackay (eds.): *Technological Literacy and the Curriculum*. London: The Falmer Press.
- MERRIAM, S. B. (1998). *Qualitative Research and Case Study Applications in Education*. San Francisco: Jossey-Bass Publishers.
- MILES, M. B. & HUBERMAN, A. M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook*. Thousand Oaks, California: Sage Publications.

REFERENCES

- MILLAR, R. & DRIVER, R. (1987). Beyond Processes. *Studies in Science Education*, 14, 33-62.
- MILLAR, R. & OSBORNE, J. (EDS.) (1998). *Beyond 2000. Science Education for the Future*. London: Kings College.
- MITCHAM, C. (1979). Philosophy and the History of Technology. In G. Bugliarello & D. B. Doner (eds.): *The History and Philosophy of Technology*, Champaign-Urbana, Illinois: University of Illinois Press.
- MITCHAM, C. (1994). *Thinking through Technology. The Path between Engineering and Philosophy*. Chicago & London: The University of Chicago Press.
- MITTELL, I. & PENNY, A. (1997). Teacher Perceptions of Design and Technology: A Study of Disjunction between Policy and Practice. *International Journal of Technology and Design Education*, 7, 279-293.
- MUHR, T. (1997). *ATLAS.ti. The Knowledge Workbench. Visual Qualitative Data: Analysis, Management, Model Building. Short User's Manual*. Berlin: Scientific Software Development.
- MUMFORD, L. (1966). Technics and the Nature of Man. In P. H. Oehser (ed.): *Knowledge Among Men*. New York: Simon & Scuster. Reprinted in C. Mitcham & R. Mackay (eds.) (1983). *Philosophy and technology: Readings in the philosophical problems of technology*. New York: Free Press.
- MURPHY, P. & MCCORMICK, R. (1997). Problem Solving in Science and Technology Education. *Research in Science Education*, 27 (3), 461-81.
- MURPHY, P. (1994). Gender differences in pupils' reactions to practical work. In R. Levinson (ed.): *Teaching Science*. London: Routledge.
- MURPHY, P. F. (1996). Assessment practices and gender in science. In L. H. Parker, L. J. Tennie & B. J. Fraser (eds.): *Gender, Science and mathematics. Shortening the Shadow*. Dordrecht, Boston, London: Kluwer Academic Publisher.
- NARIN, F. & OLIVASTRO, D. (1992). Status report: Linkage between technology and science. *Research Policy*, 21 (3), 237-249.
- NERGÅRD, T. (1994). *Hvor er det blitt av naturfagene på barnetrinnet? En undersøkelse av o-fag i 4. - 6. klasse*. Thesis for the degree of cand. scient., Faculty of Mathematics and Natural Sciences. Oslo: University of Oslo.
- NESPOR, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies*, 19 (4), 317-328.
- NIELSEN, K., NIELSEN, H. & JENSEN, H. S. (1996). *Skruen uden ende. Den vestlige teknologis historie*. Århus: Teknisk Forlag.
- NITO (UNDATED). *Teknologi i Skolen*. (Project description)

- NODDINGS, N. (1992). *The Challenge to Care in Schools. An Alternative Approach to Education*. Advances in Contemporary Educational Thought, Vol. 8. New York: Teacher College Press.
- OLSON, J., JAMES, E. & LANG, M. (1999). Changing the subject: the challenge of innovation to teacher professionalism in OECD countries. *Journal of Curriculum Studies*, 31 (1), 69-82.
- PACEY, A. (1983). *The Culture of Technology*. Oxford: Blackwell.
- PAJARES, M. F. (1992). Teachers' Beliefs and Educational Research: Cleaning Up a Messy Construct. *Review of Educational Research*, 62 (3), 307-332.
- PETRINA, S. (1992). Curriculum Change in Technology Education: A Theoretical Perspective on Personal Relevance Curriculum Designs. *Journal of Technology Education*, 3 (2), 37-47.
- PETRINA, S. (1998). Multidisciplinary Technology Education. *International Journal of Technology and Design Education*, 8, 103-138.
- PETRINA, S. (2000). The politics of Technological literacy. *International Journal of Technology and Design Education*, 10 (3), 181-206.
- POLANYI, M. (1967). *The tacit dimension*. London: Routledge & Kegan Paul.
- POWELL, J. C. & ANDERSON, R. D. (2002). Changing teachers' practice: curriculum materials and science education reform in the USA. *Studies in Science Education*, 37, 107-136.
- RAAT, J. H. & DE VRIES, M. (1987). Technology in education: Research and development in the project 'Physics and Technology'. *International Journal of Science Education*, 9 (2), 159-168.
- RCA STP (1995). (Royal College of Art Schools Technology Project) *Challenges. Design & Technology 11 - 14*. London: Hodder & Stoughton.
- RENATE (UNDATED). <http://www.renate.ntnu.no/> (information about the TiS project)
- RENNIE, L. J. (1987). Teachers' and Pupils' Perceptions of Technology and the implications for Curriculum. *Research in Science and Technological Education*, 5 (2), 121-133.
- RIIS, U. (1996). Kan man äga ett skolämne - dragkampen om tekniken. In T. Ginner & G. Mattsson (eds.): *Teknik i Skolan*. Lund: Studentlitteratur.
- ROBERTS, D. A. (1988). What counts as Science Education? In P. Fensham (ed.): *Development and Dilemmas in Science Education*, Philadelphia: The Falmer Press.

REFERENCES

- ROBSON, C. (2002). *Real World Research. A Resource for Social Scientists and Practitioner-Researchers*. Oxford: Blackwell.
- ROGOFF, B. & LAVE, J. (eds.) (1984). *Everyday cognition: its development in social context*, Cambridge: Harvard University Press.
- ROPOHL, G. (1997). Knowledge Types in Technology. *International Journal of Technology and Design Education*, 7, 65-72.
- ROSENHOLTZ, S. J. (1989). *Teachers' workplace: the social organization of schools*. New York: Longman.
- ROSS, J. A. & HOGABOAN-GRAY, A. (1998). Integrating mathematics, science, and technology. Effects on students. *International Journal of Science Education*, 20 (9), 1119-1135.
- ROWELL, P. M., GUSTAFSON, B. J. & GUILBERT, S. M. (1999). Characterization of Technology Within an Elementary Science Program. *International Journal of Technology and Design Education*, 9, 37-55.
- SAYERS, S., MORLEY, J. & BARNES, B. (2002). *Issues in design and technology teaching*. London and New York: Routledge Falmer.
- SCHEFFLER, I. (1960). *The language of Education*. Springfield, Illinois: Charles Thomas Publisher.
- SCHÖN, D. A. (1983). *The Reflective Practitioner. How professionals think in action*. London: Temple Smith.
- SCHÖN, D. A. (1987). *Educating the reflective practitioner*. San Francisco: Jossey-Bass.
- SCHWAB, J. J. (1964). Structure of the Disciplines: Meanings and Significances. In D. Ford, & L. Pugno (eds.): *The Structure of Knowledge and the Curriculum*. Chicago: Rand McNally.
- SCHWAB, J. J. (1974). The Concept of the Structure of a Discipline. In E. W. Eisner & E. Vallance (eds.): *Conflicting Conceptions of Curriculum*. Berkely, CA: McCutchan.
- SEALE, C. (2000). Using Computers to Analyse Qualitative Data. In D. Silverman (2000). *Doing Qualitative Research. A Practical Handbook*. London: Sage Publications.
- SHULMAN, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher*, 15, 4-14.
- SHULMAN, L. S. (1987). *Knowledge and Teaching: Foundations of the New Reform*. Harvard Educational Review, 57, 1-22.

- SILVERMAN, D. (2000). *Doing Qualitative Research. A Practical Handbook*. London: Sage Publications.
- SISKIN, L. S. (1994). *Realms of knowledge: academic departments in secondary schools*. Washington DC, London: Falmer Press.
- SJØBERG, S. (1995). Technology education: Diversity or chaos? *Studies in Science Education* 25, 143-153.
- SJØBERG, S. (1997). Scientific Literacy and School Science. Arguments and Second Thoughts. In S. Sjøberg & E. Kallerud (eds.): *Science, Technology and Citizenship. The Public Understanding of Science and Technology in Science Education and Research Policy*. Oslo: NIFU.
- SJØBERG, S. (1998). *Naturfag som allmenndannelse - en kritisk fagdidaktikk*. Oslo: Ad Notam Gyldendal.
- SJØBERG, S. (2000). Sluttstrek for naturfagene? (Kronikk). *Aftenposten*, 20. februar.
- SKOLIMOWSKI, H. (1983). The structure of thinking in Technology. In C. Mitcham & R. Mackey (eds.): *Philosophy and Technology. Readings in the Philosophical Problems of Technology*. New York: The Free Press.
- SOLOMON, J. & AIKENHEAD, G. (EDS.) (1994). *STS Education - International perspectives on reform*, New York: Teacher College Press.
- SOLOMON, J. (1993). *Teaching Science, Technology and Society*. Buckingham, Philadelphia: Open University Press.
- STAUDENMAIER J. M (1985). *Technology`s storytellers. Reweaving the human fabric*. Cambridge, Mass, London: Society for the History of Technology and the M.I.T. Press.
- STENGEL, B. S. (1997). 'Academic discipline' and 'school subject': Contestable curricular concepts. *Journal of Curriculum studies*, 29 (5), 585-602.
- SUNDIN, B. (1991). *Den Kupade Handen. Människan och tekniken*. Stockholm: Carlssons Bokforlag.
- TABA, H. (1962). *Curriculum Development. Theory and Practice*. New York: Harcourt, Brace & World.
- TAIRAB, H. H. (2001). How do Pre-service and In-service Science Teachers View the Nature of Science and Technology? *Research in Science & Technological Education*, 19 (2), 235-250.
- TELHAUG, A. O. (1991). *Norsk skoleutvikling etter 1945*. Oslo: Didakta Norsk Forlag a/s.

REFERENCES

- THOMAS, G. & DURANT, J. (1987). *Why should we promote the public understanding of science?* Scientific Literacy Papers, 1, 1-14. University of Oxford, Department of External Studies.
- TILES, M. & OBERDIEK, H. (1995). *Living in a technological culture. Human tools and human values*. London: Routledge.
- TYACK, D. & TOBIN, W. (1994). The "Grammar" of Schooling: Why Has it Been so Hard to Change? *American Educational Research Journal* 31 (3), 453-479.
- TYLER, R. (1949). *Basic Principles of Curriculum and Instruction*. Chicago: University of Chicago Press.
- UNESCO (1994). *Innovations in science and technology education*, Vol. V (ed.: D. Layton). Paris: UNESCO.
- VAN DEN BERG, R. (1986). Teachers' attitudes towards technology. In J. H. Raat & M. de Vries (eds.): *What do Girls and Boys Think of Technology? Pupils' attitudes towards technology*. Eindhoven: Eindhoven University of Technology.
- VAN DRIEL, J. H., BEIJAARD, D. & VERLOOP, N. (2001). Professional Development and Reform in Science Education: The Role of Teachers' Practical Knowledge. *Journal of Research in Science Teaching*, 38 (2), 137-158.
- VAN MAANEN, J. (1988). *Tales of the Field. On Writing Ethnography*. Chicago: The University of Chicago Press.
- VENVILLE, G. J., WALLACE, J., RENNIE, L. J. & MALONE, J. A. (2002). Curriculum Integration: Eroding the High Ground of Science as a School Subject? *Studies in Science Education*, 37, 43-84.
- WAETJEN, W. B. (1993). Technological Literacy Reconsidered. *Journal of Technology Education*, 4 (2), 5-10.
- WAJCMAN, J. (1991). *Feminism confronts technology*. Cambridge: Polity Press.
- WICKLEIN, R. C. (1997). Curriculum Focus for Technology Education. *Journal of Technology Education*, 8 (2), 71-78.
- WIENER, M. J. (1981). *English Culture and the Decline of the Industrial Spirit 1850 - 1980*. Cambridge: Cambridge University Press. Reprinted in A. Cross & B. McCormick (eds.) (1986). *Technology in Schools*. Milton Keynes: Open University Press.
- WILLIAMS, J. (1996). International approaches to technology education. In P. J. Williams & A. P. Williams (eds.): *Technology Education for Teachers*. South Melbourne: MacMillan Education Australia.
- WINNER, L. (1977). *Autonomous Technology. Technics-out-of-Control as a Theme in Political Thought*. Cambridge, Massachusetts: MIT Press.

- WOJK, D. (1979). The Structure of Technological Revolutions. In G. Bugliarello & D. B. Doner (eds.): *The History and Philosophy of Technology*, Champaign-Urbana, Illinois: University of Illinois Press.
- WOODS, P. (1990). *Teacher skills and strategies*. London: The Falmer Press.
- WOOLNOUGH, B. & ALLSOP, T. (1985). *Practical Work in Science*. Cambridge: Cambridge University Press.
- YIN, R. K. (1994). *Case Study Research. Design and Methods*. Thousand Oaks, California: Sage Publications.
- ZIMAN, J. (1980). *Teaching and Learning about Science and Society*. Cambridge: Cambridge University Press.
- ZIMAN, J. (1984). *An introduction to science studies. The philosophical and social aspects of science and technology*. Cambridge: Cambridge University Press.
- ZIMAN, J. (ED.) (2000). *Technological Innovation as an Evolutionary process*. Cambridge: Cambridge University Press.
- ZOLLER, U. & DONN, S. (1991). Students' versus their teachers' beliefs and positions on science/technology/society-oriented issues. *International Journal of Science Education*, 13 (1), 25-36.
- ZUGA, K. F. (1989). Relating Technology Education Goals to Curriculum Planning. *Journal of Technology Education* 1(1), 1-14.
- ØDEGAARD, M. (2001). *The Drama of Science Education. How public understanding of biotechnology and drama as a learning activity may enhance a critical and inclusive science education*. Dissertation for the degree of dr. scient., Faculty of Mathematics and Natural Sciences. Oslo: University of Oslo.

APPENDIX 1

CAST OF CHARACTERS IN THE EMPIRICAL STUDY

School A

School A is a medium sized primary school (grades 1 - 7) situated in a calm residential area outside one of the larger cities in Norway. The school is relatively new and its staff contains a high percentage of young teachers. **Ann** is one of those young teachers. She completed her generalist teacher education a year before joining the TiS project and her specialisation is in Music and Art and Crafts. This year she is a class teacher in a grade 5 class, and teaches all subjects in this class together with a colleague. In addition, Ann is fully responsible for a unit called 'Technology and Design' ('teknologi og design') which is taught as an elective organised within 'School's and Pupils' Options' (SEV) on the intermediate level (grades 5 - 7) at school A. This unit forms part of what is referred to as a 'Cultural Session' ('kulturøkt'), to which two subsequent lessons every week are allocated. The electives available to the pupils in these sessions are largely of practical and creative nature such as theatre, playing in a band and writing a book about life at School A. All pupils on the intermediate level choose three of the available units, and spend 11 weeks with each of their choices. Ann thus teaches the unit to three different groups, each consisting of 12 - 14 pupils, during the school year.

School B

School B is a medium sized primary school (grades 1 - 7) situated in a rather prosperous area close to the centre of a relatively large city. The school has adopted what can be denoted a 'whole school approach' to technology teaching, in the sense that technology is emphasised in many subjects and in all grades. All teachers, not only those who participated on NITO's course in York, are somehow involved with technology teaching at the school.

In addition to this holistic approach, technology is run as a distinct component of the subject Art and Crafts in grade 7. The subject is divided into three areas: textile crafts, drawing and technology. In this subject the pupils in the two grade 7 classes at the school are distributed into three groups of 10 - 15 pupils, and the groups rotates through the three parts of the subject spending three successive lessons weekly in 11 weeks on each part. The technology part of Art and Crafts is taught by **Benny**. He is an experienced generalist teacher who participated, together with a colleague, on the

course in York the first year it was arranged. In addition to his responsibility for technology as part of Art and Crafts in grade 7, Benny is a class teacher in grade 1.

By coincidence, the number of girls is much higher than the number of boys in the two grade 7 classes at School B. With the aim of giving the boys the opportunity to work with each other, without always constituting a minority group in the class, the school has chosen to make gender segregated groups for the sessions in Art and Crafts. Hence, the pupils attending Benny's technology sessions constitute two girls only groups and one boys only group.

School D

School D is a large lower secondary school (grades 8 - 10) in a suburban area outside one of the larger cities in Norway. The school has a high proportion of pupils with a problematic background and with social and behavioural problems, and has a long tradition for working with new ways of teaching and organising work in schools in order to cope with the problems. The school is currently requesting to be exempt from the national curriculum for compulsory education in order to experiment with teaching pupils smaller units of subject matter rather than the conventional subjects. In the educational structure they plan, grade 8 will contain providing pupils with 'tools', which means teaching them basic skills in a range of areas alongside activities more open to pupils' individual choice. Grade 9 will entail higher degrees of freedom for the pupils, and grade 10 will be structured around pupils' work within individual chosen areas and projects. This experiment involves that the school will put less emphasis on grading pupils work, and that their leave certificate will show the units and projects undertaken rather than their grades.

The school is involved in several innovative projects whereof TiS is one. **David** is one of the teachers who participated on NITO's course in York. He has a broad work experience from banking and from a hospital, and as a university research assistant. He is then educated as a generalist teacher with an emphasis on science and mathematics, which are his main subjects of teaching. His realisation of technology teaching related to the TiS project is undertaken as cross-curricular projects and as components integrated in his teaching of Science.

School E

School E is a large lower secondary school (grades 8 - 10) in a suburban area of one of the bigger cities in Norway. School E is one of the more profiled within the TiS project, mainly due to the involvement of **Eric**, who is now a principal at the school. Eric has his educational background mainly in science. He has many years' experience as a science teacher and has also worked with technical vocational subjects.

He has taken part in the TiS project from its very start, and is engaged with giving courses in technology for teachers from other schools.

At School E, technology teaching is placed organisationally in three different areas of the curriculum. Firstly, technology constitutes the content of 'Practical project work' (Praktisk prosjektarbeid) as an elective alongside the second foreign languages (German and French). Secondly, technology is one possible choice for pupils in grade 8 during a project week at the end of the term. In this week, pupils who have selected technology as their topic work the whole week with technology projects. Finally, technology teaching is also incorporated in ordinary subjects such as Science and Art and Crafts for all pupils at the school.

Many of the teachers at School E are hence involved in technology teaching in some form. One of them is **Elna**, who is among those having participated on NITO's course in York. She is an experienced teacher with an educational background is a combination of science (chemistry and biology), mathematics and textile crafts, and these are mainly the subjects she teaches. A third teacher from School E figuring in the present study is **Edith**. She has not attended the course related to the TiS project, but is involved in parts of the technology teaching at the school, such as the unit offered in the project week. Edith has undertaken studies in geo-science, mathematics and statistics at a university, and has a few years of teaching experience.

School F

School F is situated in a rural area close to one of the larger cities in Norway. The area is sparsely populated with farming as a principal industry, and the relatively small school includes all grades of compulsory education (grades 1 - 10). The modest size of the school and also its culture facilitate flexibility in timetables and ways of organising teaching.

Technology teaching is organised mainly as cross-curricular project work at School F. On the lower secondary level (grades 8 – 10), every Monday is fully allocated to project work all year round, where projects on technology represent one significant part. On these 'technological Mondays', pupils work with the same project, or different aspects of a project, throughout the whole day. In grade 10, pupils undertake a larger individual project on technology. In this project, they are expected to go more in depth into a specific technological issue or in building a model from their own ideas and investigations.

The technology teaching is mainly run by two experienced teachers, **Frederic** and **Frida**, who attended NITO's course together. Frederic has his background in science and mathematics, while Frida is educated in the humanities. Other teachers are also

involved in technology projects, but they are most often initiated and managed by Frederic and Frida.

School G

School G is a relatively large lower secondary school (grades 8 - 10) situated in a residential area near the centre of a relatively large city. Technology teaching associated with the TiS project is mainly realised as an elective unit denoted 'Technology and Design' ('teknologi og design') organised within 'School's and Pupils' Options' (SEV) for pupils in grade 10. The pupils attend their chosen unit two hours once a week. The units last half a year, and the pupils choose a new unit for the second half of the year. Besides Technology and Design, units offered to the pupils include sports, drama and music, information technology and work placement where pupils are out of school working in companies or other work places.

The technology unit is developed and taught by **Gina** and **Gerhard**. Gina is a young teacher with university education in physics, mathematics and computer science and holds a degree equivalent to a M.Sc. in physics. She mainly teaches the subjects Science and Mathematics at School G. The technology unit was initiated by the school leaders and commenced one year after Gina joined the TiS project and participated on NITO's course in York. When Gina was told that she was going to teach this new unit, she requested to be assisted by a teacher of Art and Crafts. As a consequence, she shares the responsibility for developing and teaching the unit with her colleague Gerhard, an experienced teacher with strong background in Art and Crafts. Gerhard has not attended the TiS course in York, but has joined Gina on some seminars on technology teaching organised by NITO.

School H

School H is a small primary school (grades 1 - 7) situated in a rural area. Technology teaching associated with the TiS project occurs as cross-curricular projects on an occasional basis run by the two teachers **Hanna** and **Henry** who participated on NITO's course in York. Henry has his education and work practice in technical vocational direction before becoming a teacher, and this technical background formed a basis for his interest in attending the TiS project. Hanna's participation was more coincidentally. Another teacher was intended to participate together with Henry, but withdrawn. As NITO required two teachers from each school to participate, Hanna then stepped in for this teacher. She has her education as a generalist teacher, with a specialisation in Art and Crafts. Hanna and Henry are class teachers for grade 5 and grade 6 respectively. They often co-operate and run similar projects in their two classes. However, they face difficulty in realising many of the projects they wish for with their pupils, due to the fact that the school lacks a room

and suitable equipment for woodwork. Technology projects hence need to be undertaken in the classes' regular classrooms.

School I

School I is a primary school (grades 1 - 7) in a calm area outside a medium sized city. The school has adopted a flexible approach to the subjects specified in the curriculum, and does not set a traditional timetable for the classes. Nor do they make extensive use of textbooks. The work is mainly organised around themes that run for some weeks in each grade, where the subjects in the curriculum contribute with relevant content.

Irene is an experienced teacher with a generalist teacher education. Her specialisation is mainly within languages, but also contains Art and Crafts, and she is currently a class teacher in grade 6 together with a colleague who also attended the TiS course in York. At school I Design & Technology is considered one subject alongside the others as a basis for the common themes. In the period when fieldwork was conducted, the theme in grade 6 was 'North America'. This theme covered topics such as slavery from Social Studies, production of American specialities such as apple pie in Home economics, baseball in Physical education and calculation of currency in Mathematics. The theme also involved American cars, and contribution from Design & Technology to the theme was here the building of small buggies run by an electric motor and a driving belt.

School J

School J is a large lower secondary school (grades 8 - 10) outside a medium sized city. Technology teaching associated with the TiS project is realised as 'Practical project work' (Pratisk prosjektarbeid) as one elective available as a compulsory additional subject alongside second foreign languages. In addition, technology projects are undertaken on an occasional basis in other classes. In grade 10, all pupils have undertaken a course consisting of eight sessions on technology. This course involved activities such as building a bridge from rolled paper and the construction of a siege machine.

Jim was the only teacher from his school participating on the course in York, and he is responsible for the elective unit as well as most of the technology teaching in other classes. Jim has a multifaceted background, with education as an electrician, in public administration, history and drawing. He has a strong interest in technical subjects as well as the creative arts, and has experience as a professional designer. Art and Crafts is thus his main subject of teaching.

APPENDIX 2

OVERVIEW OF FIELDWORK IN THE EMPIRICAL STUDY

The table gives an overview of interviews and classroom observations undertaken as part of the empirical study. Codes *P1*, *P2* etc in parentheses correspond to the numbering of primary documents in ATLAS/ti and to reference made to those where quotations are given in the thesis.

School A	Observation of technology sessions weekly from November 1999 to February 2000. Revisit March 2000 with tape recording of Ann's technology teaching. Interview with Ann February 2000 (<i>P1</i>) and March 2001 (<i>P11</i>).
School B	Observation of technology sessions weekly from November 1999 to February 2000. Revisit March 2000 including tape-recording of technology session (<i>P18</i>). Interview with Benny (<i>P2</i>) April 2000.
School D	Classroom observation and interview with David (<i>P3</i>) September 2000. Another interview with David (<i>P14</i>) June 2001.
School E	Two days visit during the school's project week April 2000, including classroom observations and individual interviews with Edith (<i>P4</i>), Elna (<i>P5</i>) and Eric (<i>P6</i>). Revisit with a second interview with Elna (<i>P15</i>) May 2001.
School F	One day visit and interview with Frederic and Frida together (<i>P7</i>) October 2000. Revisit including classroom observation and another interview with Frederic (<i>P10</i>) January 2001.
School G	Interview with Gina and Gerhard together (<i>P8</i>) December 2000. Repeated visits with observations of Gina's session from January to April 2001. Another interview with Gina (<i>P13</i>) May 2001.
School H	One day visit March 2001 including classroom observation and interview with Hanna and Henry together (<i>P9</i>).
School I	One day visit September 2001 including classroom observation and interview with Irene (<i>P16</i>).
School J	One day visit September 2001 including classroom observation and interview with Jim (<i>P17</i>).