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Agnieszka B. Jarvoll

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Experiences with Minecraft as an educational tool

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Thesis for the Degree of
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Nesna/Trondheim
July 2019

Summary

This thesis addresses what conditions are required in an intervention study where the commercial digital game, Minecraft, is used as a mediating artefact in the classroom. The focus is on students and teachers' experiences and on experiences gained in the initial phase of collaboration between the teachers and the researcher. The teachers' motive for joining the collaboration was to expand their practice with using Minecraft as an educational tool and to restore students' motivation for the subject of mathematics. The consequences and implications that may be drawn from such a collaboration are illuminated through three articles driven by the following research questions: (1) 'How do students experience the use of Minecraft in their classroom, and what are the consequences for their motivation?'; (2) 'How does the teacher experience the use of Minecraft, and what are the implications for his understanding and involvement in the intervention?'; and (3) 'How does initial collaboration between a researcher and practitioners create a meeting place, and what implications can be drawn from this?' In the three articles, the main research question, 'What conditions are required in a formative intervention study where Minecraft is used as a mediating artefact in the classroom?', is examined within distinct and separate thematic angles that appeared during the analytical work with the thesis.

This thesis is positioned in classroom research and development, and it seeks to contribute to teacher education and the field of educational research. In an attempt to contribute to this research, a formative Change Laboratory intervention (Virkkunen & Newnham, 2013) is suggested as an interface between the researcher's world and the practitioners' world to facilitate collaboration between the two. A Change Laboratory is based on the theory of expansive learning (Engeström, 2015); thus, this thesis is anchored in the cultural-historical activity theory (Engeström, 2015; Virkkunen & Newnham, 2013).

As an in-depth investigation of a contemporary, real-life context, this research is conducted as a single case study (Creswell, 2013; Yin, 2014) that lasted 1.5 years in a primary school with 27 students and two teachers. The main data materials include single and focus group semi-structured interviews, notes from participant observations, conversations with the teacher during the lessons, E-mail correspondence in relation to the intervention and various elements of concern found in the research situation. In addition, screenshots and Bandicam recordings are used for the developmental processes of the intervention. The analysis is conducted by using the constant comparative method (Strauss & Corbin, 1998) and situational analysis (Clarke, Friese, & Washburn, 2018).

In the study, three phases have been detected during collaboration that show continuity in the dialogue between the researcher and the practitioners to ensure the realisation of the object-oriented activity, that is, from words to practical actions. By continuing the dialogue, both parties created and expanded the space where the activity could be realised. Moreover, students' collaborative agency produced better insight into their experience and an important understanding of possibilities in connection with the educational tool, Minecraft. The students have also created their own object,

‘fooling around’, which shows that working with such a commercial digital game may produce an unexpected outcome. In addition, the first teacher described his experiences with using digital games, where the teacher was more akin to a facilitator in action than occupy the role of one who conveys knowledge.

Furthermore, in an attempt to gain more information about what actually happened in the intervention, the third generation of the activity system (Engeström, 2015; Engeström & Sannino, 2010; Virkkunen & Newnham, 2013) is employed in the extended abstract to show how the activity systems from this research are involved in the construction of a shared object.

Sammendrag (Norwegian)

Denne avhandlingen ser på hvilke betingelser som kreves for gjennomføring av en intervensjon der det kommersielle dataspillet Minecraft brukes som medierende artefakta i klasserommet. Fokuset i studien er på elevers og læreres erfaringer, og erfaringer av samarbeidet mellom forskeren og praksisfeltet knyttet til oppstarten av intervensjonen. Læreres motiv for å delta i intervensjonen var å utvikle egen praksis ved bruk av dataspillet Minecraft som arbeidsmetode og gjenopprette elevers motivasjon for matematikk. Tre artikler belyser konsekvenser og implikasjoner som er blitt trukket ut av studien. Artiklenes forskningsspørsmål er som følger: (1) Hvordan erfarer elever bruk av Minecraft i klasserommet, og hva er konsekvensen for deres motivasjon?, (2) Hvordan erfarer læreren bruken av Minecraft, og hva impliserer hans forståelse og involvering i intervensjonen? og (3) Hvordan kan et begynnende samarbeid i en intervensjon legge til rette for konstruksjon av et møtested som kan bidra til å forene forskningsfeltet og praksisfeltet, og hva er konsekvensen av dette for forskeren og læreren? Den overordnede problemstillingen i avhandlingen er: Hvilke betingelser fordres i en intervensjonsstudie der Minecraft blir brukt som medierende artefakt i klasserommet? Denne er belyst ut fra separate vinklinger som har kommet frem underveis i analyseprosessen og som videre gjenspeiler seg i de tre artiklene.

Innenfor utdanningsfeltet har forskning og praksis blitt sett på som dikotomier, eller som ineffektiv kommunikasjon. En alternativ forståelse handler om at forskning og praksis er deler av en helhet; de er ulike, men begge er nødvendige for å gi en helhetlig forståelse av utdanningsfeltet og dets utvikling. Som et bidrag til det sistnevnte, er formativ Change Laboratory intervensjoner (Virkkunen & Newnham, 2013) tatt i bruk for å forsøke å binde sammen forskerens og lærerens verden og for å legge til rette for en bedre dialog. Denne avhandlingen er plassert innenfor klasseromforskning og søker med dette å kunne være et bidrag til det mer overordnende feltet utdanningsforskning og til lærerutdanning. Change Laboratory er knyttet til konseptet ekspansiv læring (Engeström, 2015) som er forankret i kultur-historisk aktivitetsteori (CHAT) (Engeström, 2015; Virkkunen & Newnham, 2013).

Intervensjonen er definert som en kasusstudie (Creswell, 2013; Yin, 2014) og er blitt gjennomført i en klasse med 27 elever og to lærere fra grunnskolen, med

matematikk som et eksempelfag. Samarbeidet med lærerne og forskeren varte i 1,5 år. Det empiriske datagrunnlaget inkluderer individuelle intervju og fokusgruppeintervju, notater fra deltakende observasjon, samtaler med læreren underveis i undervisningen, e-post korrespondanse og studiens del-elementer slik de er blitt avdekt ved bruk av situasjonsanalyse (Clarke, Friese, & Washburn, 2018). I tillegg er skjermbilder og Bandicam-opptak benyttet til å gjenspeile utviklingsprosessene i intervensjonen. Det analytiske arbeidet med datamaterialet er blitt gjennomført ved bruk av konstant komparativ analysemetode (Strauss & Corbin, 1998) i tillegg til den nevnte situasjonsanalysen.

Analysearbeidet har avdekt tre faser fra samarbeidet i intervensjonen som viser kontinuitet i dialogen mellom forskeren og samarbeidspartnere. Denne kontinuiteten blir sett på som viktig for å sikre realiseringen av undervisningen med Minecraft i matematikk, det vil si fra ord til praktiske handlinger. Elevenes deltakelse gav innblikk i deres erfaringer og muligheter i forbindelse med bruk av Minecraft som en arbeidsmetode. Elevene har også skapt sitt eget objekt, "å tulle", noe som viser at bruk av et slikt kommersielt dataspill kan gi uventede utfall. Den første læreren beskrev sine erfaringer etter bruk av dataspillet som at en lærer blir mer en veileder enn en som formidler kunnskap ved bruk av en slik arbeidsmetode.

Den tredje generasjons aktivitetsystem (Engeström, 2015; Engeström & Sannino, 2010; Virkkunen & Newnham, 2013) er blitt brukt på et overordnet nivå i kappedelen for å få en helhetlig forståelse av involverte aktivitetssystem inkludert i konstruksjonen og endringen av det felles objektet.

PART 1: EXTENDED ABSTRACT

PART 2: ARTICLES

Article 1:
Jarvoll, A. B. (2018a). "I'll have everything in diamonds!": Students' Experiences With Minecraft at School. *Studia Paedagogica*, 23(4), 67–89. doi:10.5817/sp2018-4-4

Article 2:
Jarvoll, A. B. (2018b). Teaching at stake! In search of a teacher's experiences from an intervention with Minecraft. In D. Siemieniecka (Eds.), *Virtuality and Education. Future Prospects* (pp. 57–79). Toruń: Adam Marszalek.

Article 3:
Jarvoll, A. B. (2019). Exploring initial collaboration in an intervention: Creating a meeting place between educational research and educational practice. *Nordic Journal of Education and Practice*. 13(1), 44 – 61.

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1. Introduction

The use of digital media technology or information and communication technology (ICT) in schools has been an important topic in many countries. Several surveys have addressed the current situation from the perspective of teachers, parents or students. For instance, in Norway, the use of ICT in schools has been given much attention and is anchored in the National Curriculum for Knowledge Promotion (Norwegian Directorate for Education and Training, 2015). Digital competence is the fifth basic competence for every subject at every level of primary school in Norway. Technological tools are thus a fundamental part of education in Norwegian classrooms.

Some researchers are sceptical of what they call 'a romanticizing of classrooms employing digital media technology' (Elliot & Bulfin, 2014, p. 295). Following this statement, an interesting finding was reported concerning Norway through a European survey (European Schoolnet, 2013). When looking at the data for Norway, it appears that teachers mostly disagree that the use of ICT has a positive impact on many aspects connected to learning, such as motivation, collaborative and autonomous work and achievement. This finding is opposite to that reported by teachers from other countries, such as Denmark, Lithuania, Latvia and Estonia, which also declare a high frequency of ICT-based activities (European Schoolnet, 2013, pp. 123–124). Further, concerning this critical opinion from Norwegian teachers, some researchers point out that teachers who use digital media technology are frequently referred to as 'early adopters' (Cipollone, Schiffer, & Moffat, 2014; Cuban, 2001; Rogers, 1983), but most of the teachers are not early adopters (Cipollone et al., 2014). I think the focus should then be moved to them. Early adopters are genuinely interested in ICT, such as the use of digital games in their classrooms (Cipollone et al., 2014). However, evidently, this European survey shows that many teachers in Norway show more scepticism than teachers in other European countries. According to a national study, Monitor School 2016 (Egeberg, Hultin, & Berge, 2017), a survey that maps out the current digital situation in schools, which was conducted in Norway among teachers and students in the seventh grade, the use of computers in schools has actually increased between 2013 and 2016. However, it is still a modest percentage of students, 23%, that have the opportunity to use computers for 4

hours or more per week in school. In the survey, 4 hours a week has been chosen as the limit for achieving the curriculum's competence aims. The use of less computers for less than 4 hours a week, for about 77% of students in all school subjects, may not be sufficient to reach those aims. The survey is also concerned about the competence of teachers. Little or no resources for competence development are allocated in the fields of basic skills, pedagogical competence in ICT use and the integration of subject-specific learning resources. In addition, teachers report that time must be allocated for competence development and that pedagogical ICT support is needed, despite the fact that Norway is one of the countries in Europe that has highly 'digitally equipped schools' (European Schoolnet, 2013).

In an attempt to facilitate the formal aims stated in the national curriculum, the case is that in Norwegian teacher education programmes, the student teachers have to master the use of ICT as future teachers teaching various subjects in a competent and professional manner (Ministry of Education and Research, 2010).

Students are seen, in some aspects, as highly competent users of new technology and even so-called digital natives (Prensky, 2001). This is especially the case when it comes to digital games. Many years of research show that digital games have much to offer when it comes to the use as educational tools in schools (Nebel, Schneider, & Rey, 2016), and researchers are exploring possibilities for the future of learning (Abrams, 2017; Niemeyer & Gerber, 2015). Nevertheless, the use of digital games in Norwegian schools is restricted to 8% of the overall use of ICT (Norwegian Media Authority, 2016, p. 82). Furthermore, the amount of research about the educative use of ICT, also when it comes to digital games, is comprehensive and diverse. Regardless of the fact that the research concerns thematically various directions, in connection to this, it is important to problematize whether the various experiences from the research is reaching out to the schools and have an impact on the school's practice and development. Some researchers relate to this question when choosing intervention[1] studies as their approach to investigating closely the field of educational practice (Erstad & Hauge, 2011, p. 21). A Change Laboratory is a formative intervention method (Engeström, Sannino, &

[1] The term 'intervention' will be elaborated later.

Virkkunen, 2014; Virkkunen & Newnham, 2013) to approach school development, as well as when it comes to the use of ICT (Hauge & Erstad, 2011; Virkkunen & Newnham, 2013). This approach gives an opportunity to me, the researcher-interventionist, to participate where the action is—in the classroom. Learning and development are considered collective and complex activities in formative Change Laboratory interventions. As these activities may change, the possibility to be present and be able to grasp and to explain the change is useful for the interpretation and development of the activity further. In connection to this, the researcher-interventionist collects data for two interrelated uses. In relation to the various aspects of the activity that need to be identified and solved together with the practitioners, the mirror data (Cole & Engeström, 2007) are collected and consist, for instance, of recordings, screenshots or planning documents. Another use of the data is applied when the researcher-interventionist needs to orient herself to the research process (Virkkunen & Newnham, 2013, pp. 70–73). The strategy with mirror data is helpful to stimulate practitioners' expansive learning, which is explained as 'something that is not yet there' (Engeström & Sannino, 2010, p. 2). In practice, this means that participants can construct new objects for their collaborative activity. In other words, this can be about a comprehensive process of activity change in a community, for instance, in a school or in a class. I have considered that conducting research on change and developmental processes is something fundamental and appropriate when it comes to the opportunities and challenges of ICT in our society, as well as in schools, and it may offer support to other developmental studies in the future about what may be required in similar studies. This thesis is about a formative Change Laboratory intervention in a classroom where the digital game Minecraft is used to expand teachers' practice in the classroom and as an attempt to increase students' motivation in the subject of mathematics as an example.

The thesis consists of two parts. The first part comprises the extended abstract with associated chapters, and the second part contains the articles. In the first section in chapter one, I present the aim and the research topic. Then, I clarify the overarching research question in relation to the research questions stated in the articles.

In Chapter 2, I review the related research that has been especially selected because of its relevance to this thesis.

In Chapter 3, the theoretical framework is presented with the primary focus on cultural-historical activity theory (CHAT) as an approach connected to constructivist perspectives.

In Chapter 4, I present the methodology, the method of analysis and data collection and data corpus, ethics, the context of the intervention, the quality of the study and the role of the researcher.

Chapter 5 is dedicated to the findings presented in the articles in connection to the overreaching research question. I discuss also the contribution from CHAT, as well as what I consider the limitations and contributions of the study to the field of educational research.

In the second part of this thesis, the articles are presented. All are based on the data collected from the intervention; thus, they are empirical articles. For each article, different parts of the data material are chosen in an attempt to answer the research question in a fair way and with proper respect for what has been expressed or done by the participants at a given moment during the intervention.

Those three articles focus on different parts of the study and present associated data materials. The first article sheds light on the students' experiences connected to the use of a commercial digital game as an educational tool. The second article offers the teacher's experiences of being teacher and trying out a new educational tool. Finally, the third article contains an overarching view of the initial phase of the formative intervention by trying to explore the development of dialogical processes between the researcher and practitioner, as well as contradictions that results in the actual activity of the intervention using Minecraft in mathematics.

1.1. Aim and research topics

The aim of this thesis has been to explore what can be drawn from a formative Change Laboratory intervention (Engeström, 2016; Engeström & Sannino, 2010; Virkkunen & Newnham, 2013) when it comes to students and teachers' experiences using Minecraft as an educational tool in an example subject such as mathematics. Formative Change Laboratory interventions are anchored in CHAT, and the research based on CHAT is

called developmental work research (DWR; Engeström, 2015; Virkkunen & Newnham, 2013) or research and development (R&D; Postholm & Moen, 2011).

Moreover, it has been interesting to explore how the experiences from this thesis can contribute to what may be required in an intervention. Furthermore, the study addresses what can be learned from a collaboration between a researcher and a practitioner in a school. DWR is a 'formative intervention' (Engeström & Sannino, 2010, p. 15) methodology that promotes positive change in practice using a participatory, collaborative design (Virkkunen & Newnham, 2013).

The study is approached as a case study, specified as an intervention in a single primary school classroom with 27 students aged 11 and 12 and with two teachers. One of the teachers has elaborated the aim of the intervention in an attempt to restore the motivation for mathematics in the class by using the digital game Minecraft. Bearing this in mind, one objective of this study has been to explore students' motivation as the intervention proceeded. This is covered by the research question presented in the first article. The teacher's experiences with Minecraft, to him an unknown educational tool, were explored as a unique possibility in article 2 to gain knowledge about what kind of reflections a teacher may have when trying a commercial digital game for the first time. The collaboration during the intervention gave the possibility to have access to the classroom context during teachers' mathematics lessons and consequently to gain a more comprehensive understanding of the activity. Such a possibility has not been taken for granted, and it has thus been explored further by examining the dialogical processes to gain more knowledge about the initial phase of such a collaboration and its further development in the third article. This brief description of these three articles gives the essential features of the overarching research question:

What conditions are required in a formative intervention study where Minecraft is used as a mediating artefact in the classroom?

In the three articles presented shortly below, the main research question is examined within distinct and separated thematic angles that appeared during the analytical work with the thesis.

The research question from article 1 was, 'How do students experience the use of Minecraft in their classroom, and what are the consequences for their motivation'? This article explores what students themselves express about the use of Minecraft as an

educational tool in their mathematics lessons. Furthermore, a special focus is on students' motivation and motives for working with the mathematics tasks.

The research question from article 2 was, 'How does the teacher experience the use of Minecraft, and what are the implications for his understanding and involvement in the intervention'? This article addresses the first teacher from the collaboration, Mr Todd, and his experiences with Minecraft as a new—to him—educational tool. The teacher's reflections have an impact on what is needed from a teacher when using digital games in a mathematics class.

The research question from article 3 was, 'How does initial collaboration between a researcher and practitioners create a meeting place, and what implications can be drawn from this'? This article explores the initial phase of the intervention, with a special focus on the communication processes between the collaboration partners both before the beginning of the collaboration and during the collaboration. The findings show that e-mail correspondence in connection to the intervention seems to play a crucial role in the continuation and expansion of the dialogue towards achieving an object-oriented activity.

Figure 1 below shows the relation among these three articles and the overarching research question.

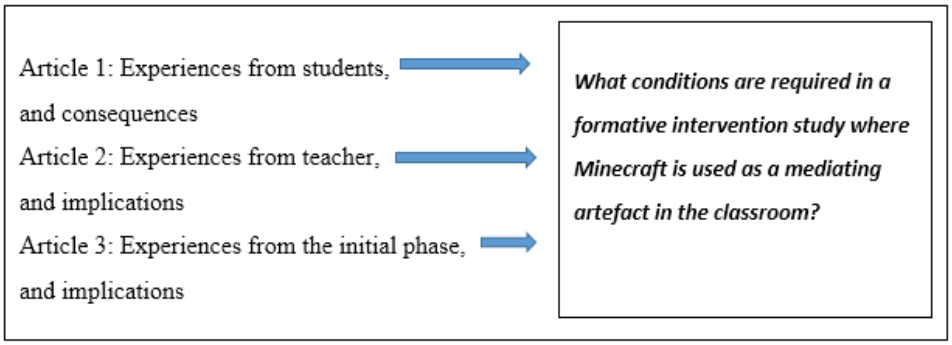

Figure 1. Experiences explored in these three articles and the main research question in this thesis.

1.2. Background for the case study

In this section, I will briefly outline the background for the intervention to contextualise this case study, which lays the basis for the thesis. In chapter 4, I will elaborate more on the methodological issues connected to the text below.

1.2.1. Intervention research and school development

Practice-oriented research can be used as an umbrella term to relate to a wide domain of research, such as action research and intervention research (Postholm & Smith, 2017, p. 71); if the latter is anchored in CHAT, it is then referred to as a formative Change Laboratory intervention[2] (Engeström, 2016; Engeström & Sannino, 2010; Virkkunen & Newnham, 2013). Research based on CHAT is, as mentioned earlier, called DWR (Engeström, 2015; Virkkunen & Newnham, 2013) or R&D (Postholm & Moen, 2011). The latter offers a model where the researchers plateau is crystallised. This model will be presented later in chapter 4, as it contributes to the understanding of the role of the researcher in formative interventions.

A formative intervention is explained by Virkkunen and Newnham as 'purposeful action by a human agent to support the redirection of ongoing change' (Virkkunen & Newnham, 2013, p. 3). In formative intervention research, such as the research presented in this thesis, the aim and the content are not decided or defined by the researcher before the intervention, but formed by the partners of the collaboration (Engeström & Sannino, 2010, p. 15). The researcher is intended as support. Thus, all participants own the intervention and have a responsibility for its directions. The overall thinking in formative interventions is that the need for transformation or development of the field is decided and defined by practitioners themselves and conducted with a researcher in the field. Therefore, the research brings a directly practical importance for the practitioners' everyday life in school. This democratic focus has been an important base for my research. For me, the idea that I could contribute directly to the field when being in the field was central at the beginning of the study, and from there, I decided on the direction for my choices about what kind of research I wanted to conduct. I wanted

[2] It is, as also identified in this thesis, often referred to as a formative intervention (Engeström & Sannino, 2010, p. 15). Formative interventions and the researcher's role will additionally be outlined in chapters 3 and 4.

not only to gather information from participants, but also to contribute with something useful when being in their context conducting research in a collaborative manner. Such a view, as I understand it, places this thesis under the social constructivist approach (Creswell, 2013; Postholm, 2010), where the research proceeds to develop through a dialogical collaboration. This is also in line with arguments presented by Levin (2017, p. 27) leaning on Berger and Luckmann (1971) that educational research is a constructivist project.

In the articles, the social constructivist approach has been emphasised as this study overarching perspective on knowledge, learning and development. This is also in line with the understanding that CHAT can be perceived as a social constructivist theory (Postholm, 2010, p. 29). Thus, social constructivist theory in connection to knowledge, learning and development is highlighted in studies using CHAT as a framework (Engerman, MacAllan, & Carr-Cellmann, 2018; Fire & Casstevens, 2013; Rizzo, Schutt, & Linegar, 2012).

Social constructivism can be described as a worldview where individuals are seeking an understanding of the world in which they are living. In doing so, they develop varied and multiple subjective meanings of their experiences. These subjective meanings are formed in interaction with other individuals in a context of historical and cultural norms. They are constructs of meanings of a situation, about what has been said or done. Following this belief, I have been looking at the complexity of views, relying on the teachers and students' viewpoints concerning various situations during the research. I will specify as my epistemological assumption in this thesis that researchers can acquire knowledge through participants' subjective experiences of collaborating in their context (Creswell, 2013, pp. 20–21). This implies that when having this stance, the role of the researcher must also be recognised. The background and experience of the researcher, me, comprise the lenses for interpreting what I find. The role of the researcher is elaborated on in the methodology chapter.

Furthermore, as a teacher educator, I am attached to educational research, where I shall understand and interpret the social processes and contexts of which I am a part. To be able to do this, my critical ability and necessary analytical distance must be supported and developed (Levin, 2017, p. 28). Formative interventions meet this kind of view, and they will be outlined later in chapters 3 and 4.

It is emphasised that there is a lack of coherence, or even a gap, between the academic knowledge presented in teacher education and the professional practice students meet in the field work-learning experience. Theory and practice are seen as dichotomies (Rønbeck & Germeten, 2014), instead of parts of a whole. As a teacher educator, I have strived to convey the latter understanding of the field of education for students, because I do believe that both are necessary to show the complexity of the field (Løfsnæs, Jarvoll, & Dalen, 2014). Thus, after reading some relevant research on the field, I have been curios to determine in my own research how a formative intervention can help me to grasp both parts of the field of education. I think this study can contribute with insight to what is required in this kind of research through the transparency I strive to convey.

In addition, it has been argued that the practical basis of professional teacher knowledge has to be supported and strengthened. Thus, there is a need to educate teachers as researchers, and this should be a part of general teacher education in Norway (Hiim, 2017). It can be drawn from Hiim's argumentation that teacher educators must have enough practical experience from the field themselves to be able to create authentic challenges for students. I connect this to the relevance and quality of the teacher education, which has during the last years been questioned by researchers (Hiim, 2017, p. 48). I hope this thesis can illuminate the complexity between theory and practice by joining both into the activity related to the intervention I am about to present in this thesis.

As a teacher educator, I think it is essential to be concerned with children's viewpoints. When it comes to the use of digital games, doing otherwise would be unfair, because, as I have experienced, it is their arena. Children have been viewed as digitally competent for decades and referred to as 'digital natives' (Prensky, 2001). Although, children's competence regarding various aspects of ICT have been exposed lately to further research, such as digital competence in relation to gender (Corneliussen & Prøitz, 2016) or in relation to parental guidance and competence (Gila, 2017; Nikken & Opree, 2018). However, children's own perspectives and involvement have not always been given enough attention and captured in research (Beavis, Muspratt, & Thompson, 2015; Wernholm & Vigmo, 2015). Grasping children's own voices is important, because it must be remembered that children have the most experience of being children

(Nilsen, 2010, p. 24), regardless of whether they are viewed as digital natives or just children.

1.2.2. Formative interventions and related approaches

Understanding the social context and getting a necessary distance, stated as important by Levin (2017, p. 27), are possible when using CHAT (Postholm & Moen, 2011; Virkkunen & Newnham, 2013). Rooted in CHAT, formative Change Laboratory interventions address different actions taken in an activity system (Engeström, 2015), for instance a class with their teacher, which collectively constitutes a specific kind of activity that is connected to a continuous change in the activity system. An activity system will be outlined later. Here, I will shed light on some differences between other, but related, approaches, and I will connect these to my choices when employing CHAT.

As mentioned earlier, both action research and intervention research can be sorted under the term 'practice oriented research' (Postholm & Smith, 2017, p. 71). Levin (2017, p. 35) presents five essential points that must be present in action research. The first point is that the owners of the problem, the practitioners, must join in a research collaboration with the researchers, which also occurs in CHAT. How this has been conducted is described later in this thesis. In CHAT, it is clarified that the key outcome of collaboration in formative interventions is agency among all the participants, but the participants own both the process and the outcome (Engeström, 2015; Engeström & Sannino, 2010). Lewin's second point addresses the research, or the knowledge gained, saying that a concrete solution must be identified to overcome the problem. The most trustworthy action research shows that the solution works. CHAT does not address one single problem, but the whole activity system, its transformation processes and the history of the activity itself in a cultural context (Cole, 2005, p. 104); thus, the two approaches differ greatly in their overarching goals and contributions. In my research, the focus has been on the whole activity system, meaning that all factors in the activity system have been important to examine. In connection to the thesis, some themes had to be emphasised more than others did. Furthermore, when it comes to the action research, Levin's third point says that the development and implementation of concrete solutions form the basis of scientific structure and analysis. This thinking is familiar in CHAT, but the focus is not quite on the concrete implementation of a

solution, but on the development of the whole activity and documentation of the processes, for instance, the dialogical processes that may occur in connection to various contradictions in a formative intervention during transformation. Levin's fourth point emphasises that action research is a circular process with concrete experimenting and learning. Again, the focus is on concrete solutions. According to CHAT, humans are engaged in a complex ongoing activity that is socially situated. When individuals begin to question their activity, demands for change may grow. The implementation of a new practice happens when learning is achieved with the help of different learning actions, as depicted in an expansive learning cycle, that together constitute a change to the object (Engeström, 2016, p. 49). Expansive learning and the expansive learning cycle will be outlined in chapter 3. Furthermore, when an activity needs change, for instance, to meet challenges from society, it appears that nobody knows exactly what is needed to be learned to cope with these challenges or the challenges that may appear in the future (Engeström, 2016, p. 39). This comprehension about how to work with learning, which is aimed at targeting future challenges, has been interesting when it comes to how to understand the use of digital games in school. There are many various kinds of games, and trying out one only one time would not necessarily contribute much to learning in the future. A deeper understanding of technology and its meaning regarding humans' purposeful activities, for instance, their motives, has been necessary to explore (Jarvoll 2018a) and to be able to contribute with something more general that can be extracted from this research.

Levin's last point states that action research is situated in the context of the practitioners. This is also the case in this formative intervention where the participants worked out expansive solutions to deal with contradictions in their activity system (Jarvoll, 2019).

Leaning on Leontjev (2002)[3] and his demonstration of the division of labour, the relation between actions and activity is carefully explained by Engeström (2016, pp. 40–41). An action has a start and an end, but an activity is a collective reproduction of

[3] The name of this key figure from the Russian cultural-historical school, Leontjev, is written in various versions in the different theoretical sources, for instance, as Leont'ev in Engeström (2016). My choice 'Leontjev' is from the source I have been using most frequently.

various actions that do not have a predetermined endpoint. The activity is generating seemingly similar actions repeatedly, but there may be a continuous or discontinuous change in the activity. In short, the idea of expansive learning builds on this fundamental distinction between action and activity. According to Engeström (2016, p. 40), the movement from actions to activity is basically expansive learning. This idea is interesting when thinking about a class that is facing some challenges. The fundamental movement from actions to activity is relevant, where the students and the teacher are exploring together a new educational tool many times in various tasks. The division of labour between the students and their teacher (and the researcher) constitutes this kind of collective activity in a classroom. The researcher, the teacher and the students are interacting deliberately (Jarvoll, 2018a). They can keep interpreting and reinterpreting the challenges they meet in their own diverse and sometimes highly unpredictable ways that do not obey the laws of linear causality (Engeström, 2016, p. 209). Thus, the researcher, me, recognises the limits of the methodological rules of positivist science.

Engeström (2016, p. 210) characterises a formative intervention to be 'a radical methodological approach' inspired by Vygotsky and his colleagues. One related approach, design research, which, according to Engeström, follows to some degree a linear view, is another kind of possible intervention approach that can be carried out in schools. In this approach, it is assumed that researchers makes the design of what is to be implemented, teachers carry out what has been planned and then students achieve better learning outcomes.[4] The problem with this approach, according to Engeström, is that nobody asks who creates the design and why. According to Bjørndal (2013), it is sometimes a question about definition, and both action research and design research are intervention research (Bjørndal, 2013, p. 246). Design research is more focused or restricted regarding the development of the field of practice, where management is in the hands of the researcher (Bjørndal, 2013, p. 247). On the contrary, Virkkunen and Newnham (2013), using a systematic overview of the various aspects of interventions, show the main differences between formative Change Laboratory interventions and interventions that have predetermined objects and are evaluated by measuring the

[4] Unfortunately, there is no room to picture other problems that can be brought into being from such a linear reasoning.

situation both before and after its application (Virkkunen & Newnham, 2013, pp. 11–12). They emphasised that the aspects of significance for all interventions concern the 'object', the 'starting point', the 'process', the 'outcome' and the 'researcher interventionist's role'. The 'object' in formative Change Laboratory interventions is about a historically developing system of collaborative activity and not a local practice or habitual way of acting in a group. In this study, the object has been traced through the articles as it developed (see chapter 5). The 'starting point' in formative Change Laboratory interventions is about contradictory demands, which the participants encounter in their life activity. In the process, the subjects gain agency and eventually take charge of it. In addition, the content and the course of the intervention are subject to multivoiced negotiation. Especially, in article 3, the contradictions gained a necessary focus as they emerged, including how they were solved. In other interventions, the subjects are expected to experiment with a given solution, and difficulties are seen as a weakness in the solution. The 'outcome' in formative Change Laboratory interventions is about new concepts that may be used as instruments of analysis and problem solving in other settings. According to Virkkunen and Newnham (2013, p. 12), the outcome in other kinds of interventions may be seen as a solution that can be as such transferred to other settings and can in full or in partial reach the pre-established goal. In the first article, fooling around becomes an explicit object constructed by the students in a group (Jarvoll 2018a). As I see it, it can be a reasonable help in the analytical work in other studies, but it should not be understood as an outcome that can be generalised. The last aspect, the 'researcher interventionist's role', is intended to provoke and sustain a collaborative-led expansive transformation process. This is opposed to, for instance, the already mentioned design research, where the researcher owns, designs and controls the process. The researcher's role in this study has received attention in several places in this thesis, where it has been carefully described in an attempt to make it as clear as possible. In short, these aspects can be traced in this thesis as they emerged during this intervention. In addition, Virkkunen and Newnham (2013, p. 12) see formative interventions as 'an interface between two worlds, the researcher-interventionists' world of research and development and the practitioners' work'. As it is especially shown in article 3 (Jarvoll, 2019), this is a highly relevant statement for this thesis. The process of collaboration between the practitioners and the researcher, me, is described. The need

for change comes from the field itself and the teacher, and the object of the study has been developed collaboratively.

These above-described moments led me to position the classroom research project within the CHAT universe.

1.2.3. Minecraft description

Minecraft is described in article 1 to provide a thorough understanding of this particular digital game. Here, it will be outlined to give an understanding and an overview.

The digital game Minecraft was created by Mojang, but since 2014, it has been owned by Microsoft (Willett, 2016). According to contemporary research, Minecraft is a popular digital game (Abrams, 2017; Beavis et al., 2015; Marklund, Backlund, & Johannesson, 2013; Nebel et al., 2016; Willett, 2016) that has, according to Marklund et al. (2013, p. 308), received much acclaim.

The game allows players to design the game themselves and create their own goals, choosing whether they want to play independently in single player mode or with others in multiplayer mode (Niemeyer & Gerber, 2015). Without boundaries from traditional goals, such as collecting points or struggling to reach the next level, the game offers the possibility to show innovative ideas and features a player-driven narrative that differs from other games. In Minecraft[5], players can collaborate and create stories with characters, because the Minecraft world provides players with freedom and much space to express themselves (Canossa, Martinez, & Togelius, 2013; Cipollone et al., 2014). The earth, the vegetation and the mountains are made of blocks that can be engineered collaboratively in various ways. In creative mode, the players have unlimited resources if they want to build advanced structures, such as landscapes and buildings, or to rebuild other visual compositions from history or mathematics (Gallagher, 2015) using different tools, such as a pickaxe to dig or a torch to light up a labyrinth.

Because of the possibilities mentioned above, Minecraft is known as a sandbox game (Canossa et al., 2013; Hanghøj, 2014; Mail, 2015; Niemeyer & Gerber, 2015; Skaug & Guttormsgaard, 2014; Senter for IKT i Utdanningen, 2014) that can be

[5] Or the Minecraft Education Edition, which is especially made for schools. See https://education.minecraft.net/.

modified to suit curricula (Gallagher, 2015, p. xi). In addition, from a constructionist perspective, Minecraft can be viewed as an educational tool, whereby meaningful interactions contribute to knowledge building (Cipollone et al., 2014, p. 10) in collaborative groups that work on challenging projects (Rizzo et al., 2012). Moreover, according to the Norwegian Media Authority (2018), the game appeals to boys and girls, which is not the case with most other digital games. In a survey conducted by Beavis et al. (2015) of 270 students aged 9–14 years, Minecraft was the only game nominated by both genders as a favourite among numerous digital games (Beavis et al., 2015, p. 27).

1.3. Positioning the research project

The research is engaged in the practical benefit and experience that can be drawn from a formative intervention in a school context, for further use in general teacher education. I consider the research to be a small-scale classroom project, where no extra funding has been available; the research does not fit to any overarching project with other researchers, and it has simply evolved from an interested researcher and a teacher with a challenge. It stands on its own, as it is.

Bearing these above thoughts in mind, I position the theoretical point of departure within the field of educational research or, more precisely, classroom research and development to contribute to teacher education. This thesis relates also to the use of ICT in school, that is, the use of the commercial digital game, Minecraft, as chosen by the teacher. The national curriculum has an implicit but overarching function concerning the subjects of mathematics and ICT and the construction of tasks. Because of the purpose of the intervention, the National Curriculum has not been questioned or investigated further. The research has been about the theme of ICT in schools or, more precisely, the use of Minecraft. The field of educational research is in this thesis about classroom research informed by CHAT. A Change Laboratory is an approach that connects this research to the field of practice, including the students. As a teacher educator, I have a professional interest in teacher education, and it constitutes my motive to contribute to the field.

2. Relevant Research

2.1. Tracing the field

This chapter builds on related research that has been especially selected because of its relevance to this thesis. The approach to this case study has been an assumption that research must be cumulative if it is supposed to move forward in any direction.

The search for relevant and preferably recently published studies has been continuously maintained through frequent searches in Oria with access to many databases and with the possibility of choosing peer-reviewed journals. The search has been done in an attempt to provide an overview of the existing studies about Minecraft and the use of CHAT, especially in connection to the field of educational research. During the search process, I used the following key words: Minecraft, Minecraft in school, digital games in school, motivation and digital games, game-based learning, formative interventions, initial collaboration, start-up phase, CHAT and school research, classroom research, learning and digital games and case study. The combination of 'CHAT' and 'Minecraft' gave limited results, where only three articles were found.[6] The search using such words as 'initial' phase or 'collaboration' or 'start-up phase' with 'CHAT' also gave poor results.[7]

Both national and international research has been considered when going through empirical articles, review articles or books. In addition to Oria, and especially the connected databases ERIC, Google Scholar, MathEduc, Idunn and DOAJ, I have followed references that emphasised an especially interesting point or finding in an attempt to explore it closer and to consider the relevance for my research. Because the game Minecraft was released in 2009 (Gallagher, 2015; Nebel et al., 2016), the search could then be restricted. However, some older articles are especially selected because of

[6] Because I had poor success with finding articles about Minecraft and CHAT, I turned to a professional from the library to validate my results. The last searches, on 1 February 2019, were conducted in the following databases: Oria, Scopus, Science Direct, ERIC and Academic Search Premier.

[7] The last search was conducted on 13 February 2019, where 36 articles were found, most with scant relevance.

their relevance when tracing certain terms, such as ‘early adopter’, ‘digital native’ or ‘new technology’.

2.2. Tracing CHAT, initial phases of collaboration and classroom research

Researchers have strived to achieve a common understanding of school development and change of practice in collaboration between practitioners in the field of education (Engeström & Toiviainen, 2011; Gjøtterud, Hiim, Husebø, Jensen, Steen-Olsen, & Stjernestrøm, 2017; Postholm, 2008; Quartz, Weinstein, Kaufman, Levine, Mehan, Pollock, Priselac & Worrell, 2017; Thorgeirsdottir, 2018; Zeichner, Payne, & Brayko, 2014). It has been pointed out that one challenge is connected to positioning the theory as overarching with consequences for student teachers who encounter a lack of inner coherence between what they learn on campus and what they experience in the field. This has been connected to the idea that knowledge in the teaching profession has not been sufficiently grounded in professional practice (Hiim, 2017, p. 45). This challenge may be connected to the fact that, traditionally, research and practice have been seen as dichotomies and, therefore, there is a need for a common understanding (Rønbeck & Germeten, 2014). Nevertheless, the communication between the field of research and practice has been viewed as ineffective (Biesta, 2007), which does not necessarily contribute to good solutions for schools. Furthermore, according to Zeichner et al. (2014, p. 10), there is a need for a fundamental shift in teacher education, where the focus is on substantive transformations in the current systems. By recasting who is an expert and rethinking how institutional boundaries can be crossed, the collaboration can be more innovative. To make such transformations, there is a need for a meeting place where educational research and practice can work together to provide a coherent understanding of the field of education (Rønbeck & Germeten, 2014, pp. 22–25) and its development (Postholm & Moen, 2011).

Researchers have shown that CHAT offers interpretive lenses for studying the development of practice in school (Anthony, 2011; Goodnough, 2018; Hauge & Erstad, 2011; Lund & Hauge, 2011ab; Falcão, e Peres, de Morais, & da Silva Oliveira, 2018; Postholm, 2008; Thorgeirsdottir, 2018; Virkkunen & Newnham, 2013). Various developmental studies using CHAT have addressed the importance of collaborative

activity in such a meeting place (Botha, 2017; Engeström & Toiviainen, 2011; Postholm, 2008; Thorgeirsdottir, 2018). However, few studies have focused on how such a meeting place could be developed at the beginning of a collaboration.

In some studies, an initial phase of collaboration between practitioners and researchers is described as being a part of a meeting place (Postholm, 2008, Engeström & Toiviainen, 2011). Engeström and Toiviainen (2011), in their study about three different groups of people—researchers, users and software designers[8]—addressed how the groups developed their multi-voiced dialogue by bringing in their various elements of expertise and addressed what it takes to achieve a shared object. If the object is absent in a collaboration, there may be consequences. For instance, the meaning and the motive of the activity may be taken for granted, and the analysis can be characterised as a narrowing down of the situation to a here-and-now situation. Their study includes project talk that is only considered if it facilitates or prevents the continuity of the work (Engeström & Toiviainen 2011, p. 40). They conclude that such a collaborative design is a long learning process without shortcuts or the straightforward adoption of easy solutions, which is actualised in the construction of the object of collaboration. Their data allow for a further examination of how project talk may contribute to dealing with tensions and to the construction of the object.

Lack of time is also identified as being of crucial importance and addressed in developmental studies using CHAT (Goodnough, 2018; Postholm, 2008). Lack of time can impede a project from proceeding, and it was found to be problematic for teachers in an initial phase of a study conducted by Postholm (2008) in a Norwegian lower secondary school. The researcher addresses the role of the researcher and the teachers and, furthermore, what collaboration in an initial phase means concerning the progress of a project. During the initial phase, only when the teachers found the project useful, they no longer struggled to find time for the project. The teachers changed their attitudes and wanted to reflect together because they were interested in improving their teaching methods. Thus, this enabled the project to move forward.

[8] This study is not conducted in school with students, but with software designers from French and Finnish organisations, with in-house developers from a consulting and engineering firm and with researchers from two Finnish research centres. The relevance of this study to my study is related to the focus on an initial collaboration and developmental processes. See article 3.

The object-oriented activity is an emphasised part of CHAT. When I was tracing the various uses of CHAT and classroom research, one study caught my attention about how students may work with objects and what their understanding of the outcome may be. Lund and Hauge (2011a) writes about changing objects in formative interventions. Four boys, aged 17 years, are engaged in knowledge-creation activities and the construction of a shared object. The researchers define knowledge creation as something that emerges through interaction with social, semiotic and material resources and argue that it is of crucial importance to analysing and understanding the relation between an activity and its object(s). The learners received an interdisciplinary project work about the tragedy in Beslan, and they had to present the outcome (poster, PowerPoint and role-play) to the rest of the class. They were working with various kinds of activities, such as information gathering, negotiating diverse views and opinions and producing various representations of the theme. The learners' efforts in this project were followed to identify their shared object, including how the object changed through dialogue and exploratory and artefact-mediated activities.

When the researchers did trace the object through various phases during the two weeks of the boys' project work, the researchers found that conceptual development and dialogic approaches do not reduce the compound object to a 'fact' on which learners agree, but challenge their understanding of it and its implications. Finally, the group's project presentation reveals that it is important to identify the impact of non-productive interactions and strategies. For instance, how objects may become blurred, with a consequence that the outcome may be not as expected to serve knowledge advancement purposes. This research shows the boys' disappointment and some reflections on the outcome, especially regarding role-play and regarding what they ought to have done differently.

CHAT, according to Nussbaumer (2012, p. 45), manifests its applicability to classroom research. Giving an overview of the theory's use in classroom research, she points out that CHAT can be employed in various learning situations. This can also be traced in the review section.

2.3. Tracing CHAT and ICT

It is suggested that CHAT (Engeström, 2015, 2016; Virkkunen & Newnham, 2013) offers conceptual tools that combine the necessary sources of expertise to help individuals or groups find innovative solutions (Botha, 2017; Zeichner et al., 2014) and interpret engaging meaning-making processes (Engerman et al., 2018, p. 328) regarding technology-rich learning environments. Studying the various ways of supporting learning with the help of ICT has become an important area of research and development (Virkkunen & Newnham, 2013, p. 118). According to Kaptelinin and Nardi (2018, p. 3), the human relationship with technology is of special interest to CHAT because of the focus on mediating artefacts. CHAT started to be employed internationally in relation to ICT in the late 1980s and early 1990s to address new challenges that appeared with computers. The idea was that CHAT did make it possible to reach a thorough understanding of technology and its meaning to people. An opposite view, presented by Rückriem (2009), is that ICT is a challenge to CHAT. He says that digital technology has entered our lives and that we have to acknowledge the fact that it determines the activities of people, even though people avoid using technology. Furthermore, our reality has changed since the days of Vygotsky (1978) and Leontjev (2002)—the notion of the web in our information society was not accessible to them (Rückriem, 2009, pp. 88–89). Thus, the concept of mediation that is fundamental in CHAT must be comprehended as a historically specific solution to the question of mediation to accept its limitations. The theory must reformulate itself and acknowledge that we are entering a new phase where we need boundary crossing among CHAT, systems theory and media theory (Rückriem, 2009, p. 111). Clarke, Friese and Washburn (2018) share Rückriem's worldview by presenting nonhuman actants, such as technology, with their own agency.[9]

Linking those two contradictory opinions about the role of CHAT in relation to ICT has led me to Cole (2005). Leaning on Wartofsky (1979), he presents the notion of

[9] Very carefully, I have explained my use of situational analysis and the understanding of artefacts in article 3. However, I find this view interesting and I am supporting that CHAT should be challenged more in the future when it comes to the position of ICT in our everyday lives.

'tertiary artefacts'[10] that may constitute imagined, relatively autonomous worlds with free play or game activity, explaining that such imaginative artefacts may 'color the way we see the actual world' and can bridge the tool-mediated activity and context (Cole, 2005, p. 91). Furthermore, such tertiary artefacts acting as tools can change the current praxis. In other words, the praxis acquired when interacting in these imaginative worlds can be transferred beyond the immediate contexts of their use. Cole (2005) exemplifies how this 'third artefact' can be a useful concept in relation to ICT when designing activities for 6- to 12-year-old children to foster their social and cognitive development. The artefact is called 'the 5th Dimension' and is a bounded alternative world with tasks, computers and its owns social norms. It has been designed to address the low academic achievements among youngsters regarding ICT. The Wizard has the overarching authority in the 5th Dimension. The children must build rapport with the Wizard, who encourages and helps them. People from different geographical areas can communicate with the Wizard; this can even be about conflict between adults and children. Adults can come to a secret understanding about the pretence of the Wizard's existence and play with the children. The experience with the 5th Dimension, over the course of the year, shows that children achieve goals and become familiar with a variety of computer-based activities. The 5th Dimension has continued to propagate itself, and both schools and a university want to join this activity. The notion of a 'tertiary artefact' offers comprehension of the digital arena and contains, as I understand it, the potential to be generalised further to an understanding of digital games, something that can be explored in the future.

2.4. Tracing CHAT and the use of Minecraft

As mentioned earlier, three articles were found about the use of Minecraft and CHAT. They will be presented here, as they have relevance to the theme presented.

[10] With help from Wartofsky (1979), Cole describes that 'primary artefacts' include directly used tools, such as axes, or, as he emphasises in his article, computers and mythical cultural personages. 'Secondary artefacts' consist of representations of primary artefacts and of modes of action using them. They preserve and transmit modes of action (Cole, 2005, p. 91).

The first article from Rizzo et al. (2012) is about knowledge-building processes of young people[11] with Asperger's syndrome and with high-functioning autism in an after-school technology club where Minecraft was one of the available software. CHAT is used as a framework for analysing the activities within this particular context. The researchers follow Minecraft as a successful tool where the young member's agency and interest are connected to the fact that they feel in charge because they 'own' it. They can freely choose how to interact with the game and create their own environments. The participants want to share their 'worlds' by inviting friends into them and exploring them further. This study shows that CHAT has been a helpful tool to describe the technology club, as a community, and to explore the complexities of how learning emerges from activity in this community and, furthermore, how certain situations afford opportunities to learn or inhibit learning. It became evident according to the researchers that a unique social space as the club, constructed over time through interaction between members and facilitators, has been influential regarding members' practice and development of important social and technological skills.

On the contrary, the article by Engerman et al. (2018) barely mentions Minecraft. The game is only presented in appendix 4 as one of the games played, with the benefits connected to learning (Engerman et al., 2018, p. 336). Their study addresses how boys may be re-engaged and enhance their learning opportunities in traditional classroom settings. The researchers outline boy culture that largely is about participation in commercial off-the shelf games that align with their competitive and aggressive personas. Participants consisted of 12 boys between the ages of 10 and 17 years. CHAT is used as a framework to identify relevant learning in commercial off-the-shelf games. Researchers were looking at the school culture and the boy culture that includes gaming and discussing that the power of spaces, such as games, gives boys the possibility to exercise agency. They mention that boys' distinct cultural patterns, the indigenous knowledge connected to the digital landscape, were able to be investigated using CHAT lenses. Based on the boys' descriptions, the researchers suggested that

[11] Unfortunately, it remains unknown in the article the age of the participants and how many participated in the study.

teachers might seek to incorporate more agency, relevance, interest in and respect of indigenous knowledge to improve boys' engagement in the classroom.

A case study conducted by Goodnough (2018) focused on 38 teachers and their professional learning, The teachers were engaged in a professional development programme in science, technology, engineering and mathematics (STEM) from August 2015 to June 2016. The main goal of the study was to support teachers in adopting inquiry-based approaches to teaching and learning and to enhance confidence in STEM subjects. The teachers had various professional needs and had, for this reason, different research questions. One was connected to 'How does using Minecraft enhance student collaboration when learning mathematics?' Concerning the division of labour, one of the teachers in the study said that 'some students were experts on Minecraft, so they became resources for other students in the classroom' (Goodnough, 2018, p. 2190). Another teacher commented that he was curious about Minecraft and that it was time to do something new (Goodnough, 2018, p. 2192).

When teachers' contradictions were addressed and examined, it resulted in an expansion of their object and professional growth. Many new tools were tested and some were adopted. When asked why teachers had not used the tools in the past, the teachers noted a lack of time as being a barrier to exploring and evaluating the relevance of the tools. CHAT, especially the activity system and the concept of contradictions, has been used as a conceptual framework; however, the expansive learning cycle has not been applied in this study.

2.5. Tracing ICT in schools

Tracing earlier research on applied digital technology in school gives an understanding that the use of computer technology is not quite new, despite this technology often being referred to as new technology (Cuban, 2001). A second-order meta-analysis with 25 meta-analyses conducted by Tamim, Bernard, Borokhovski, Abrami and Schmid (2011) focused on 40 years of conducted research in the field of technology in schools and concluded that '[…] one of technology's main strengths may lie in supporting students efforts to achieve rather than acting as a tool for delivering content' (Tamim et al., 2011, p. 17). However, they point out that many factors are present in such a study

that must be sorted out in an attempt to use computers as effectively as possible to support learning. Their finding points in the direction of favouring the use of technology to enhance learning processes, but they express that this finding must be interpreted cautiously. This is reasonable, as their analysis brings together more than 40 years of research; thus, I think it raises many uncertain moments. When it comes to some studies, it is difficult to make comparisons with *no use of technology* since the focus, according to Tamim et al. (2011), is on strategies for learning and support and on different conditions of technology use with the aim of progressing the field. Some newer published articles, selected especially because of their focus on Minecraft, exemplify that this may be the case (Abrams, 2017; Beavis et al., 2015; Callaghan, 2016; Canossa et al., 2013; Cipollone et al., 2014; Ellison, 2017; Mail, 2015; Niemeyer & Gerber, 2015; Sáez-López, Miller, Vázquez-Cano, & Domínguez-Garrido, 2015). Furthermore Tamim et al. (2011) argue that technology alone does not necessarily influence the wanted outcome in schools, but the teachers' pedagogy and dedication to technology implementation, teacher effectiveness and subject matter, among other factors, may have a more powerful impact (Tamim et al., 2011, p. 17). When the focus is more directed to digital games, especially Minecraft, it seems the situation is quite similar to that described by Tamim et al. (2011). In a design-based research study with students, parents and teachers from several countries conducted more recently by Sáez-López et al. (2015), no significant improvements regarding academic outcomes were found. However, the majority of the school community recognises the pedagogical benefits, such as enhancing creativity and facilitating learning through discovery. In addition to the fact that it is fun, it provides interactive advantages using virtual learning environments. The study showed that teachers' attitudes towards using Minecraft as an educational tool are, in general, moderately positive (Sáez-López et al., 2015, pp. 125–126).

These two outlined quantitative studies above convey that the use of technology is dependent on the teachers who employ it in their classrooms. To summarise from the section above, the research shows that the use of technology, including digital games, such as Minecraft, can support students' learning processes, and various conditions connected to the teacher and his or her role have an impact. To follow this, I have been

tracing the literature concerning the teacher's role in technologically rich classroom environments.

2.6. Tracing teachers and Minecraft

The tracked research shows that the teacher's role is critical when it comes to engaging and motivating students to work in Minecraft in school. A case study with 168 secondary students from Sydney conducted by Callaghan (2016) shows that the teacher's involvement in the game Minecraft when she followed them evoked students to feel privileged, to show what they constructed in Minecraft and to take screenshots of their work. Students wanted also to complete their work in an attempt to attract their teacher's attention, and the teacher felt that their relationship to the class had strengthened (Callaghan, 2016, pp. 255–256). Furthermore, I turn to Cuban (2001), who describes one teacher as an innovative user of technology in the classroom and who is occupied with integrating computers into the interdisciplinary curriculum work. The teacher believes in the power of technology as a teaching and learning tool and wants to exploit its potential. The students are using the Internet and making presentations and films. They are working in pairs or groups on projects while the teacher plays the role of facilitator, moving from group to group, supporting and challenging them (Cuban, 2001, pp. 69–70). It is worthwhile to look closer at the description of this teacher, even though it is from 2001. Cuban (2001) describes the teacher as an 'early adopter'. The category of early adopters can be traced back to Rogers (1983) and his research on the diffusion of innovation in the tradition of education research (Rogers, 1983, p. 62). According to Cuban (2001, p. 71), teachers who are early adopters differ from other teachers in their teaching methods and how often they use computers to teach. They are serious in adopting technological innovations, and they believe in the potential of technology as a teaching and learning tool.

In a newer relevant case study from a U.S. classroom with a teacher and 20 students from ninth and tenth grade conducted by Cipollone et al. (2014), the 'early adopter' category is used in the description of the teacher, thus giving special attention to the teacher who wanted to explore literary concepts using Minecraft. This early adopter was willing to let the students be experts, and he considered the use of

technology in the classroom as a source of enjoyment. Learning Minecraft was not difficult for the teacher. Part of his motivation to learn to play the game stemmed from his own personal interests. According to the research presented, such teachers are typically the minority in their profession (Cipollone et al., 2014; Cuban, 2001). It may be fair to say, following Cipollone et al. (2014), that the presence of personally-interested teachers may imply non-traditional approaches to support pupils' learning, and not being 'a seat of knowledge' (Cipollone et al., 2014, pp. 9–10). Furthermore, instead of perceiving Minecraft as a threat, the teacher saw the opportunity to develop a closer relationship with the students. The teacher as 'a seat of knowledge' has been interesting to follow up with and elaborate on in article 2. I understand Cipollone et al.'s (2014) assertion that 'a seat of knowledge' is the opposite of letting students direct their own learning and be responsible for their own experiences. This is an interesting viewpoint that must be explored further, because it must be remembered that students have the most experience with being students (Nilsen, 2010, p. 24), and, as I understand it, to gain knowledge of students' own experiences, researchers and teachers have to listen to them. Research shows that relatively little attention has been paid to students' own voices (Beavis et al., 2015, p. 21).

2.7. Tracing student's experiences with Minecraft

There is an unquestionable situation that nowadays, many young people play digital games in Western society. Moreover, they have many games from which to choose. Statistics from the Norwegian Media Authority (2016, 2018) show that about 96%–97% of boys and about 63%–89% of girls ages 9–14 years play different digital games every day. Minecraft stands out as one of the most popular digital games for children of this age group. Moreover, according to the Norwegian Media Authority (2018), the game appeals to boys and girls, which is not the case with most other digital games. The study conducted by Engerman et al. (2018) mentioned above supports this.

In a survey conducted by Beavis et al. (2015) in Australia with 270 primary and secondary school students aged 9–14 years, Minecraft was the only game nominated by both genders as a favourite among numerous digital games (Beavis et al., 2015, p. 27). In fact, Minecraft was the most popular game, followed by Call of Duty. The majority

(93%) of students in this survey did argue that they believed digital games could be used in school as an educational tool, and 87% of students have already tried this. Minecraft was one of the games mentioned as having been used in school; however, among the top 10 games used in school, Minecraft was placed at the bottom as the least used.

According to statistics from the Norwegian Media Authority (2016, p. 82), where children from primary school (n = 2,506, age 9–16 years) share their use of and experiences related to digital games in school, about 8% stated that they have had the opportunity to use digital games in school. Unfortunately, the statistics do not distinguish between Minecraft and other digital games. However, some researchers and practitioners share students' excitement about employing Minecraft in school and other contexts (Abrams, 2017; Canossa et al., 2013; Goodnough, 2018; Niemeyer & Gerber, 2015; Rizzo et al., 2012). From their shared experience, there is some knowledge about this particular game in use.

2.8. Tracing research and experiences with Minecraft

Lately, researchers have drawn their attention to Minecraft. Besides describing what makes this game different from other digital games, they seek to gain knowledge about the possibilities or limitations of the game. The researchers have also been occupied with what implications can be drawn from using Minecraft for future learning (Abrams, 2017; Niemeyer & Gerber, 2015).

Some research concludes there is not necessarily any improvement in academic results after implementing Minecraft in schools (Sáez-López et al., 2015, p. 125), despite the advantages highlighted in contemporary research on motivation (Canossa et al., 2013; Plass, Homer, & Kinzer, 2015; Sáez-López et al., 2015). Motivation seems a topic often featured by researchers, not only those focused on Minecraft, but also those who are in general occupied with game-based learning (Turkay, Hoffman, Kinzer, Chantes, & Vicari, 2014). Motivation is defined as both the reason for behaving a certain way and the desire to do something. Motivation is divided into extrinsic (external) and intrinsic (internal) motivation, with a special focus on the latter in recent research (Canossa et al., 2013; Plass et al., 2015; Turkay et al., 2014). It is also

emphasised that students may be intrinsically motivated to play, but not necessarily to learn (Jessen, 2011; Plass et al., 2015). Students can find ways to complete their game without learning the educational content, the reason being that 'to play', according to Jessen (2011, p. 159), is not a means but an end in itself. He connects this assumption to a possible understanding of the motivation to play games. Among others, he draws on Huizinga (1955), expressing that play is, in and of itself, a meaningful human activity that we practise for the simple joy of it (Jessen, 2011, pp. 158–159). Another explanation for the assumption that games can but do not necessarily motivate learning is connected to the idea that the learning content and game mechanics are not linked tightly enough (Plass et al., 2015, p. 269). In their review, Plass et al. (2015) discuss the design elements of games that facilitate learning, such as motivation and affective elements, summarising that constructs related to motivation often include affective components, such as emotions and attitudes (Plass et al., 2015, pp. 270–272). This finding is investigated further by Abrams (2017), who presented the case of 11-year-old Anita, exploring how feelings and imagination may influence creation and play within a space such as Minecraft. The study illuminates the importance of emotions when working in the Minecraft world that should not be dismissed as supplementary resources to motivate and engage students (Abrams, 2017, pp. 505–506). Another research study connecting emotions with Minecraft involved a survey distributed by Canossa et al. (2013) to participants from 21 different countries aged 12–49 years. Their research indicates that the greater a player's dedication, the more he or she will use and craft objects made with diamonds, the stronger his or her curiosity will be and the greater the use of stone objects will be. Their survey showed that curiosity, as a part of intrinsic motivation (Reiss, 2012), seems evident among Minecraft players. Canossa and his research fellows define curiosity based on Reiss (2012) as the universal desire for intellectual activity, learning and creating. They also explain that Minecraft affords significant freedom for expressing curiosity.

2.9. Summing up: Tracing the field

The research above has been selected because it problematizes and illuminates various themes connected to this thesis; thus, it has been a helpful resource for information and

for problematizing the central aspects of the research process. For instance, the digital game Minecraft can be understood in connection with motivation, play, emotions and learning; in connection to CHAT, it can be understood as a 'tertiary artefact'. The presented research also showed that CHAT could be used as a conceptual framework to gain insight into how a commercial digital game can be explored by students and used by teachers. From the research above, an ordinary teacher can be pictured as a hard-working individual who needs to experience a developmental project to be meaningful enough to give it necessary priority and who needs support from a researcher. Students are highly involved in digital games, and Minecraft has gained popularity between both boys and girls. The research about the use of Minecraft does not report negative experiences.

Furthermore, the selected research did influence me, a qualitative researcher, by offering assumptions about what topics have been given attention lately and what topics needs to be explored further. This is especially the case with the 'initial' collaboration. Thus, while proceeding with my study, I have been open to the fact that my research could be supportive of other studies in their initial phases. Moreover, it could contribute as an example of how a popular commercial digital game in a school context can be understood through the CHAT lens, possibly offering other perspectives.

3. CHAT as a theoretical framework

In this chapter, the theoretical key perspective will be provided with a special focus on the central concepts presented in the three articles. The theoretical perspective is connected to research and school development, specified as classroom research, as outlined in the introduction part.

In technology-rich learning environments in Norway and in other countries, CHAT has been shown to be a useful theory and method. Many researchers have shown that CHAT offers possibilities for studying classroom or school, research and development (Aas, 2011; Anthony, 2011; Engeström, 1999b, 2016; Goodnough, 2018; Hauge & Erstad, 2011; Lund & Hauge, 2011a; Nussbaumer, 2012; Falcão et al., 2017; Postholm, 2015; Virkkunen & Newnham, 2013). Moreover, within this type of research, CHAT has been used as a framework in the implementation of ICT (Engerman et al., 2018; Erstad & Hauge, 2011; Goodnough, 2018; Lund & Hauge, 2011b). CHAT as a framework is applied in this study in connection with ICT, that is, more precisely, the digital commercial game Minecraft, as a contribution to the above-mentioned discourse. CHAT (Engeström, 1987, 2015) has been used as a tool to understand both teachers and pupils with the help of Engeström's model of an activity system. I have investigated how the students and their teacher experience the digital game Minecraft in their classroom context and what implications can be drawn. The object of a classroom activity system, as I see it, is activity that somehow relates to learning and knowledge construction. According to Engeström (2016, pp. 107–108), an activity system is built around its object. However, the students' school activity does not necessarily have the same object as the teacher's teaching activity. The motive and meaning of their activity can differ. It can be challenging in an intervention to construct a shared object, as objects are unstable. Objects can change across various activities, and they can be perceived differently by individuals and groups (Lund & Hauge, 2011a). However, Engeström (2016, p. 108) says that a shared object is never completely achieved and never completely impossible. In this study, the object, as it changes, can be traced in the work presented in the articles, but it will also be followed more closely at the end of this chapter. This can show what conditions are required in an intervention study such as this, where Minecraft is used as a mediating artefact in a classroom context. Based on

the reviewing process presented in the previous chapter, I would like to pay attention to the fact that more research is needed to explore possibilities in CHAT in connection to classroom research and the use of digital games.

CHAT lenses have contributed to gaining more insight into the situation in the classroom both before and after this formative intervention in relation to the subject of mathematics as the teacher explained it. In addition, another important reason for using CHAT is that the 'general model of an activity system' (Engeström, 1999a, 2015, 2016) offers an approach for the development of the processes in a case study like this. Because CHAT addresses the fact that people change their work using cultural artefacts (Virkkunen & Newnham, 2013), it has therefore been interesting to focus on processes that occurred during this intervention and question how they have stimulated change or development. In addition to the fact that CHAT has analytical and explanatory power, it can also provide, according to some scholars, useful support when it comes to change in teaching practice (Lund & Hauge, 2011b, p. 259).

In the following, I will first outline shortly the epistemological assumptions connected to this research work. Then, I will advance towards CHAT, approaching its background and presenting a Change Laboratory (Virkkunen & Newnham, 2013).

3.1. Cultural–Historical Activity Theory

Michael Cole (1996) introduced the term Cultural–Historical Activity Theory, CHAT, but the fundamental ideas of CHAT are based on theories developed by Lev Vygotsky and later by his student and follower Alexei Leontjev (Cole, 1996, pp. 104–105). These two are most commonly identified as sociocultural theorists from the Russian cultural–historical school; thus, CHAT can be traced to sociocultural theory (Engeström, 2016; Postholm, 2010; Wertsch, 1998) and further be classified under the heading of social constructivism (Postholm, 2010, p. 29). With this in mind, I identify this research as a social constructivist project, where the process among the participants is addressed with a focus on the specific context, the classroom, to understand the historical and cultural settings that belong to the participants. Moreover, any change or development is a product of the participants' activity using various means as mediating artefacts, constructing knowledge through their interaction.

This social constructivist approach is also brought into being through the understanding of Minecraft, as outlined earlier, as well as the use of the method of analysis that is rooted in the grounded theory approach, with a special awareness of the perspectives of Charmaz (2014). For instance, from an epistemological stance, this is about the presence of me as a researcher who wants to conduct research related to the participants. This is also about me striving to understand multiple realities; thus, from my ontological viewpoint, using multiple sources of evidence is a possibility to show these various views of reality that may be present in an intervention. The social constructivist position will be followed up with a more purposefully elaborated concretisation in the methodology section.

Returning to CHAT, Engeström (2015) describes how CHAT has evolved through three generations of research and explains these three generations of CHAT by connecting the first generation to Vygotsky and the second to Leontjev. Engeström contributed further with the third generation of activity theory (Engeström, 2015; Erstad & Hauge, 2011).

Furthermore, this section is also about what is meant by an activity system and which role contradictions may have in such an activity system. The processes of solving contradictions and expansive learning shall be illuminated, and a Change Laboratory, which serves as a microcosm (Engeström, 2015; Engeström & Sannino, 2010) where new ways of working can be experimented with gaining new experiences, will also be outlined.

The first generation of activity theory is connected to Vygotsky's idea of *mediation*. His triangular model, with the subject, the object and the mediating artefact, shows that the activity of an individual cannot be understood without cultural artefacts (Vygotsky, 1978). The further idea, presented by Leontjev (2002), is that higher human psychological processes are culturally mediated (Leontjev, 2002, p. 68). Consequently, culture cannot be understood without individuals who produce and use the artefacts, and objects are cultural entities (Engeström, 2015; Leontjev, 2002) that give direction for actions (Engeström, 2018, p. 47). One emphasised limitation of Vygotsky's model was that the analysis was concentrated on a single individual. Following this first contribution to CHAT, Leontjev moved the focus from a single individual as the unit of analysis to a focus on the collective activity with a division of labour. This movement

represents the second generation of activity theory. In short, Leontjev extended the view of cultural mediation with the argument that cultural mediation is always related to the division of labour between people. In other words, he showed a differentiation between the actions of a single individual and those of the collective activity (Leontjev, 2002, p. 68). The differences between an individual action and a collective activity are described in Leontjev's example of 'primeval collective hunt' (2009, p. 187)[12]. According to Engeström (2015, p. xv), Leontjev himself does not depict his contribution to Vygotsky's model and the first generation of activity theory by creating a model himself, but Engeström (1999a, 2015, 2016) shows a graphic solution that captures a human activity system (see Figure 2).

The third generation of CHAT arose when the theory received international interest and started to be questioned in relation to cultural diversity. To meet this new challenge, the theory expended to include at least two interacting activity systems, as shown in the last chapter in the discussion section, and to develop conceptual tools to understand different networks, dialogues, multiple perspectives and voices (Engeström, 2015, p. xv). In this study, it has been important to use Engeström's contribution in the

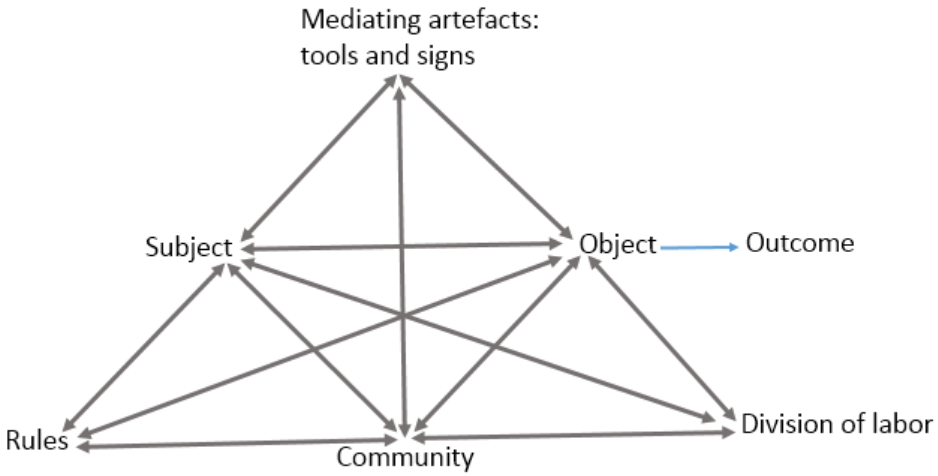

Figure 2. General model of an activity system (adapted from Engeström, 1999a, 2015, 2016)

[12] This reference is written on the list as follows: Leontyev, A. (2009). *The development of mind*. Ohio: Marxists Internet Archive.

focus on the horizontal process of collaboration between different activity systems (Engeström & Sannino, 2010). As shown in the last chapter, all participants in this study influenced the understanding of the object and contributed to its change. This is also problematized in article 1 when the two groups of students somehow developed separate motives when working with the game (Jarvoll, 2018a).

As shown in Figure 2 an activity system consists of six factors in mutual relation to each other (Postholm, 2015, p. 46), as visualised by the arrows. In Figure 2, we can see the factors: rules; subject; mediating artefact, such as tools and signs; object; community; and division of labour.[13]

The subject in the model can be an individual, such as a teacher, or a group, for instance, as in this intervention, 27 students. The acting subject(s) can use mediating artefacts to obtain defined objects in a specified context, such as a classroom. The concept of mediating artefacts can be elaborated as a material object that has been modified by participants as a means of regulating their interactions with the world and each other (Cole, 2005). This can be exemplified by installing Minecraft on school computers. Nevertheless, mediating artefacts are not only to be understood as material objects, but also as culturally evolved tools and signs that bring to a specific situation a generalisation of earlier experiences and insight that can be developed further (Virkkunen & Newnham, 2013, p. 39). This means, according to Vygotsky (1978), that signs can be understood as psychological tools that people can use to control, for instance, their social interactions. Language and words are such signs that have evolved historically in collaborative work in human communities (Virkkunen & Newnham, 2013, p. 39).

Furthermore, any action that exists, for instance, in a classroom context, exists in the context as determined by the three factors' *rules*, *community* and *division of labour*. *Community* refers to the people who share the same goals. *Division of labour* means the object-directed actions are distributed and conducted by all participants in the community, making it possible to distinguish between the individual and collective activity. A teacher may have tasks that differ from those of his or her students, though

[13] You will find the factors carefully explained in Engeström (2015) and in Postholm (2015); see also in Engeström and Sannino (2010).

they all agree that they do learning activity. The activity is influenced by the *rules*, which include norms and conventions in this particular community. This may be a shared understanding of what is reasonable to expect in a classroom. Are students discussing how to solve the given tasks or are some of them doing anything else? This question is answered in article 1.

The crystallisation of an activity system in such a model, see Figure 2, is helpful to reveal the connection between the subject(s) and the object-oriented activity through mediating artefacts in the classroom. The arrows in the model show a triangular activity and complex inner relations that give an understanding that any change in any factor has implications for the whole activity system. This gives a deeper understanding of how the classroom activity is embedded, and it may offer some notion about implications if something new is introduced or a change suddenly happens, such as if a collaborating teacher is leaving the school and another teacher is replacing this first teacher. As the first collaborating teacher was offered and accepted a position as a principal at another school, a second teacher, Mr Marvin, participated in the last half-year of this intervention. In short, in this intervention, an unexpected and sudden change occurred when Mr Marvin, the new teacher in mathematics, arrived. The established agreement concerning the activity with Minecraft in the classroom was at stake, but the object was transferred to Mr Marvin so the activity could proceed. The third generation of activity theory shows how several activity systems can interact.

The students' activities in this case study can be described and understood through the help of such an activity system, and so can the teachers' activity. As I see it, the actions of both the teacher and the students are understandable when interpreted against the background of the entire activity system. Another possible understanding of an activity system is that it has a multi-voicedness (Engeström, 2018, p. 49). When looking at the division of labour that may constitute participants' different positions, including how their previous experiences create various histories, I think it is reasonable to assume that when considering their ages, the teacher and the students may have different viewpoints concerning the other factors of the activity system. Such a point of departure can give different interests or motives concerning what they want to or are supposed to do, as outlined in article 1. Furthermore, multi-voicedness can be, for instance, a source of innovation or negotiation. The teachers and students grew up with

different influences of digital technologies. Leaning on Engeström (2018, p. 50), their activity can be understood against their own history in connection to the development of digital technology. A focus on such differences is made important by Prensky (2001)[14] when he refers to digital natives and digital immigrants, or by Krumsvik (2014)[15] when he discusses the role and focus of teachers using digital tools in their classrooms. Furthermore, according to Erstad and Hauge (2011), theoretical perspectives presented by Vygotsky and Leontjev are quite suitable to understand the complexity between digital technology and practice in schools. They are helping to focus on the cultural aspects of technology when it comes to knowledge acquisition and social activity (Erstad & Hauge, 2011, p. 33). For instance, activities that are mediated through new technology give children other opportunities, such as reading or writing on a tablet early, which may challenge teachers' understanding of the role of the artefacts in their classrooms and the development of the school. In such cases, some tensions may develop between or within activity systems that may be found in connection to the school. Engeström (2018, p. 50) defines contradictions as historically accumulating structural tensions and a source of change and development. As tensions grow, a teacher may start questioning what has been established and may involve others as an attempt to achieve a more collective change. In this way, activity systems can move through cycles of transformation.

To summarise, contradictions, tensions developed through time, within or between activity systems, provoke innovation and change. This happens when activity systems adopts new elements from outside, such as a new educational tool. Objects and motives develop to contain new possibilities and practices, for instance as offered by Minecraft. It is also about continuous learning processes related to activities that have not yet been settled or explored. When this happens, as I understand it, an expansive transformation is accomplished according to the third generation of activity theory, where several activity systems are collaborating (Engeström, 2018, pp. 49–51).

[14] It is especially the term digital natives, which is often used by researchers concerned with new technology.

[15] His discussion also includes teachers who are not using digital tools in their teaching.

3.2. Contradictions

As outlined above, contradictions are valued as something essential in expansive transformations. According to Engeström and Sannino, contradictions are an important part of the development of processes at different levels and they function as driving forces (Engeström & Sannino, 2010, p. 7). The concept of contradictions have been useful in this case study, as described in article 2, to distinguish between different levels of contradictions. The primary contradictions are explained to be inner conflicts between user value and exchange value within each constituent in the previously shown activity system (see Figure 2). The secondary contradictions exist between the different constituents in the activity system (Engeström, 2015, p. 70–71).

According to what has been illuminated earlier, a contradiction may be resolved within or between the acting subjects using an artefact, such as Minecraft, as a tool to reach the object and a desired outcome. Then, when contradictions are resolved, new forms of activity emerge. These new kinds of activity can be understood as solutions to an earlier expressed problem or challenge. During this process, 'invisible breakthroughs' take place (Engeström, 2015, p. 73). One's initial reaction may be resistance to something new from outside that requires a new activity and for which efforts must be made in busy environments, but then understanding happens in the form of these invisible breakthroughs, as was the case with the teacher in article 2 (Jarvoll, 2018b). As I understand Engeström, this invisible breakthrough, identified in relation to the teacher, has been essential regarding the continuity of the intervention, and it is depicted in the model of the expansive learning cycle (see Figure 4).

The model of the activity system (see Figure 2) has been helpful to me as the researcher in the process of detecting a particular contradiction. When I managed to access an understanding of a contradiction, it gave me the chance to foster further developments of the intervention. In the next section, a presentation is made about the conceptual tools offered by CHAT in connection to conducting interventions and notions about learning.

3.3. Formative interventions and expansive learning

'Formative intervention' is a term used by Engeström and his colleagues in Helsinki at the CRADLE research centre (Engeström, 2015, p. xxx), and it refers to their developmental work related to CHAT and the associated empirical research and living practice. Moreover, they describe formative intervention as a collaborative concept where the whole activity must be reconceptualised because the existing activity is no longer sufficient to meet the occurring situation (Virkkunen & Newnham, 2013, p. 7). They explain that the interventionist researcher comes between an actor's actions and ensures that the activity can find new directions. Virkkunen and Newnham (2013) define what they think is an appropriate understanding of the term intervention: 'purposeful action by an human agent to support the redirection of ongoing change' (Virkkunen & Newnham, 2013, p. 3). It can be understood that the term intervention refers to an application of specially planned forms of empirical experiences, but it can also be connected to theories that provide reasons and rationales for such planned empirical experiences.

Engeström compares the more traditional interventions, the linear interventions, with formative interventions (Engeström, 2015, p. xxxi), and a list that clarifies the distinctions between formative and linear interventions has been developed (Engeström & Sannino, 2010, p. 15). The list can be seen in relation to the text in chapter 1 about formative interventions and related approaches. In an abbreviated version, adjusted for this case study and focused on formative interventions, the key differences contain four main points: (1) the starting point, (2) process, (3) outcome and (4) researchers' role.

(1) The starting point is about how in formative interventions, one or several participants faces a contradiction embedded in their life activity. They analyse it and expand by constructing a new solution with content unknown ahead of time to the researcher.

(2) In the process, the content and course of the intervention are subject to negotiation. The participants determine the shape of the intervention and take charge of the process.

(3) The key outcome is agency among the participants. In addition the aim is the generation of new concepts that may be used on other contexts, for instance as frames when suggesting new solutions to challenges.

(4) The researchers' role is the last point and captures the researchers' work towards provoking and sustaining an expansive transformation process that is led and owned by the practitioners.

According to researchers from CRADLE (Engeström & Sannino, 2010, p. 5), expansive learning typically calls for formative interventions based on Vygotsky's principle of double stimulation, in which a neutral, external artefact is filled with meaning and then increases the possibility of solving a problem (Sannino, 2015, p. 3). This principle of double stimulation is considered an epistemological principle (Engeström, 2015, p. xxxii) where, at first, the subject faces a conflict of motives (Sannino, 2015, p. 2), referred to as the first stimulus. Then, an artefact is discovered. When filled with meaning, the artefact turns into a sign and is referred to as the second stimulus. This in turn enables the subject to redefine the situation and solve the problem (Engeström, 2015, p. xxxii). As Sannino (2015) points out, some empirical studies using double stimulation to analyse participants' agency build on an understanding of double stimulation as a device for cognitive performance. This is not the case in this study, despite the involvement of the subject of mathematics as an example and some focus on the learning outcomes (Jarvoll, 2018a). Instead, the participants' experiences are especially illuminated to understand the participants' motives and, for instance, their construction of their new object (Jarvoll, 2018a, p. 85).

Expansive learning is the process of resolving contradictions, including dilemmas or conflicts (Engeström, 2015, p. xxiii) embedded in the lives of the participants in an intervention, whether students or teachers. When a contradiction is resolved, a new form of activity emerges. In addition, a new practice has been experienced among participants. This new practice is referred to as the *outcome*. When it comes to this study, the teacher outlined his contradiction, describing that books in mathematics were not good enough for his students. He discovered also that motivation for mathematics was decreasing, and it worried him. He expressed the need for change. His new solution was to try another educational tool to obtain his object: restoring students' motivation for mathematics. He discovered a new to him artefact through an

informal study[16] in his class. This artefact was the commercial digital game Minecraft, popular among his students. The solution was then to apply this new artefact in combination with mathematical content.

There is a crucial difference between *objects* and *outcomes*. *Objects* are carriers of motives, meaning they are foci of attention, volition, effort and meaning. People, through their activities, are constantly changing and creating new objects. In addition, new objects can also emerge as unintended consequences of activities (Engeström, 2015, p. xvi). This means that after applying and experiencing a new practice, the development of unplanned, unpredicted objects might occur among the participants. This implies that the participants' motives for their activity can be redirected towards this new unpredicted object. The *outcome*, however, is the actual product of the action taken with the help of tools (Engeström & Sannino, 2010, p. 6; see Figure 2). This may be the motivation gained for mathematics using a digital game, learning outcomes or even something more concrete as screenshots from conducted tasks in mathematics using a specific digital game.

Furthermore, participants can redesign the artefacts (Virkkunen & Newnham, 2013). Two important processes explain this activity, as shown in Figure 3. The

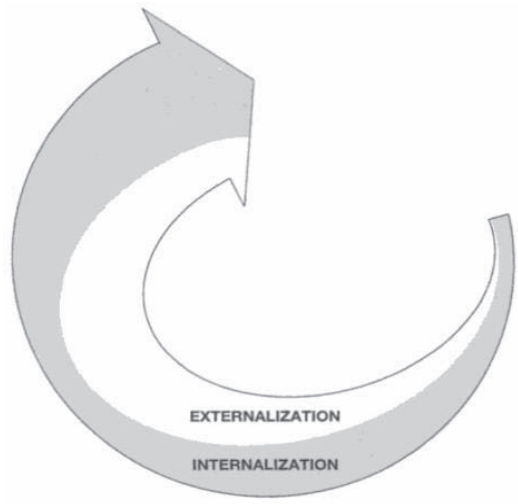

Figure 3. The expansive cycle (Engeström, 1999a, p. 34)

[16] Because of the acquired necessary anonymity, and according to NESH, this informal study cannot be provided as an attachment for documentation.

internalisation process entails the reproduction of a culture, including an artefact, and the *externalisation* process is about how artefacts can be used innovatively (Engeström, 1999a; Postholm, 2015). Engeström crystallises all this in his *expansive learning cycle model* (Engeström, 1999a, pp. 33–34), depicted in Figure 3.2 below. According to Engeström, this circular process of development linked to Vygotsky's (Vygotsky, 1978) zone of proximal development can also occur at the level of collective activity (Engeström, 1999a, pp. 33–34). Vygotsky was interested in investigating how things can grow and how they can be developed further, and not so much in how things are just now, at that very moment. Vygotsky's concept of the zone of proximal development (Vygotsky, 1978) captures these ideas (Säljö, 2016, p. 120), and it is depicted in Figure 3.2, with the arrow implying further movement. Any activity begins with an emphasis on internalisation, for instance, on training to become more competent in an activity as it is carried out. Externalisation first occurs as discrete individual innovations. As the activity becomes more demanding, the search for solutions increases, accompanied by the growing process of externalisation, which will reach its peak when a new model for the activity is applied (Engeström, 1999a, p. 34). At the level of collective activity, such expansive cycles are not predetermined courses of development, but should be approached from the viewpoint of historicity. According to Engeström, an activity system is a multivoiced formation, with different viewpoints and historical backgrounds and with contradictions that have to be addressed and eliminated, or no expansion will take place. Historicity means then the identification of the previous cycles of an activity system (Engeström, 1999a, pp. 34–35).

3.4. Change Laboratory (CL)

In this section, I will give an outline about expansive learning actions and the Change Laboratory. Because of the limitations connected to the articles, these have not been specifically described earlier. Subsequently, I will provide an overview of the development of the intervention and the experiences based on sequences of learning actions in connection to an expansive learning cycle.

As mentioned earlier, CHAT is often used to conduct analyses, but when it is used in further development, it is referred to as a Change Laboratory (Aas, 2011, p. 275).

The Change Laboratory, based on Engeström and his research fellows' experiences of DWR (Aas, 2011, p. 279), is typically conducted in an activity system, for instance, a school that is facing transformation (Engeström & Sannino, 2010, p. 15). A Change Laboratory is designed so that the participants meet tasks that call for expansive learning actions and, to this end, a complete expansive cycle (Engeström et al., 2014, p. 123). Furthermore, through the cycle of expansive learning actions, the process of ascending from the abstract to the concrete is carried out (Virkkunen & Newnham, 2013, p. 51). Engeström and Sannino (2010, p. 8) say that expansive learning manifests primarily as changes in the object of the collective activity. All factors of the activity system are expected to meet qualitative transformation before successful expansive learning has been achieved. Figure 4 below shows the expansive learning cycle as a spiral with specific sequences of learning actions (Engeström, 1999b; Engeström & Sannino, 2010; Virkkunen & Newnham, 2013). The idea is to follow these specific sequences that may lead from a current phase of an activity to its development (Virkkunen & Newnham, 2013, pp. 74–75). Figure 4 below attempts to show the possible relations between Change Laboratory sessions and expansive learning actions. (1) The process starts with questioning the problem. (2) This may continue with the identification of a contradiction in the activity system that can explain the experienced problem. The situation is analysed according to both historical and current practice. This is called double bind in the model of an expansive learning cycle, as depicted in Figure 4. (3) In the next phase, a new solution can be modelled based on the newly found cause of problems. (4) The new outlined model is examined through running it and experimenting with it. The potentials and limitations are explored. Then, Virkkunen and Newnham explain that between phases 4 and 5, the examining phase and the implementing phase, there is a phase of concretising the new model. This includes adjustments and enrichments, for instance, using new kinds of actions or new tools. After such practical experimentations, the new model can be implemented (5). The last two phases, 6 and 7, are about reflecting on the process and evaluating and consolidating its outcome to a new and stable practice (Engeström & Sannino, 2010;

Virkkunen & Newnham, 2013). In such a cycle of expansion, see Figure 4, the above-described process between phases 4 and 5 can be analysed and repeated several times in an intervention before a new model is implemented and reflections on the process can continue into the concluding phase (Engeström, 2001, pp. 152–153). The focus here is on smaller cycles that take only minutes or hours. Engeström explains that smaller cycles should be regarded as potentially expansive and that large transformations always consist of small cycles of learning (Engeström, 1999b, pp. 384–385). However, small cycles do not always contribute to development. Small cycles can also be simply isolated events. If this is the case, expansive learning stagnates and it may be regressive or even stop (Engeström, 1999b, p. 385).

A Change Laboratory can be understood as a set of tools that gives support for collaboration between the researcher and the practitioners in the developmental

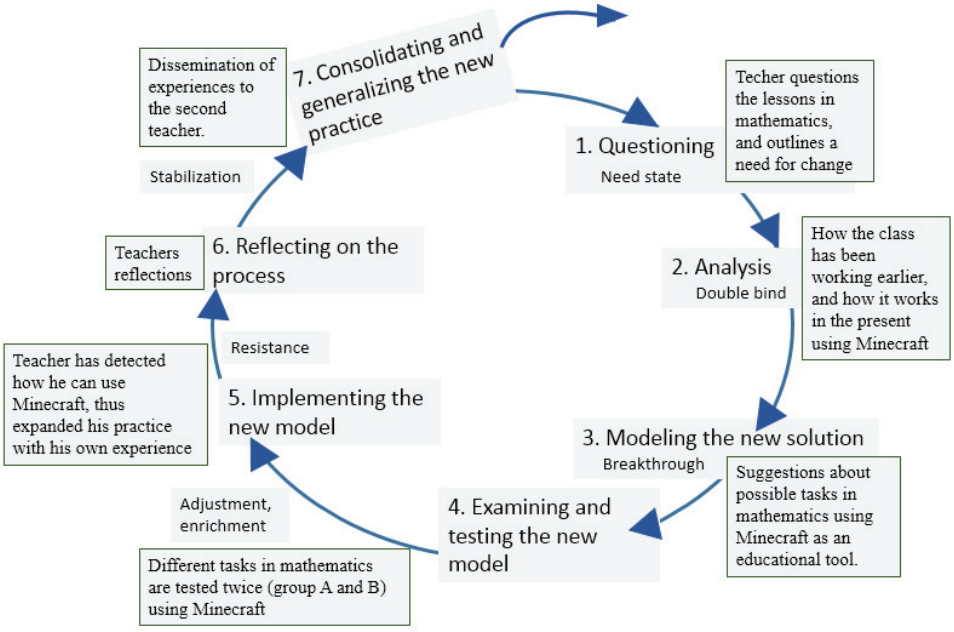

Figure 4. Crystallised sequences of learning actions in an expansive learning cycle informed by Engeström (1999b) and Engeström and Sannino (2010) and supplemented with learning actions from this intervention study

intervention.[17] According to Virkkunen and Newnham, the Change Laboratory intervention '[…] can be seen as a dialogue and a process of co-production between the representatives of these two worlds' (Virkkunen & Newnham, 2013, p. 12).

Soon, I will follow up with a part about the Change Laboratory space in this study. However, first, how the work started and how it was followed up with by the teacher and me in the Change Laboratory will be described in connection with the expansive learning cycle.

3.5. Change Laboratory sessions and learning actions

Based on sequences of learning actions in an expansive learning cycle (Engeström, 1999b; Engeström & Sannino, 2010; Virkkunen & Newnham, 2013), see the square text blocks in Figure 4, I attempt to give an overview of how the teacher and I have been working in connection to the eight Change Laboratory sessions we conducted during the intervention. It must be remembered that an expansive learning cycle is a spiral and that different learning actions can occur in connection to the same session. This is exemplified by Engeström (2016, p. 151). Here, I have chosen to describe different learning actions that can be categorised in the above outline sequences in an attempt to follow the intervention's timeline to show how the intervention was brought into being. Another choice could be to follow Engeström (2016) in his example by trying to identify what kind of learning actions were observed during the different sessions, but this would require another research question.

During the first action, the teacher questioned the lessons in mathematics, and then he outlined the need for change. Between the first and second learning actions, the teacher and I had meetings and frequent e-mail correspondence about how some practical issues could be solved. This is described in article 3 in the identified second phase (Jarvoll, 2019).

During the second action, the teacher and I discusses how the class has been working using the books earlier, how he knew this class and how his practice has been. In

[17] Virkkunen and Newnham explain the difference between change interventions and formative Change Laboratory interventions (2013, p 12). Meanwhile, Engeström and Sannino distinguish between linear interventions and formative interventions (2010, p. 15). I use developmental interventions here in an attempt to understand the connection to DWR (See Postholm, 2015).

addition, I was present during one lesson in mathematics before we started lessons using Minecraft. This is explained in the methodology section. During this action, Minecraft was mentioned as a possible educational tool. Then, both during and after the lessons, we discussed how it went using Minecraft. We had in addition a focus on practical issues that should be solved. In the third action, we were mainly concerned with modelling suggestions about possible tasks in mathematics using Minecraft as an educational tool. How could the class work in the future? During the fourth action, we tried different tasks in mathematics using Minecraft. We had the chance to try the same tasks twice with adjustments or changes because the class was organised into two groups by the teachers. The groups are explained in the next chapter. The first group, Group A, had mathematics on Mondays, and the second, Group B, had mathematics on Tuesdays (Jarvoll, 2018a). Thus, we had time to share our experiences and make any changes if necessary. We discussed the possibilities of Minecraft in connection to other subjects. Our ongoing realisation of the lessons in mathematics may be placed between the fourth and fifth actions. Here, the students from the class are also strongly involved. They are asked about their experiences using Minecraft, and some of their suggestions are tried out. This is shown in article 1 (Jarvoll, 2018a). During the fifth action, the teacher detected how he could use Minecraft, thus expanding his practice with his own experience. He could now decide whether, when and why he should chose to use Minecraft or any other digital game. In addition, during this sequence of learning actions, several contradictions were detected, such as following other rules, relaxing classroom management and recognising students' competence. This is elaborated in article 2 (Jarvoll, 2018b). When it comes to action 6, it is about teacher's reflections, which are captured in the interview, presented also in article 2. The last action is mainly about a generalisation of the teacher's and my experiences and a dissemination of these experiences to the second teacher, Mr Marvin, who took over the class in December 2015 and followed the class during spring 2016. This is explained in article 3 (Jarvoll, 2019). The class obtained some user experiences and showed that their positive attitude towards the lessons reached stabilisation.

3.6. The Change Laboratory space outlined

To analyse and specify the challenges of developing a new practice takes five to 10 (Engeström & Sannino, 2010, p. 15) or 12 (Virkkunen & Newnham, 2013, p. 15) Change Laboratory sessions. In the study presented, eight sessions were conducted, including the introductory study. The process in a Change Laboratory is supported by a 3×3 set of surfaces: model/visions, ideas/tools and mirror (see Figure 5). The mirror surfaces are used to reflect the activity back to the participants as an overview of what has been achieved during an intervention and may be a point of departure when planning the next course of activity. In short, the source of the mirror data on which the Change Laboratory builds is from the context in which it is conducted (Engeström & Sannino, 2010, p. 15), as shown by the arrow in Figure 5. For instance, the screenshots of different tasks in mathematics solved using Minecraft served as such mirror data. The

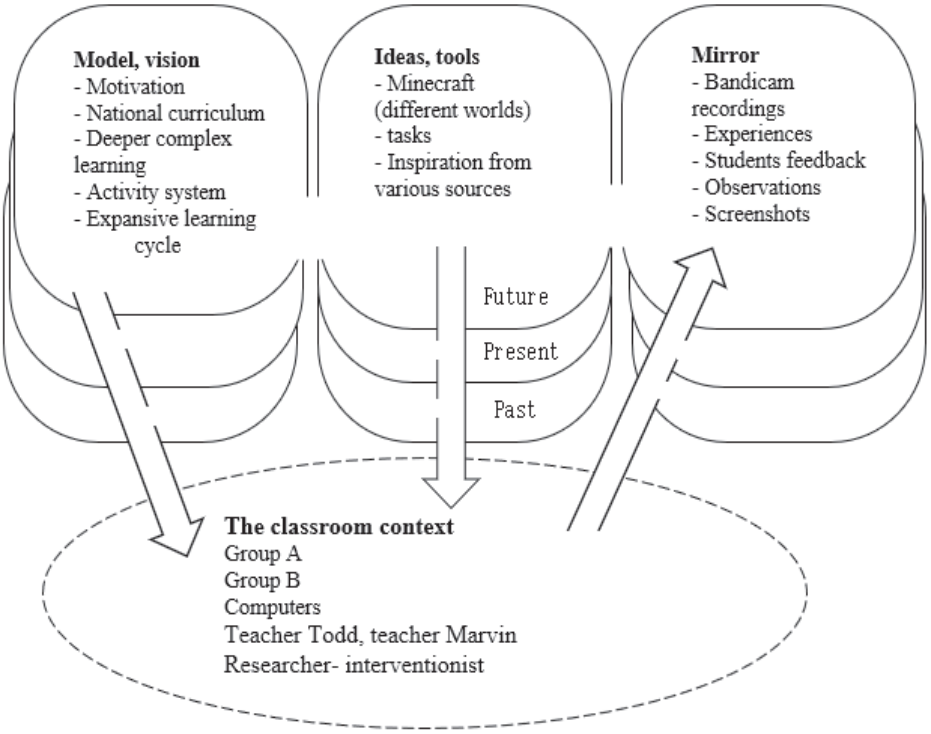

Figure 5. A modified model of the Change Laboratory space based on Engeström (2007), Engeström and Toiviainen (2011) and Virkkunen and Newnham (2013) presenting this study classroom context.

researcher has the responsibility of collecting mirror data. I have been asking the students to take screenshots when working in Minecraft, and later I did show these screenshots to the teacher. Mirror data can also consist of observations and experiences from the past, and they can be compared with present experiences. When it comes to the future layer, an anticipated change in the object can be outlined because it builds on present experiences and thus calls for special attention. For instance, article 1 (Jarvoll, 2018a) has a special focus on students' motives for doing tasks. When different motives evolved during the intervention, the screenshots were interesting to examine and to follow up with concerning groups A and B. What kind of activity would these groups build up in the continuation of the intervention and what would the consequences be?

On the next surface, the model/vision is about how the activity was brought into being in the past and the present and how it is modelled in the future. This surface also contains the contradictions that might have shown up. In this surface, the activity system is used to analyse the progress of the intervention as a systemic structure (Virkkunen & Newnham, 2013, p. 16), with a focus on how various connected components in the activity systems involved are changing. In article 2 (Jarvoll, 2018b), this is exemplified with the teacher's contradictions in every factor in his activity system, and it is concretised in a model. In addition, the different sequences outlined in the expansive learning cycle (see Figure 4) are in this surface helpful to identify the present status of the intervention. In other words, the researcher is introducing an overarching way of thinking about the processes that may appear. It should also be important to note that even though this model/vision surface gives support and inspiration, interventions have their own inner logic and differ, and this must be considered when introducing models. The last surface in the middle, the ideas and tools, are about the experiences that participants have gained and upon which they have reflected. The experiences can be used to take the project to the next stage when summarising mirror data in relation to the theoretical surface model/vision. In article 1, the students were asked about their experiences with Minecraft, and if they had any suggestions about how Minecraft could be used in the future. Vertically, the surfaces in the model are divided into rows that represent the past, present and future of the activity (Virkkunen & Newnham, 2013, p. 15) and have a potential to follow such suggestions from the participants through the intervention. Students' experiences were used as

mirror data, and their suggestions were a part of the next activities. For instance, their idea about playing together in the same game was attempted several times, and the last time, the teacher and I used a MinecraftEdu version. I experienced carrying students' suggestions and involvement from the interviews in the meetings with the teachers. The role of the researcher implied in other words being a tool in this surface. This allowed the teacher and me to work on different levels of abstraction and systemic integration. In addition, Virkkunen and his colleagues (Virkkunen, Vilela, Querol, & Lopes, 2014) stress the point that if a researcher is conducting research without any time perspective backwards and forward about future possibilities, the research will not necessarily be useful or relevant because things in real life develop further.[18] It is reasonable to have an understanding that the researcher, me, could be presenting 'old data' to the teachers, meaning that no further data besides the first data collection would be collected during the intervention. Such a notion is especially important when it comes to digital games, which are continuously developing. The students could just be tired of the game, or another game could suddenly catch their attention. A Change Laboratory focuses on opening new perspectives and ways to further development. The focus, rooted in Vygotsky, is then not on the established or defined change, but rather on an open-ended process of inquiry and learning (Virkkunen & Newnham, 2013, p. 68).[19]

When modifying the model presented in Figure 5 inspired by Engeström (2007), Engeström and Toiviainen (2011) and Virkkunen and Newnham (2013), I had in mind that a classroom context is not a closed and static system. The members of this community also belong to other contexts. The community does not exist in a vacuum, but is in a living and continuous interaction with other smaller or bigger contexts. Because of this notion, I have tried to keep the circle open by making a broken line in the model. The arrows are also open to past, present and future layers because being in a dialogue with each other means that all participants are looking backward and forward in our processes of reflection.

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[18] This is also what makes the Change Laboratory and the DWR different compared with other approaches, including action research and design experiment (Virkkunen, Vilela, Querol, & Lopes, 2014).

[19] Virkkunen and Newnham (2013) discuss the difference between a Change Laboratory and other approaches to the development of an activity. There is not enough space for such a discussion in this text.

3.7. The limitations with applying CHAT

According to Nussbaumer (2012, p. 46), limited research actually apply CHAT. The research she refers to shows that CHAT may be difficult for researchers and practitioner to make sense of. Nussbaumer points out that the reason may be that CHAT is complex in application and can be perplexing. Nevertheless, as researchers show, CHAT can be adjusted to clarify educational issues because of its flexibility in that meets a variety of contexts with different approaches and instruments. In essence, regarding this study, employing CHAT did involve an understanding of the activity system and its constructs. The theory, as it is facilitated by the CRADLE research centre and is employed and interpreted by other researchers, appeared challenging. Nevertheless, by applying this theory, my comprehension evolved of the developmental processes and nature of the collective changing activity in a classroom context. CHAT did explain different learning situations and dynamic relationships among the students, the digital game Minecraft and for instance the construction of the new object 'fooling around'. Virkkunen and his research fellows emphasise that descriptive research employed by some researchers does not give information about dynamics and the reason why things happen (Virkkunen et al., 2014). For instance, if the researcher is where the action is, then the researcher will have the possibility to not only be supportive when needed in a process, but also to get necessary insight that can be shared later (Reason & Bradbury, 2011). This brings us to the role of the researcher, which will be elaborated on in the methodology chapter.

As discussed in the previous chapter, Rückriem (2009) is challenging CHAT according to the understanding of the impact that digital technology may have nowadays. There may be a limitation of the theory when it comes to the comprehension about digital technology and its potential as 'actant' (Clarke, 2015; Clarke et al., 2018), which may create unpredictable circumstances. An understanding is presented by others (Cicconi, 2014; Erstad, 2014; Gee, 2008, 2013; Jessen, 2011; Pellicone & Ahn, 2015), where digital technology, such as digital games, is no longer understood as a tool, but as an arena where activity happens. As mentioned in the beginning of this chapter, an idea in CHAT is that people are changing the work, and attention is then drawn to the process (Virkkunen & Newnham, 2013) in an intervention, not to the impact of new

technology. Nevertheless, it is important to keep in mind that for the students, the game can constitute something more than simply an educational tool.

4. Methodology and research design

In this chapter, the aim is to outline the methodological choices made and give an overview of the research design. In the accompanying empirical articles, the methodology and research design are explained, although in abbreviated and condensed versions, adjusted especially for each respective article. In this chapter, the methodology will be presented in a more comprehensive manner with a focus on the entire PhD project. An elaboration of purpose related to data collection will also be provided as the overall thinking during the intervention. Finally, the chapter will conclude with reflections on the role of the researcher in research and developmental work, ethical issues and the quality of the study.

First, I will present the research design of the study followed by the context of the intervention. Then, the focus will be drawn to the data material and the data corpus. Table 2 is an attempt to provide an overview of the data material as distributed in the respective articles.

4.1. Research design

The conducted research is designed as a *single case study* (Yin, 2014), which implies an in-depth investigation of a contemporary phenomenon, in this case, an intervention in its real-life context (Creswell, 2013; Yin, 2014), the classroom. According to Postholm (2015), a case study design is one of the methodologies used in CHAT and it fits well in research related to school-based development. A case study design is a useful approach when it comes to formative interventions where the researcher is collaborating with a teacher in a school context to try out a new educational tool for a period (Postholm, 2015, p. 52). Following such an approach makes this study a *bounded system* (Creswell, 2013, p. 148), where both the processes and individuals are in focus (Stake, 1995, p. 2).[20] This study follows actions over time, actions connected to the expansive learning cycle (Engeström, 1999b, p. 383) that are traced and linked (Yin, 2014, p. 10) and that may show change in outcome among the participants involved.

[20] Stake (p.2) says that 'processes' fit the definition of case study less well than, for instance, individuals do. Creswell (2013, p. 150) is aware of his stance, but does not make such a distinction.

Single case means in this study that the research has been conducted in one school context, in one class. In addition, the study has also several units of analysis and is according to Yin 'embedded' (Yin, 2014, pp. 54–55). This is related to various kinds of data, which also belong to different levels of analysis. For instance, the small unit may be the individual interviews, and data that belong to the intervention itself belong to another level of analysis. In the data corpus later in this text, various kinds of data are shown, and it is outlined how the data were analysed. One pitfall about embedded designs is, according to Yin (2014, p. 55), that a study can end with having a focus only on this sub-unit level, and in doing so, it fails to return to the larger unit of analysis, the original case. Regarding this case study, all the elements connected to the study, i.e. the study itself, have been considered. This is emphasised in article 3 (Jarvoll, 2019), but it is also a topic later in this chapter. Furthermore, because the study itself, as the original phenomenon of interest, is a unit of analysis at an overarching level, it qualifies, according to Stake (1995, p. 3), as an instrumental study because the researcher wants to accomplish something more than an understanding of a particular unit of analysis.

The *emic* perspective (Fetterman, 2010) of the processes and the intracultural diversity between students involved have been important to understand their actions. According to Wolcott, the emic perspective '[…] calls attention to differences important within a particular community' (Wolcott, 2008, p. 142). Community corresponds to the classroom community in this study, where the members share rules, aims and different goal-directed actions that include the division of labour. When returning to CHAT, the theory is concerned with the collective activities, and its primary focus is not on explaining individual variations. With this in mind, I am also leaning on Stake (1995), who argues that emic issues can emerge when issue statements no longer fit the case circumstances well. Issues from inside, from the individuals who belong to the case, are then evolving. Such a situation is found and discussed in article 1 (Jarvoll, 2018a).

CHAT also propounds such an emic perspective with the explanation that CHAT is a dialectical theory in which a new concept is transformed into a new form of practice, step by step, by participants (Engeström & Sannino, 2010, pp. 4–5) and where the dialogue is accompanied by an activity during an interaction (Postholm, 2010). The nature of this understanding classifies, as already stated, this study under the social constructivist approach (Creswell, 2013; Postholm, 2010), with the epistemological

assumption that researchers can acquire knowledge through participants' subjective experience of collaborating in their context (Creswell, 2013, pp. 20–21). This is, I think, relevant when it comes to the role the researcher plays in R&D work (Postholm & Moen, 2011), and the researcher is approved as a part of the construction of data material (Charmaz, 2014). The most explicit example by using this approach is the e-mail correspondence between me and others connected to the research, which is analysed as data material in article 3. The role of me as the researcher conducting a formative intervention will be discussed later.

4.2. The context of the intervention

The host school for this case study is located near the fjord and mountains in a small municipality in northern Norway. The school has approximately 70 employees and 300 students, both from Norwegian and from immigrant families, and it offers education from first to tenth grade. In the beginning, the principal expressed a special interest in expanding the teaching practice connected to the use of ICT at his school. He also expressed that collaboration with institutions of higher education was emphasised in the school's policy plan. His school participated in a collaborative network of schools at my university and was thus purposefully selected (Creswell, 2013, p. 156). Moreover, the principal clarified that he was unable to allocate extra resources, such as time, to any teacher interested in participating in the research project. However, he did take responsibility for informing the teachers about collaboration with me in a research project, outlined later as a formative intervention project.

The teacher who reported his interest, Mr Todd, was the first to join the research project; he has about 30 years of experience as a primary school teacher. He expressed that the books they were using in mathematics were dissatisfying for his students and that the motivation was decreasing. He organised an informal study in his class that showed him that about 20 of his students had their own Minecraft user profile and played this particular digital game for fun in their leisure time. At the beginning of January 2015, the teacher clarified his motive to participate in the intervention, and he selected Minecraft as our entry into working both with ICT and with mathematics. He wanted to restore students' motivation by bringing in this new educational tool,

Minecraft, to teach mathematics. He was curious and wanted also to expand his teaching by trying Minecraft.

An ICT-responsible teacher from the same school told me that accessibility issues related to the computers and busy school days had prevented Minecraft from being an option for the teachers as an educational tool.

The participating class had 11 girls and 16 boys, and six of the 27 students had a mother tongue other than Norwegian. For practical reasons, the class was divided into two groups in several subjects; this was also the case during the intervention. Group A consisted of 16 students. They had lessons in mathematics on Mondays. This group were doing well in mathematics, but was considered by the teachers as a noisy and sometimes too energetic group of students. The smaller Group B consisted of 11 students who needed more support and attention. Group B had lessons in mathematics on Tuesdays.

With the principal's permission, the game Minecraft was successfully installed on 16 school computers and was then available as a new resource in the school. Because the class was divided into Groups A and B, 16 computers were sufficient.

4.3. Overarching ideas about pedagogical issues connected to the tasks in mathematics as the example subject

All tasks in mathematics were prepared according to the overarching national curriculum for Knowledge Promotion (Norwegian Directorate for Education and Training, 2015). The students' books in mathematics were used to check what they had done in the chapters to know how advanced the new tasks in Minecraft could be. The students and the teacher did also use their books when they had their usual lessons in mathematics.

Tasks in mathematics using Minecraft focused on problem solving, cooperation, creativity, orality, engagement, differentiation and the understanding of mathematical concepts, such as area, volume, perimeter, scale, fraction, reflection of patterns and parallels (see Appendix 4). Working with abstract concepts in a digital world gives the opportunity to understand them more concretely. Gee (2008) says that this is not only about giving students digital games in school: 'I want to give them worlds that make

words meaningful, whether these worlds are virtual, real or a mixture of the two' (Gee, 2008, p. 4). This understanding of the possibilities in a context connected to the digital arena was interesting for the teacher and me in relation to mathematical concepts, and we decided to maintain this perspective during our work.

Another interesting issue was the students' practical knowledge connected to digital games and 'affinity spaces' (Gee, 2013, pp. 96–106) compared to the school context. Gee explains affinity spaces using the concept of a 'community of practice' (Wenger, 1998) and connects the term to social organisations associated with games and fan communities that provide assistance and resources to 'members'. In affinity spaces, members relate over common interests, and they encourage individually distributed knowledge, which allows the members to know more and do more than they could by themselves (Gee, 2013, pp. 97–99). This is unlike schools, whose characteristic features are unclear to students and serve much less as resources for their own effort (Gee, 2013, p. 101). Gee explains that in classrooms, students are encouraged to gain the same knowledge, and there is rarely space for everyone to share their interests or knowledge, which further can be a potential resource for others. In addition, Gee expresses that we used to think that learning was the work we do at school, and 'When we think of games, we think of fun' (Gee, 2008, p. 43). The teacher and I were curious about exploring how accepted Minecraft as a commercial game would be among students as they were used to playing it without adults telling them on what they should focus. This is followed up with in article 1.

The teacher wanted to work with the mathematics tasks according to ideas about deeper complex learning using digital tools. Such a focus included reflections, for instance, on the choice of the sizes of the blocks and an evaluation of this choice in collaboration, as exemplified in article 1. In article 2, Mr Todd explains his thoughts on collaboration as an approach to the tasks and that some students did not like working in groups. Other tasks that are presented in the attachment part show also the focus on deeper complex learning.

Mr Todd and I were inspired by a study conducted by Jahnke and her colleagues, whose findings show different components of deeper learning when it comes to group learning (Jahnke, Nordqvist, & Olsson, 2014). Others, like Gee (2013), also emphasise the possibilities for deeper learning using digital games.

One last moment that can be mentioned was how we approached the understanding of learning or outcome in our planning. Leaning on Säljö (2016), who points out that learning moves from simply mastering something to the ability to think and talk about it as part of relevant developmental processes (Säljö, 2016, p. 174), we decided not to have any tests after using Minecraft. This decision was connected to a larger discussion of the reproduction of knowledge, which can be tested in school, versus the ability to solve problems in other contexts, such as the digital world, innovatively. According to Säljö, learning can have a performative aspect and should contribute to something new, not repeat something already known (Säljö, 2016, p. 174). With this in mind, we were curious about students' understanding of mathematical concepts, including how they would manage to transfer them to a more practical working method using Minecraft. Table 1 gives an overview of the given tasks and their content; in addition, the tasks are presented in Appendix 4.

Table 1. The content of the mathematics tasks during the intervention using Minecraft

Week	**The abbreviated content of the tasks**
22 (2015)	In groups, students build houses, poles, sculptures and gardens in Minecraft. They worked with area, perimeter and volume and visited each other's work.
41	Students worked with patterns and symmetry on walls and floors in a Minecraft world.
44	Students are trying to find hidden tasks and a secret message in a Minecraft world. They work with multiplication and explain to each other the results after trickery with numbers.
45	Build your classroom task. Students work with measurement and scale and have to reflect together on how big their rebuilt classroom in Minecraft shall be.
2 (2016)	Build a colourful house task. Students work with fractions, where they have to take into consideration many possibilities and solutions when building their house.
3	Build a garage and provide instruction to another group so they can rebuild your garage.
6	The teacher made the tasks about area and perimeter on his own. (He chose not to publish them.)
24	Students work in a Minecraft world where they find various figures and receive tasks written in English about volume that they have to solve.

4.4. Practical organisation and challenges

The teacher and I conducted an introductory session in week 22 in spring 2015, where we tried some tasks in mathematics, as shown in Table 1, and we observed how well students knew Minecraft. Then, we had a session without Minecraft in week 39, where I conducted participant observations; this session is not in Table 1, as the students worked in their book in mathematics and showed their homework. After that, we had sessions in both groups in 2015–2016 during weeks 41, 44, 45, 2, 3 and 6, as well as a follow-up session in week 24. As mentioned, all tasks in mathematics were prepared according to the overarching national curriculum. We also applied the creative mode in Minecraft, with unlimited resources and with players not having to struggle for their lives. We wanted to keep the focus on the tasks in mathematics.

In article 1 (Jarvoll, 2018a), Figure 1 shows the given task during week 45, where students had to rebuild their classroom in Minecraft. Our learning objectives connected to this task were concerned with measurement, scale, collaboration and orality. In pairs, students measured the classroom, decided how big blocks should be and then rebuilt it in Minecraft. Students had to work with questions such as should one block correspond to one meter or should it be smaller? If the blocks were too small, for instance, 5 centimetres, then they had much more work before them. Students could see each other's solutions in multiplayer mode to understand the consequences of their choices. Figure 1 in article 1 shows that pairs from Group A were working near each other. Hence, the classroom in front, from one pair, will be much smaller than the other classroom.

From the stated object of this intervention, the teacher paid special attention to signs that could be interpreted as motivation, meaning that he was interested in capturing feedback from the pupils and that we could use student feedback in the further development of the tasks. For instance, play together was a suggestion from pupils that came up several times and that was followed up with in week 45 and week 24. We also followed suggestions about tasks written in English in week 24. Students' experiences have been pointed out in article 1.

The next section is about the data material. Much happens in a school context at the same time. Students are busy doing stuff. Not everything is possible to understand

or grasp for a researcher. This concerns both the observations in the classroom and the focus group interviews, where they had several conversations going on simultaneously. Getting screenshots from their tasks was also a challenge, as students were sometimes in a hurry and forgot to save the screenshots before they went out.

4.5. Data material

My overall aim with data collection during the intervention was that the collected data had two purposes. The first purpose was for the structure and development of the processes connected to the intervention. For instance, some of the conversations between the teacher and me were recorded during lessons, both as ordinary taped recordings or captured on Bandicam[21] recordings when the students played Minecraft and explained what they were doing and thinking about the tasks. Together with the screenshots from the tasks, these recordings were used as mirror data (Cole & Engeström, 2007; Virkkunen & Newnham, 2013) in the further planning of the intervention. It must be clarified that in connection to this, I refer to myself as a collaboration partner. The second purpose with data collection was connected to the research work, the case study. The focus in this chapter is on this second objective. Some of the collected data were used for both purposes. Table 2 shows how the data material was distributed in the three articles.

Data used in the research work are named *main data*, while data collected for the developmental processes of the intervention are named *background data*, because these data were helping to obtain a more comprehensive understanding of the actions and experiences during the intervention.

The distinction is not consistent when it comes to the notes from participant observations. In article 1, the notes from the observation during the whole intervention are used as main data, but in article 2, the notes from observation during autumn 2015 are used as background data. The reason for this is explained in article 2.

[21] A screen recording software program for Windows: https://www.bandicam.com

Table 2. The data corpus applied in the three articles.

Article 1, data collected during 2015 and spring 2016		
Type of data	***Status of the data***	***Source***
Recordings of eight single semi-structured interviews	Main data	Week 40, 2015, four students from each group. From 5 to 15 min.
Recordings of eight focus group interviews with four students every time	Main data	Weeks 44, 45 (2015), 2 and 24 (2016). Four interviews from each group with four students in every interview. From 15:32 to 28 min.
Notes from participant observations	Main data	Notes from 23.5 (twenty-three and a half) h in the classroom (2015–2016).
Recordings of four conversations with the teacher during lessons	Main data	Weeks 2 and 3 (2016), total 22:34 min.
Physical artefacts	Background data	133 screenshots from tasks, week 44, 45, 2, 3 and 6
Article 2, data collected autumn 2015		
Type of data	***Status of the data***	***Source***
Interview with the teacher	Main data	Transcription of 50:31 min interview (9.11.2015)
Notes from participant observation	Background data	10 h in the classroom with the teacher (week 39, 1 h; week 41, 3 h; week 44, 3 h; week 45, 3 h)
Recordings of four conversations with the teacher during lessons	Background data	One recording week 41, 4 min Three recordings week 45, 2 min
Bandicam recordings	Background data	Autumn 2015 about 1 h of recordings (week 41, 8 recordings, 13.5 min and week 45, 8 recordings, 47 min)
Physical artefacts, screenshots	Background data	62 Screenshots from tasks (week 44, 33 screenshots and week 45, 29 screenshots)
Article 3, e-mails collected from 16 October 2013 until the end of the intervention on 13 June 2016.		
Type of data	***Status of the data***	***Source***
e-mails	Main data	Correspondence/communication in relation to the intervention 56 e-mails
Research situation	Main data	Various elements of concern found in the research situation

Following Clarke and her research fellows (2018) as a researcher, I considered it important to use my experience of the phenomenon under study, the intervention, and of doing the research as one of several data sources. This is especially visible in article 3 (Jarvoll, 2019). As I have read about qualitative research, it is an accepted thinking that in the world of qualitative research, the person doing the research is the 'research instrument' (Clarke, Friese, & Washburn, 2018, p. 107). Having this guiding me, the status of the data applied in article 3 (see Table 4), the e-mails and research situation itself are considered main data.

A relevant data corpus consists of eight single semi-structured interviews (Kvale & Brinkmann, 2015, p. 46) with the pupils, conducted after the introductory study in week 22 spring 2015, and eight focus group interviews with four pupils every time, conducted after the lessons during weeks 44, 45, 2 and 24. Moreover, interviews, recorded conversations with the teacher during the lessons and participant observations from 23.5 hours in the classroom, are important parts of the data corpus. In addition, e-mail correspondence connected to the beginning of the intervention and during the intervention is considered an important data source. Screenshots from the tasks and Bandicam recordings of the students' products were taken to document how they solved the tasks and to support my observations.

4.5.1. Data collection

The collection and data storage followed requirements for personal data (NESH, 2016) and I have received research permission from the Norwegian Social Science Data Services (NSD; see Appendix 1). A letter was sent home to the students' parents with information about the project and the interviews at the beginning of the study (see Appendix 5). I was also in the class informing about this research. I received permission to interview and make recordings of 20 of 27 students from their parents. The students and parents were informed that the study would be anonymised and that students could withdraw from the interviews any time, which two students did. Students could also listen to the recordings of the interviews. Some students wanted to do so, and some expressed that they did not like to listen to their own voice. I had also received permission in writing from the teachers and the principal to make recordings. They were

given the same information about the collection and storage of data (see Appendix 6 and 7).

Interviews, taken by a Dictaphone, with the teacher were conducted in the classroom (see Appendix 3), and most of the interviews with students were carried out at the library, but some have been done in the classroom. In my notes, the library context is described as follows:

> I am at the Library, going up the stairs to the second floor and looking around. It is here I shall make the interview today. The second floor is like an indoor terrace. I became dizzy when trying to look down at the bookshelves. Big nice windows are allowing the light to get inside. In the end, I see a dark red sofa. There are also chairs and tables on the other side of the terrace, but I think I will choose the sofa. It is inviting. I just hope that we will not be disturbed; another class is in the library. Their voices rise up to this second floor (My translation, autumn 2015).

This library context was relaxing, even though some noise did reach us during the interviews. When students from other classes were finished with the lessons and were allowed to visit the library, we were disturbed. It happened that we had to stop until it was quiet again. However, most of the time, it was really quiet and easy to keep the focus on the interview.

Individual interviews were conducted after the introductory study to obtain students' own meanings and attitudes (Kvale & Brinkmann, 2015; Yin, 2014) towards Minecraft and other digital games, their attitudes about mathematics in school and their expectations concerning the use of Minecraft in mathematics (see Appendix 2). The focus group interviews were conducted to grasp their different experiences (Kvale & Brinkmann, 2015; Yin, 2014) from the lessons and their suggestions about new tasks in mathematics (see Appendix 2). During the focus group interviews, the pupils had the possibility to reflect on their experiences (Kvale & Brinkmann, 2015; Yin, 2014) and make new suggestions that the teacher and I could try out in the classroom to collect new observations. This is also an example of how Change Laboratory interventions can be put into practice (Virkkunen & Newnham, 2013).

The notes from participant observations that form the lessons were written down both during the lessons and right after the lessons. Because of much activity in the

classroom and my own participation, there was no space for me to withdraw to take notes, and I did not want to miss anything that was happening. In addition, the teacher and I had brief conversations during the lessons to reflect on what was happening in the classroom. Some of these conversations were recorded during lessons, and they capture the activity in the very moment (see Appendix 3). The conversations have been a possibility to talk about the observations made that give access to other understandings or alternative views (Yin, 2014, p. 117) and to make a summary of what is happening when and where it happens. To ensure the classroom context and conversations remain as natural as possible, it was not suitable to record everything. The situation decided when I could begin recording. Sometimes a student was curious about what we were talking about or had a question that was not appropriate to record.

The screenshots are taken by the students themselves during the lessons with mathematics. They are of variable quality because of several possibilities to take such screenshots. Furthermore, some students forgot to save the screenshots. This loss of interesting data confirms that even though everything is planned and shown to 11–12-year-old students, it is necessary to have a plan B. I managed sometimes to retrieve some screenshots if the computers were still on after the lessons.

Bandicam recordings were taken when the students were working with the tasks in Minecraft. The recordings show the activity on the screen commented on by the students or a conversation between students and me or the teachers. Students decided themselves whether they wanted to make Bandicam recordings.

I have done all transcriptions. According to Kvale and Brinkmann, this is seen as a good procedure (Kvale & Brinkmann, 2015, pp. 104–105). They argue this is important because the process of analysis starts already when the researcher is working with the transcriptions (Kvale & Brinkmann, 2015, p. 106). This meant for me a coherent way of working with the data material. Already at this early stage, the process where I transformed the recordings of the text was helpful regarding the analysis process, which I will explain later in the chapter.

Interviews with one single person, student or teacher, were easier to transcribe, even though I had to repeat a particular sequences several times when the voice was lowered. The transcription of the focus group interviews was more laborious, especially when all four students were talking at the same time. I had to go back and forth many

times to catch whether this special sequence was a part of the same dialogue or was two simultaneously ongoing dialogues. I experienced often that the students were eager to talk during the interviews and I embraced this. Consequently, the transcription work could be highly time consuming.

During my observations in the classroom, I asked the teacher what he thinks about the activity right now. These short conversations are recorded, as mentioned earlier. I asked similar questions of some of the pupils and used this programme called Bandicam that gives the ability to make video recordings of their voices simultaneously when they are solving tasks in Minecraft. These recordings, inclusive conversations with the teacher, cooperation meetings, screenshots and observations are used to strengthen the key interpretations or the findings. Following Yin (2014, p. 121), I have in Figure 6 tried to show the convergence of evidence (Fetterman, 2010, p. 109) in this case study. Figure 6 is presenting an overview of multiple sources of evidence, i.e. data material, from this case study in an attempt to be used in the triangulation of the evidence to help me answer the main research question and hopefully contribute to strengthening the validity of this case study.

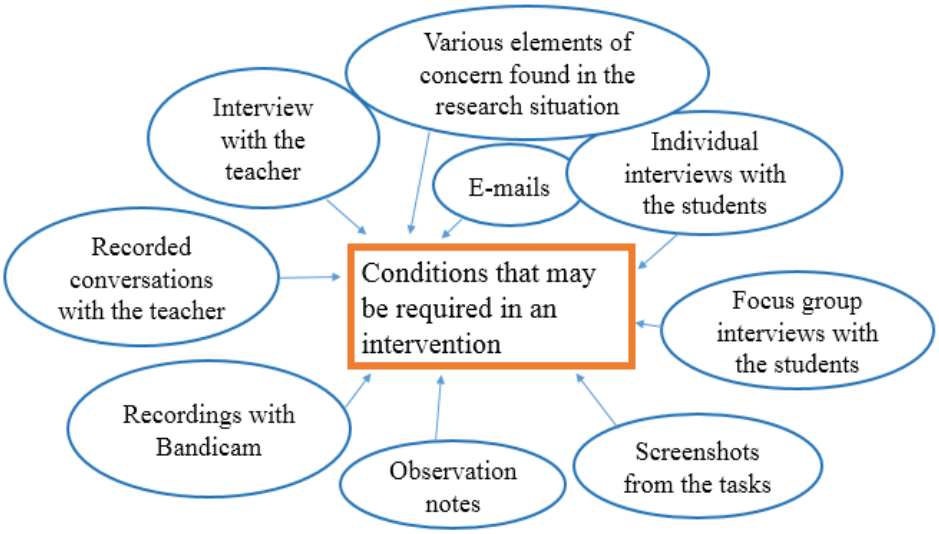

Figure 6. Multiple sources of evidence (not all have been used in all articles, as specified by Table 4)

4.6. The Analysis

In this part of this chapter, I will first give an overview of the collected data material in connection to multiple sources of evidence (Yin, 2014). Then, I will present shortly how I approached the analytical work by using the constant comparative method of analysis (Corbin & Strauss, 2008, 2015; Strauss & Corbin, 1998). I have applied this in all three articles, and situational analysis (Clarke, 2015; Clarke et al., 2018) is used only in the third article. I shall outline why I have chosen these methods of analysis and relate this to the process of the analytical work conducted. Then, the position of the researcher, the research ethics and then the quality of the study will be reflected upon at the end of this chapter.

4.6.1. Conceiving the analytical work

I have made several maps trying to comprehend what this research was about, where it goes and what it contains. Everything I could come up with, from various theories to practical solutions, was put on maps. In short, I have been making maps during different stages in this research in an attempt to have control over its life. According to Clarke et al. (2018, pp. 106–107), situational maps can be helpful already early in the design stage of a research project to the preparation of publications. To do the maps, the researcher must know the data and the project, and I have experienced that spending time making these maps helped me to know my project better. Another helpful tool during the research process is memos. Memos are written interactions with data material when doing analyses or when the researcher is trying to indicate how concepts might relate to each other (Corbin & Strauss, 2015, p. 107). Looking at my memos, the latter is especially visible when it comes to article 2, in which I try to understand teachers' experiences in relation to various factors outlined in the model of an activity system and what the contribution of the research may be. In the memos, I am modelling the contribution as a new concept, the 'breakthrough adopter' based on 'invisible breakthroughs' as defined by Engeström (2015, p. 73), and on 'early adopters', a category developed by Rogers (1983, p. 62) and used in resent research presented in article 2.

The use of memos is a tool recommended in situational analysis, as it is in the constant comparative method of analysis (Charmaz, 2014; Clarke, 2015; Clarke et al., 2018; Corbin & Strauss, 2015; Creswell, 2013; Strauss & Corbin, 1998). Memos can be related to the maps at any stage of the research process (Clarke et al., 2018, p. 106). When I started to collect my data material, I wrote my first memos. By using memos, I did preserve my dialogue with my data material, and I maintained my direction during the process of analysis. In addition, I noted my thoughts and ideas that emerged in the research process in a research diary (Corbin & Strauss, 2015, p. 36). I tried to keep a record of all the activities, thoughts and plans for the future about what was needed to proceed. For instance, the research diary was helpful when I was creating the semi-structured interview guide (Kvale & Brinkmann, 2015, p. 46) for the interview with the teacher at the end of the autumn term used in article 2. In short, both memos and my research diary were necessary to keep a dialogue with my research processes, such as making certain decisions and where the empirical data and experience led me (Charmaz, 2014, p. 162).

During the process of analysis, I went back and forth between the data material, making constant comparisons. This has been a useful working method for me to validate my own ongoing interpretations (Strauss & Corbin, 1998, p. 137). In addition, I have been striving to work abductively, meaning that a repeated process of alternating between theory and empirical facts must be done. According to Alvesson and Sköldberg (2013), this is the third alternative that can not only be understood as a mix of induction and deduction, but requires that something innovative and creative be added (Alvesson & Sköldberg, 2013, pp. 55–56). Clarke et al. (2018) elaborate on this, expressing that such an abductive process, over time, through working with the data and generating conceptual possibilities for handling that data more theoretically, the analyst conceives, refines, selects, rejects and connects robust concepts toward theorising a substantive area. Clarke et al. (2018, pp. 28–30) connect abductive processes to a gestalt understanding, saying that such an understanding captures the empirical data analytically and can generate a life of its own.

In addition, Alvesson and Sköldberg (2013, pp. 55–56) explain that abduction means a hermeneutic process where the researcher, so to speak, eats into the empirical data with the help of theoretical pre-conceptions. Such a process helps with developing

and elaborating the theory. In article 3, the process described above is especially visible (Jarvoll, 2019). Leaning on Virkkunen and Newnham (2013, p. 12), a Change Laboratory intervention has been in this study understood as a dialogue and a process of co-production between the representatives of the worlds of practice and research. Dialogue has been by me processed as something essential when analysing the data material. This is because I was informed by theory that collaboration can emerge through dialogue (Sannino, Engeström, & Lahikainen, 2016) and that dialogical processes appear to connect ongoing communication and future-oriented actions (Sannino, 2008; Sannino et al., 2016). Thus, I have followed dialogical processes with the result of conceiving an abstract model concretising an expansive dialogue in a completed intervention (Jarvoll, 2019).

When working with the data material, I did often read the whole text in an attempt to comprehend the overall picture. I did not have predefined categories. Working abductively, I tried to be open and let the data speak. During the process of analysis, I tried NVivo but experienced it as a fragmentation of the wholeness. I decided not to use NVivo as a support, as I was afraid that this would influence my understanding and interpretation of the data.

The e eight single semi-structured interviews were analysed first. Table 3 is an example of the analysis at a particular time early in the process. The categories were the subject of discussion in a fellowship of other PhD candidates. This made me more certain of the constant comparative method of analysis, and it made me gain a deeper understanding of the empirical world and the playfulness this method allows (Charmaz, 2014, p. 137).

Table 3. An extract of the coding process from single semi-structured interviews at a given time early during the process of analysis (Source: my own data)

Åpen koding	Aksial koding	Verktøy: paradigme	Selektiv koding	kommentarer
1. Refleksjon om egen bruk **2. Preferanse for Minecraft-bruk (kreativ eller survival modus, digital plattform: pc/nettbrett)** **3. Tidsbruk** **4. Regler** **5. Vaner** **6. Spille sammen** **7. Teknologisk innsikt** **8. Minecraft i fag** **9. kunnskap/kjennskap til Minecraft (ulike modus, bygging, muligheter og begrensninger)** **10. «noe barn holder på med nå»** **11. Forventning** **12. Mestring** **13: Usikkerhet** **14. Artig/veldig artig, morsomt/kjempemorsomt, gøy, spennende, veldig greit/helt greit** **15. andre aktiviteter (være ute, fotball)** **16. Matematikkundervisning ellers** **17. Engelsk** **18. Tysk** **19. Arabisk**	Brukererfaring Preferanse for Minecraft-bruk, kreativ eller survival modus, digital plattform: pc/nettbrett, tidsbruk, regler, vaner, spille sammen eller alene (single- eller multiplayermodus), teknisk erfaring. Refleksjon Kunnskap om Minecraft Inkluderer andre spill/arena/teknologisk innsikt: muligheter og begrensninger, bygging, kreativ eller survival modus, spille sammen eller alene (single- eller multiplayermodus). Forventning, mestring og usikkerhet Positiv holdning Artig/veldig artig, morsomt/kjempemorsomt, gøy, spennende, veldig greit/helt greit Samtidsorientering Noe barn holder på med nå Språk Engelsk, Tysk og Arabisk Fag og Minecraft Matematikkundervisning ellers (før bruk av Minecraft)	Refleksjon skjer på grunnlag av den brukererfaringen elevene har, men ikke nødvendigvis språk som konsekvens av brukererfaring	**Metaperspektiv** **Brukererfaring:** Viser til det mer praktiske **Refleksjon:** hever blikket Brukererfaringen blir gjenstand for refleksjon, men ikke nødvendigvis.	utvikling av kjerne-kategorien

4.6.2. Constant comparative method of analysis

Besides situational analysis used in article 3, a method I will return to soon, the analytical work in this thesis has been conducted with the constant comparative method of analysis (Corbin & Strauss, 2008, 2015; Strauss & Corbin, 1998). The constant comparative method of analysis is developed from grounded theory, but it can be used in other qualitative studies (Postholm, 2010, p. 87), as in this case study approach.

In addition, the constant comparative method of analysis is concerned with a reduction of data material; it helps to structure it and see new patterns. The main benefit of using this method in an intervention study is that it acknowledges multiple realities (Charmaz, 2014, p. 236). I connect my understanding to Charmaz's (2014) description of the analysis method. This is also one important argument related to the emic perspective outlined earlier (Fetterman, 2010, p. 20). Moreover, this study is about grasping the experiences from the acting subjects (Charmaz, 2014; Creswell, 2013) and using them in the further development of this intervention.

Furthermore, the advantage of using this method of analysis in this case study is the understanding of the interactions between collaboration partners in constructing data

material (Charmaz, 2014, p. 236). Thus, this method acknowledges the presence of the researcher. The researcher is not discovering the data, but is a part of its construction (Charmaz, 2014). This means that data material is not only something I collect, but also something I participate in constructing. Because this thesis is positioned within CHAT, I think it is important that such a view is pointed out and emphasised, as it is in the Change Laboratory. As a researcher, I am involved in the formative intervention and the processes of knowledge building connected to expansive learning (Engeström & Sannino, 2010, p. 5), as presented in the theoretical framework of this study. This means that this method of analysis is, according to Charmaz (2014), in line with a social constructivist approach.

The constant comparative method of analysis requires the researcher to be well acquainted with the data material when constructing theoretical concepts or categories, which are then grounded in the data material. The data material is first structured and then reduced through this method of coding and categorising (Corbin & Strauss, 2008). Central to this activity is the *open*, *axial* and *selective* processes of coding (Strauss & Corbin, 1998), which have guided the process of analysis in this case study. In the open process of coding, the researcher breaks down and examines thoroughly the data material by considering possible meanings during the reading. I made every time (for every article) a list of codes, as shown in Table 4. The list is from article 3. Then, I reduced the amount of codes by searching for similarities or differences between the emerging categories, constantly comparing until I had a few main categories. In such an axial phase of coding, where categories are related to their subcategories as an attempt to form a more precise and complete explanation, the data are synthesised in new ways. The researcher sees new connections when focusing on context and conditions, different actions and their consequences (Strauss & Corbin, 1998, p. 125). This process of analysis is especially visible in connection to article 3, where three phases emerged connected to the collaboration in the intervention.

Table 4. The process of open coding connected to article 3

Meeting with the collaborative schools and my institution, followed by a meeting with the principal Meeting with the Principal Suggestions about a startup of collaborations (Meeting miscellaneous teachers Lack of time
3 Meetings with the teacher Report, send to the principal Suggestion about the tasks to the introductory lesson Lessons conducted by the researcher in the class of the ICT-responsible Practical issues connected to installation of Minecraft Positive feedback from teacher Lack of time Miscellaneous information
Planning lessons in mathematics Planning interviews with the pupils Planning/meetings with the teachers Interviews with the teachers Suggested tasks in mathematics Practical issues connected to Minecraft Lack of time Miscellaneous information Positive feedback from teachers

In short, subcategories specify a category further by referring to or including information, such as when, where, why and how a phenomenon is likely to occur (Strauss & Corbin, 1998, p. 119). This axial phase is in other words about asking such questions as 'when does this particular category show up'? In this case study, this question had an additional importance connected to when positive expressions, such as *fun*, *joy* or *funny*, did show up. Positive expressions appeared both in the classroom when I did the observations and during the interviews, and they were accounted for during the intervention and the process of analysis. This is especially highlighted in article 1, when during the third phase of coding, selective coding, a core category emerged through integrating and refining the main three categories. A core category, according Strauss and Corbin, is systematically related to all categories, and although it evolves from the research, it is an abstraction that eventually will take the form of theory (Strauss & Corbin, 1998, pp. 143–147). In article 1, the research was about students' comprehensive 'positive attitude' about Minecraft in their lessons in mathematics and during the interviews. This central finding appeared often in the data material, and it could easily be taken for granted. For this reason, I challenged this core

category at the end of article 1 by asking whether such 'positivity' is taken for granted and whether this should be expected. According to Strauss and Corbin (1998, p. 147), a core category should be able to explain contradictory or alternative cases. I interpret this as follows: that in another comparable study, such a 'positive attitude' does not have to be present, but it can still be used for an explanation of the conditions.

The process of analysis in article 2 followed the same procedure. First, three main categories emerged: 'teacher's position', 'students' motivation' and 'Minecraft as an educational tool'. When these three categories emerged, I turned to my observation notes to development these categories further. I asked, for instance, when the category 'teacher's position' appeared. This category appeared when the teacher described himself and how he understood his role both before and during the intervention. The second category, 'students' motivation', is based on Mr Todd's and my interpretations of students' dedication to the tasks and that the teacher understood the signs of dedication as 'motivation'. The third category, 'Minecraft as an educational tool', consists of Mr Todd's and my thoughts about the possibility for the further use of Minecraft as an educational tool. These three main categories laid the foundation for the core category 'breakthrough adopter', which is explained in the fact that teachers' considerations about choosing a new educational tool are anchored in expanded learning instead of teachers' lack of experience.

A list of codes from article 3 was presented above. Further, this article will be followed up in the next section in connection to situational analysis and then to the constant comparative method of analysis.

4.6.3. Situational Analysis

Situational analysis (Clarke, 2015; Clarke et al., 2018) was used in the third article. The reason for this is that situational analysis was developed to analyse the research situation itself (Clarke 2015, 99) by acknowledging a situation, such as an intervention, as something more than the sum of its parts. Situational analysis is outlined as a contribution to grounded theory (Clarke et al., 2018, p. 6) with some influence from constructivist grounded theory (Charmaz, 2014). Situational analysis is also considered by Clarke (2015) as a supplement to the more traditional method of analysis, the

constant comparative method. According to Clarke (2018), both methods work well together, as they are two different kinds of analysis pursued separately.

Situational analysis differ from the constant comparative method of analysis, where the goal is, as explained by Clarke et al. (2018, p. 27), to interpret critically particular social process(es), such as human actions and interactions (Clarke et al., 2018, p. 108) described or enacted in language. Instead, in situational analysis, the focus is on interpreting the situation per se, and 'relationality' is fundamental in situational analysis (Clarke et al., 2018, p. 108). The gestalt understanding of what situational analysis offers has been helpful regarding the focus of the third article, an intervention as a meeting place between the researcher's world and the practitioners' world. Clark indicates that situational analysis is so far used to a limited extent (Clarke, 2015, p. 108), but it contributes to an understanding of the whole research situation, including nonhuman actants (Clarke, 2015, p. 91), as noted in the previous chapter. The important reason for applying this method of analysis is that it is concerned with mapping the relation among various elements in a research situation, as well as the nonhuman elements, such as Minecraft or e-mails. This contrary understanding of the position of digital technology is challenging the established understanding of 'artefacts' in CHAT and may serve as a contribution to the discussion part of this case study. It must also be said that the use of Minecraft was a conscious choice made in relation to the intervention, as explained earlier. The situation was different in that the use of e-mails did not receive more attention than communication through mobile phones or informal meetings at the beginning of the research. Through situational maps, e-mails were revealed as an element related to most of the others elements in the study. This is emphasised in article 3. The analytic work using situational analysis involves the construction of situational maps. These maps are centred on elucidating the key elements as discourses, structures and conditions of possibility in a research situation, and they provoke analysis of the relation among them. The situational maps helped me to comprehend the complexity of the intervention, and they were modified and redone several times during the research work. First, I identified the miscellaneous elements of the intervention. A messy map (Clarke, 2015, p. 104), as shown in Figure 7, accompanied me in this first process. The lines in the map visualise relations. Then, a more organised situational map was constructed later. Figure 1 in article 3 (Jarvoll,

2019) exemplifies this procedure, and it provides a more visible focus on the relationship between e-mails and the other elements detected in the study. Figure 1 shows that e-mails are somehow related to most of the other elements. This led me to ask how and when the emails relate to the other elements. With these questions, I examined closer the e-mails using the constant comparative method of analysis (Strauss & Corbin, 1998).

Figure 7. A messy situational map from the analysis of this case study, after inspiration from Clarke (2015, p. 104).

After reviewing the content of 56 e-mails, which began before the intervention was planned, starting on 16 October 2013 and lasting until the end of the intervention on 13 June 2016, several themes emerged. Furthermore, three basic phases, i.e. main categories, emerged, and their content is outlined in the third article. The first phase of the e-mail correspondence, from 16 October to 12 November 2013, consisted of the dialogue with the principal about the future collaboration. The focus is on the principal's acceptance of the research topic and his permission to conduct the intervention at his school. The second phase, from 11 November 2014 to 24 September 2015, is about my e-mail correspondence with the first teacher regarding the possibilities and contradictions connected to the emerging collaboration. This phase was fundamental in laying the groundwork for the possible collaboration in the classroom. The third phase, from 2 October 2015 to 13 June 2016, consists of e-mails about concrete planning and task suggestions, as well as all the practical solutions and pedagogical thinking that led to the accomplishment of the lessons as the intervention progressed.

4.7. Researcher's background and role

As a teacher educator, I think that knowledge of various teaching tools and methods is essential, and it has been a fundamental goal for me to enhance my experience with digital games, as well as to understand how and when teaching with digital games can be practiced or why or how it should not be practiced. I think that technology is expanding our everyday lives, and it is important that teacher educators have knowledge enough to guide their students when it comes to the use of ICT in schools in the future.

I have approached this research as a teacher educator within the subject pedagogy, with a background in both psychology and media education. My interdisciplinary lenses gave me some competing choices as the research proceeded. From a psychological viewpoint, it was interesting to investigate how people understand and experience technology, both as individuals or collectively, where in collaboration, they construct knowledge and new objects. Thus, this thesis is positioned within CHAT. From a media education approach, it is interesting to gain knowledge about the use of technology as it changes in everyday life. Technology, represented here by using

Minecraft, could be the main subject of interest. Moreover, as a teacher educator, I think it is important to meet students with a baggage consisting of practical experience from school combined with related theory, which shall both complement and challenge each other. I am also of the opinion that educational research is a constructivist project (Berger & Luckmann, 1971), where the researcher is in a dialogical collaboration with the field. These three lenses had some impact on my process of analysis; thus, they are possible to trace in the three affiliated articles. The main challenge has been how to balance these three angles against each other, and it has accompanied me during the whole research process. Considering it now, I think it contributed to enriching the research by giving me the possibility to broaden it and reflect from different angles. In addition, the choice to be where the action is, in the school with the teacher in his class, gave me two roles. In the following text, the focus will be on the researcher-interventionist role.

The R&D model outlined by Postholm and Moen (2011) is used to approach the processes of development during formative interventions and to explain the role of the researcher. The model, as shown in Figure 8 below, helped me to visualise my own processes during the research work. Postholm and Moen (2011) defined a third level of the R&D work that takes place in a formative intervention, calling it the 'researcher's plateau', as we can see in Figure 8 (Postholm & Moen, 2011, p. 399).

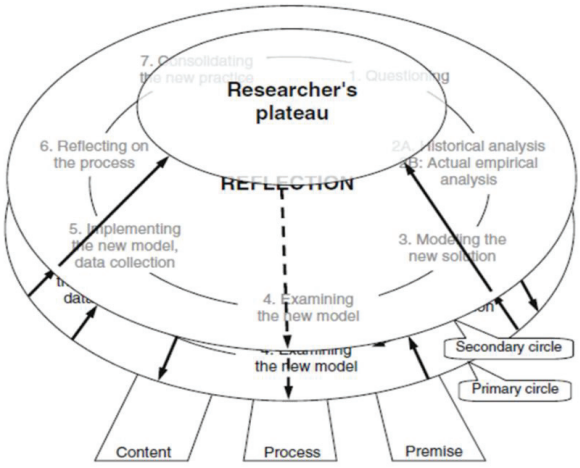

Figure 8. The R&D model (Postholm & Moen, 2011, p. 399)

The researcher's plateau is about the researcher's work when he or she is trying to highlight the most crucial activities when bringing them to a meta-level. This involves an understanding of what is the most essential from the collected material and experiences. As can be seen in the model, the sequences of learning actions are the point of departure. During my research work, such an understanding has been helpful to sort out what of my (researcher's) work is related to the research and what belongs to the more practical completed intervention. At this third level, the 'researcher's plateau', the researcher no longer cooperates with others involved in the intervention. The researcher is on a transparent roof (plateau) trying to overview all the relevant activities that have taken place in the R&D work. In article 3, I connect this third level explicitly to the use of situational analysis. The argument about this relation is that when sitting on a 'transparent roof', in an attempt to answer the research question, on the researcher's plateau, the components found in the intervention were visible to me. Furthermore, the researcher's plateau was for me about seeking the necessary distance to obtain an overview. Such an understanding, I think, is also fruitful from the viewpoint of the outlined situational analysis. It helps the researcher, me, to become situated in relation to the data material and analysis. In short, as I experienced, the R&D model is a tool to visualise processes that are shared between those involved. In addition, it may be a good solution to the critical point highlighted by Aas (2011) that it is difficult to distinguish between the different tasks the researcher-interventionist is occupied with in a research project.

Being on the inside as a cooperation partner involves a closeness to the context, as well as many shared goals with the teacher and the pupils. This is seen by Yin (2014) as a good opportunity to get insight into the case. However, moving away from the context and to free ourselves from obligations and relations, as Aas (2011, p. 283) puts it, can create the necessary space for further analysis and may solve some major challenges connected to participation (Yin, 2014, p. 117). When the intervention was finished, I had to move from being a 'cooperation partner' to this transparent level, where I was in the process of analysis and consolidation; in the end, I started to prepare myself for a presentation to a research community.

Being a 'cooperation partner' is to some extent a description of my participation as a research-interventionist. According to Virkkunen and Newnham (2013), the

research interventionist is 'provoking and sustains collaboratively led expansive transformation process' (Virkkunen & Newnham, 2013, p. 12). These processes shall not be led all the time by the researcher but "[…] led and owned by the practitioners" (Engeström & Sannino, 2010, p. 15). The ideal definitions of a research interventionist and the expansive transformation process have not always been the case in my research. From the teacher, I was given the responsibility of introducing the digital game Minecraft and of providing most of the suggestions for different tasks in mathematics. I was not quite prepared for this kind of obligation, but I felt grateful for the trust I received. Furthermore, leaning on the mentioned theory above, I tried to direct the intervention more towards involvement and ownership of the object to the teacher. For instance, what is a reasonable time spent on a meeting? I had to be satisfied with shorter meetings between the teacher and me than I had planned in the first place.[22] Thus, all suggestions and our experiences were considered when we were planning our further lessons.

Nevertheless, it was expected that I had new suggestions, could solve problems and had the necessary information or theory to run the processes. The teacher expressed that he would not have started using Minecraft in mathematics on his own. His statement is presented in article 2. The teacher had never tried this game before and felt unsure. He was clear about the fact that it was the students and me who had the necessary competence. In addition, it was expected that I could correct the direction if something went wrong. With this in mind, I felt a kind of pressure during the intervention. The pressure was mainly connected to the time I had available. Otherwise, I saw this as an opportunity to gain valuable practical insight and to be challenged to connect theory and explore Minecraft by trying out the tasks myself.

Aas (2011) has an interesting critical view. She says that in many ways, the researcher is also providing premises (Aas, 2011, p. 280). In my case, the premise was always in a process of negotiation, change and interpretation between me and my cooperation partners, the students and the teachers. I experienced that the position of

[22] In Change Laboratory intervention planning, current experience as mirror data (not a self-explanatory concept) is addressed as essential for further development of the intervention. The teacher and I had (some) different ideas about how much time we should spend on this mirror data.

researcher-interventionist had to follow the busy life in school, meaning that some considerations connected to the research were subordinated. For instance, I had to let go of some screenshots and I could not interview students more than I did because they could not miss more of their lessons. They also had to prepare themselves for other activities and were sometimes tired, so it would be wrong of me to fatigue them. The teacher had also other obligations to consider, so I had to adjust my research work, and I think this is a part of being a cooperative partner.

4.7.1. Agency and the etic perspective

According to Engeström (2015), the key outcome of conducting formative interventions is agency among all the participants (Engeström, 2015, p. xxxi), including the researcher. Being a participant during the lessons and making participant observations (Yin, 2014, p. 115) were a natural part of the intervention. As a participant, I had the possibility to ask both the teacher and the pupils about what they were doing, about what they were thinking and about what they had planned to do next during the lesson. Such a possibility was a way to test my own understanding of the observations made and to give access to other understandings or alternative views (Yin, 2014, p. 117). The fact that I was a participant made it easier to understand what was going on. I could easily speak with the pupils about our object and their performance. This gave me another kind of control over the processes and the possibility to grasp experiences that could be used as mirror data and correct the direction of the intervention. This kind of control can decide the agenda and can be used to manipulate minor events (Yin, 2014, p. 117). I could easily been responsible for making more decisions, but then I feel that the emic perspective would be treated unfairly. According to Fetterman (2010),[23] the researcher must attempt to be unobtrusive and try to reduce his or her influence on the natural situation. Striving to understand the native's perspective of realities gives recognition and acceptance to those who participate (Fetterman, 2010, p. 20). I think it is essential to be honest and to recognise that the researcher's presence has some impact. When it comes to the data material, as I mentioned earlier, the researcher is part of the construction of the data material (Charmaz, 2014, p. 236), for instance, via the

[23] How an intervention is understood as natural is a matter of discussion, I think.

conversations with the teacher during the lessons, and involved in making choices connected to the collaboratively led expansive transformation processes (Virkkunen & Newnham, 2013, p. 12). For instance, when students had suggestions of different tasks we could try, the teacher and I would discuss the possibilities and limitations based on previous experiences. In this kind of research and development work, the researcher's presence is defined (Virkkunen & Newnham, 2013) and is, with an advantage, I think, a subject of necessary critical discussion (Aas, 2011). Such a discussion can also be seen as an etic responsibility or, as Fettermann put it, '[…] external, social scientific perspective of reality' (Fettermann, 2010, p. 22); as far as I can see, it can also be anchored or visualised in the R&D model, where the researcher has the chance for necessary distance when reflecting on ethical issues. Such ethical issues are provided by the National Committee for Research and Ethics (NESH, 2016). Their guidance and advice about research ethics in the Norwegian research system have been helpful in striving to obtain good scientific practice. Not all moments from the guidelines have been relevant to this case study. For instance, there are no constraints on the freedom and independence of this research because there are no commercial considerations or interests connected to it. Furthermore, the responsibility is connected to me, and I have been critical of my own decisions during the whole process to ensure that nothing harmful happened in connection to this research. For instance, to include children in research demands particular caution because there is no equality between adults (researchers) and children. Adults will always be in a superior position, and researchers have a responsibility to keep this in mind. Furthermore, I have strived to maintain openness about theoretical and methodological choices as an integrated part of my research. I have provided all the participants and parents with information about the purpose of the research, about the storage of the data and about the intended use of the results, as well as that the research material would be anonymised. Any personal matters that arose during the research have been treated with necessary confidentiality and have been considered as irrelevant to this research.

4.8. The quality of the research

Throughout the entire PhD process, I have been associated with The Norwegian National Research School in Teacher Education (NAFOL), where I had the chance to challenge my ongoing research with other NAFOL PhD students and invited researchers, both from Norway and from other countries. We were working in smaller groups, where all of us had to contribute inclusive feedback to each other. Such continuous participation in NAFOL ensures connection to a scientific community where everything connected to my and others' research could meet critical views and contrasting suggestions. This, I think, has contributed to the validation of my choices, processes and theoretical understanding.

Through two PhD courses in methodology, I have also presented parts of my data material and understandings during the process of analysis and received feedback both from other PhD candidates and from the supervisor about the conducted analysis. This has been a fruitful and interesting contribution to my analytical awareness, and, as I see it, has helped to strengthen the validity of the study.

Participation in conferences in connection to PhD work has allowed me to reflect on my own and others' research and has provided a connection to a fellowship of researchers. In addition, at the time of writing, two empirical article have been printed and one is in press. The articles have been through a peer-review process. This means they have been through many phases, such as oral presentations and feedbacks, revisions and changes. The most important is that they have met some interest and an audience.

I returned often to the notes from 23.5 hours of participant observations when analysing the interviews. These notes have been a necessary tool to validate (Fetterman, 2010, p. 39) the interviews with the students. For instance, both during the single and focus group interviews, the pupils expressed positivity towards the digital game Minecraft. During observations, this positivity revealed itself when the pupils were entering the classroom and when they were working with the tasks. The pupils had the chance to talk about something related to their efforts made during the lessons. These interactions were recorded with the Bandicam programme. The screenshots show concretely to what extent they have completed the tasks.

The teachers also observed this positivity during lessons. A summary of their experiences is recorded during these lessons. A benefit of making these recordings was that the case study could be enriched with additional interpretations (Stake, 1995, p. 115) from the teachers, challenging my understanding of what was happening in the classroom. Another aspect of these recordings was that they could be seen as 'member checking' (Stake, 1995) when the teachers and I were talking about what is going on in the classroom, during not only these particular lessons, but also the whole intervention (Postholm & Smith, 2017, p. 89).

In addition, I asked the teacher to read my interview transcripts and give me feedback. This is a part of the technique of member checking (Stake, 1995, p. 115), which allow an interviewee to eliminate unwanted words or meanings. My observations, together with my conversations with Mr Todd, the interview and his approval of the transcript, serve as multiple sources of evidence (Yin, 2014, p. 121) that support the study's construct validity (Yin, 2014, p. 45).

Stake (1995) claims that in case study research, there is an '[…] ethical obligation to minimize misrepresentation and misunderstanding' (Stake, 1995, p. 109) when analysing or interpreting data. This means there is a need for confirmation to increase credibility in the interpretation of the data material. With this in mind, I turn to Yin, who suggests multiple sources of evidence; thus, different data material are necessary to strengthen the validity of the study and make '(…) converging lines of inquiry' (Yin, 2014, pp. 120–121). Triangulation is typically about corroborating evidence from different sources (Creswell, 2013, p. 251). In this study, several approaches when it comes to data collection have been used to illuminate additional interpretations or confirmations of an understanding. In connection to this, the students' views have been emphasised, as they have been considered important collaboration partners with experience with not only digital games, but also how it is to be a child today.

4.8.1. Children as competent collaboration partners

Some of the contemporary related research was conducted primarily on children, not with children (Beavis et al., 2015). Alternatively, this case study had its focus on the latter, for which there are several reasons. The first is ethical. The focus in schools is on

learning; this is an undeniable statement. According to Jessen (2011) and Gee (2013), the use of digital games in schools is related to achieving pedagogical goals. The students in schools are not necessarily asked about their views, which is interesting because they know best how it is to be a student (Nilsen, 2010). The second reason is an acknowledgment of students as competent users of digital technology. This reason is connected to them as consumers of, for instance, digital games. The third reason is connected to the choice of research. In which way can children contribute and at the same time receive something meaningful to them in return? How can I, as a researcher, strive to ensure that their time spent on research is somehow valuable to them? What does the research have to offer? I think this view is an important acknowledgement of their time, and it is not necessarily reasonable to use children's time in the name of research. In the case of digital games, I think adults do not keep up with the development of digital games, and children have much important knowledge with which they can contribute. As I experienced, it was interesting to them to speak to me about something they mastered, as well as that they could influence the content of the tasks, informing the teacher and me about possibilities. Furthermore, perhaps the most important factor is that the students were familiar with this educational tool and their teacher was not. Their contribution was exclusive and possibly gave them the experience of a comprehensive skilfulness.

5. Summary of articles and discussion of findings

In this chapter, the three articles that together represent the conducted research and constitute the thesis will be summarised. The focus will be on the key findings from each article, which together address the overarching research question, ***'What conditions are required in an intervention study where Minecraft is used as a mediating artefact in the classroom'?***

This classroom research is framed within DWR (Engeström, 2015; Virkkunen & Newnham, 2013) and is approached as a case study, specified as a formative intervention, in a single primary school classroom of 27 students aged 11 and 12 years and two teachers.

As stated in the introductory part of this extended abstract, the aim of this thesis has been to explore what can be drawn from a formative Change Laboratory intervention when it comes to students and teachers' experiences using Minecraft as an educational tool in mathematics. The study has also been concerned with what can be learned from a collaboration in a primary school between a researcher and a practitioner. The initial phase of such a collaboration has been especially emphasised as particularly interesting to investigate as the larger unit of analysis and thus a phenomenon of interest. This has been given attention in the methodological part of the extended abstract.

In the following text, the articles will be summarised with their respective research questions and with special attention paid to the findings and what they may have contributed in my answers to the overall research question and thus to the field of educational research. The articles are numbered and presented in the order in which I started working with them, not according to their publication. They have had this numbering—as a working title—throughout the entire process of this thesis. I have chosen to keep this practical arrangement. This is because it presents a developmental timeline showing that the focus on experiences with Minecraft as an educational tool was maintained when working with article 2 about the teacher's new insights into the position a teacher should take when working with Minecraft, into the research situation itself and into the phases that emerged during this study.

Later, I will provide an overview, in a table, of the articles, including a short summary of the findings. A discussion of the findings in connection to the overarching research question will follow.

5.1.1. Article 1: 'I'll have everything in diamonds!' Students' experiences with Minecraft at school

The research question that was posed in article 1 was, 'How do students experience the use of Minecraft in their classroom, and what are the consequences for their motivation'? In this article, the focus has been on the students' experiences, including what the teacher and I could draw from their experiences in connection to motivation for mathematics lessons. It has been both interesting and important to explore what students themselves express about the use of Minecraft as an educational tool in their mathematics lessons. Students were highly positive thorough the whole intervention, even though it lasted one and a half years. When I asked a group of students after the last lesson with Minecraft if there was too much Minecraft, they answered clearly, 'No'. In this article, it is emphasised that it should not be taken for granted that students show a positive attitude when teachers are trying to exploit digital games in their lessons to reach educational goals.

Furthermore, a special focus is emphasised concerning students' motivations and motives for working with the mathematics tasks. According to observations made by the teacher and me, there were differences between Group A and Group B. The teacher and I observed that in Group B, the working process was different. Students worked in a more dedicated manner, showing how they managed to solve the tasks using Minecraft. They did also take screenshots from Minecraft. The teacher was surprised that this group was more interested in working with the tasks. The main argument given by the teacher for splitting this class into groups was that Group B needed more support. Teachers in this class have divided this class into two groups, and this has been practiced for a while during some lessons. The teacher with whom I collaborated wanted to keep this arrangement during the intervention, as well. According to the teacher, the students from Group B managed well on their own during the lessons with Minecraft, but some were unsure of whether they were learning. The same situation was found in Group A.

Students from Group A developed an alternative object about their mathematics lessons during the intervention: fooling around. They did the tasks, but were highly interested in discussing different things they have managed in Minecraft. For instance, they wanted to talk about how they built a crafting table and that they could make weapons for other students. This additional and creative activity (Abrams, 2017; Canossa et al., 2013) allowed them to express many things, such as satisfaction, openness and pride. Various emotions appeared that give an understanding of the overall Minecraft experience (Abrams, 2017).

The findings from this article can be summarised that Groups A and B had different motives when working with the tasks and that motivation was double-sided. In Group A, motivation appeared when students played or talked about playing Minecraft, but in Group B, motivation appeared for mathematics tasks when students worked dedicatedly to complete them in Minecraft. As the intervention proceeded, it became clear that students in Group A created their own new object (Engeström, 2015): fooling around. Fooling around can be described as doing something other than the tasks, that is, to play, such as by 'hang[ing] some zombies'.

In this article, I discussed how Minecraft offers enough space for students to discover possibilities in collaboration with each other. Regardless, not everything they did was according to the curriculum, and this shows what a popular game from the youth culture can bring to teaching. Such a study as this can provide teachers with some inspiration for thinking about the manner of selecting, introducing and using digital games when it comes to a particular subject and, in addition, the choice about the game itself. For instance, both boys and girls show an interest in Minecraft.

5.1.2. Article 2: Teaching at stake! In search of a teacher's experiences from an intervention with Minecraft

The research question in article 2 was, 'How does the teacher experience the use of Minecraft and what are the implications for his understanding and involvement in the intervention'? This second article is about the teacher with whom I was collaborating and his experiences with Minecraft. Minecraft was a new educational tool for him. He had never tried it before, but he was brave enough to choose it for his lessons in mathematics knowing that most of his students played this game in their leisure time.

One interview with the teacher at the end of the autumn term was selected because it crystallises the teacher's reflections and experiences. This interview was conducted to summarise the half-year of the intervention and to plan the spring term. During this interview, the teacher highlights who he is as a teacher, reflecting on what is needed from a teacher who uses digital games in his classroom.

Describing himself as a traditional teacher, he explained that he needed support to try something new, such as this popular digital game. He also expressed that he is open to projects such as this intervention, and it was not odd to think differently or non-traditionally.

The teacher experienced new insights into the position a teacher should take when working with Minecraft in such a learner-centred working context, as described in the article. In connection to this, the teacher found himself more akin to a facilitator in action (Cuban, 2001) trying to be present and able to answer questions. On the contrary, a more traditional teacher is likely found in front of a blackboard (Cipollone et al., 2014). To be a facilitator, a teacher must be in situations with his students and try to meet them in their lived experiences (Callaghan, 2016).

He also included in his reflections that a teacher could learn from using digital games as educational tools. This can be understood as arguing that teachers must stay up-to-date with digital games, and treat these games as he or she would treat any other educational tool. Such a view requires some efforts from the teacher. However, it does not necessarily mean that a teacher must be genuinely interested in Minecraft or other digital games (Cipollone et al., 2014).

The implications that can be drawn from the teacher's experience is that classroom management should be loosened up so the teacher's role becomes more akin to a facilitator. The teacher's focus was also on varying educational methods to increase students' motivation. He emphasised that experiences familiar to the students could be used for teaching. The implications were understood as repositioning the teacher, and they are captured in an abstract understanding of the teacher as the 'breakthrough adopter'. This concept of 'breakthrough adopter' concerns Mr Todd's understanding of himself as a teacher when he acknowledged that a teacher should be more like a facilitator when using Minecraft. The teacher created a new type of agency that corresponded to what the new activity required.

5.1.3. Article 3: Exploring initial collaboration in an intervention: Creating a meeting place between educational research and educational practice

To investigate how the beginning of an intervention contributes to important collaboration between the collaboration partners, I asked the following research question in article 3: 'How does initial collaboration between a researcher and practitioners create a meeting place, and what implications can be drawn from this'?

This third article explores the initial phase of the intervention, with a special focus on the dialogue between the collaboration partners, both before the beginning of the collaboration and during the collaboration. After conducting a situational analysis (Clarke, 2015; Clarke et al., 2018) and discovering that e-mails were discursively related (Virkkunen & Newnham, 2013, p. 113) to most of the other elements, I then moved forward with the analysis of the e-mails. Three phases were identified. In addition, the contradictions (Engeström & Sannino, 2011) that emerged were also outlined in these phases.

The first phase was about gaining admittance from the principal. Furthermore, in the first phase, the principal expresses uncertainty about whether teachers would find such a collaboration beneficial. This might be a dilemma for the principal. When I asked about teachers' needs, he wanted me to concretise what I had in mind, writing, 'We could hope that someone would join this collaboration'. This could be a beginning expression of helplessness, such as in double binds (Engeström & Sannino, 2011, p. 375). However, I did not draw a conclusion in the article about this because the overall tone in the e-mail was encouraging. Regardless, the situation was resolved with Mr Todd. The teacher had a clear suggestion about the collaboration. The beginning of the collaboration with Mr Todd started in the second phase. Continuous dialogue was maintained using e-mail planning activities. One conflict started to emerge when the ICT-responsible teacher had no time to install Minecraft. As I see it, if the e-mail correspondence had stopped, particularly about this matter, further activity in the intervention would be difficult. To secure the installation of the game, we entered into a compromise where I offered to lead lessons in his class. Mr Todd also had one dilemma: he did not know how to use Minecraft, but he had no problem with reformulating his role in the introductory lesson and becoming a student.

In the third phase, I was obliged to design the tasks to facilitate the collaboration. In this phase, the second teacher, Mr Marvin, joined the intervention. The e-mails from the third phase show that both teachers had positive responses to the received tasks, but they also demonstrated that they did not make many suggestions themselves. Due to lack of time, it seems the teachers were expecting the researcher to make suggestions.

As I see it, if the e-mail correspondence had stopped, the further activity in the intervention would be limited or even impossible. It must be remembered that while the e-mail correspondence was not the only form of communication, it structures the different steps that were taken. Because the e-mails show the continuity of the dialogue, it is reasonable to assume they were important during the intervention. I think the dialogue kept the space open, which was essential for the intervention to proceed with the object-oriented activity (Sannino et al., 2016) in the third phase. Dialogue was in this article understood as something essential for developing a space in which the researcher, the practitioners—that is, the collaborating teachers—and I could meet. By continuing the dialogue, both parties created and expanded the space where the activity could be realised. Conversely, withdrawal from or closing the dialogue would end the collaboration. It is reasonable to assume that the participants perceived the dialogue as satisfying when they continued engaging in it and contributed to further action, which was to organise and complete lessons in mathematics using Minecraft. A model has been developed to grasp the essence of the study (Engeström, 2016, p. 42). It represents the continuation and expansion of dialogue through a mediating artefact facilitating a meeting place that works towards realising an object-oriented activity, that is, from words to practical actions, as emphasised in a Change Laboratory (Sannino, 2008, p. 237).

Practical implications from this study may be that phases in other studies can be compared to or analysed with the help of the phases that emerged during this study. This article did emphasise the need for research that aims to clarify the importance of the initial phases in a formative Change Laboratory intervention and that further empirical studies are needed to question and refine phases that may appear in transformative studies, especially with a focus on the initial phases and what they may

lead to. In addition, contradictions are interesting to explore when it comes to the initial phases, especially with a focus on how they appear and may be resolved.

5.2. Discussion of findings

In this section of chapter 5, I will discuss the findings presented in the three articles above. The objective here is to examine them from a more coherent perspective in an attempt to unify them and relate them to the overarching research question: 'What conditions are required in an intervention study where Minecraft is used as a mediating artefact in the classroom'?

In Table 5 below, an overview of the articles, including a short summary of the findings, is provided.

This part of the last chapter contains a discussion based on the contribution from each article, as summarised in Table 5, about how the articles together are contributing to answer the overarching research question. Then, there will be an attempt to combine the articles by exploring closer the dialectic movement of the object thorough the entire study. Furthermore, I will attempt to discuss the contribution from CHAT to this classroom research, particularly concerning what can be gained from such an understanding of a changing object, which is a central notion when employing CHAT. Then, I will examine briefly the limitation of this study and conclude with the contribution of this study to other similar studies in the future.

Table 5. An overview of the thesis with accompanying articles

The overall aim: To explore what can be learned about a formative Change Laboratory intervention between a researcher and practitioners, as well as what experiences could be drawn regarding students and teachers using a digital game as an educational tool. **The overarching research question:** What conditions are required in an intervention study where Minecraft is used as a mediating artefact in the classroom?			
Theoretical framework: Cultural–historical activity theory (CHAT)			
Empirical grounding: A formative Change Laboratory intervention conducted in a primary school context in a class with 11 girls and 16 boys aged 11 and 12 years and with two teachers.			
Title	**Research question**	**Main data**	**Findings**
Article 1: 'I'll have everything in diamonds!' Students' experiences with Minecraft at school	'How do students experience the use of Minecraft in their classroom and what are the consequences for their motivation'?	- Recordings of eight single semi-structured interviews - Recordings of eight focus group interviews with four students every time - Notes from participant observations - Recordings of four conversations with the teacher during lessons	Students show a positivity throughout the whole intervention, but some were unsure of whether they were learning mathematics this way. Students' motives to work in Minecraft differ. Group A developed their own object, fooling around, while Group B worked dedicatedly with the tasks.
Article 2: Teaching at stake! In search of a teacher's experiences from an intervention with Minecraft	'How does the teacher experience the use of Minecraft and what are the implications for his understanding and involvement in the intervention'?	Interview with the teacher	The teacher describes himself as a traditional teacher. He is experiencing new insights into what is needed from a teacher using digital games, and he found himself to be a facilitator in action. The concept 'breakthrough adopter' is suggested to capture this type of agency.
Article 3: Exploring initial collaboration in an intervention: Creating a meeting place between educational research and educational practice	'How does initial collaboration between a researcher and practitioners create a meeting place and what implications can be drawn from this'?	- 56 e-mails, a correspondence connected to the intervention - Various elements of concern found in the research situation capture the different phases of the collaboration	E-mails were experienced as discursively related to most of the other elements in the case study. Three phases were identified that show the importance of continuity in this e-mail dialogue. An abstract model aims to grasp the continuation and expansion of a dialogue concerning an object-oriented activity: lessons using Minecraft in mathematics.

5.2.1. Tracing the answer to the research question

Table 5 above summarises the different findings in this study. These findings, as they were brought into being, construct the different conditions that were found when trying to realise this research.

First, such a study as this requires time and some unexpected effort to be made, as disclosed in the third article. As the three phases detected in the collaboration show, to ensure continuity of the dialogue, the dialogue must be emphasised as essential and not taken for granted. It must cautiously be given necessary attention, even if it is time consuming. I think this is connected to the researcher's responsibility for the research situation, and it has an ethical dimension about not spending unnecessary time away from the participants' busy workdays.

Second, as a multi-voiced collaboration, the students' voices have been a fruitful part of this study. Their collaborative agency gave better insight into their experiences and important understanding of possibilities in connection to the educational tool, Minecraft, which we were using. The teachers and I have, along with the students, explored some of their suggestions, but there were more to explore, meaning the intervention could continue over a longer period with the teacher, Mr Marvin, than it did. I interpret this as there being a need for other studies, because the potential of Minecraft has not yet been uncovered. I think that considering the 'potential' and 'possibility' in a stated aim of a collaboration can be done by leaning on other research. In the beginning, Mr Todd and I started to explore different research about Minecraft, and we discovered that this digital game has much to offer. Moreover, the students' positivity from the beginning and throughout the whole intervention made it easy to employ Minecraft as an educational tool and to explore some of this game's potential.

Third, the teacher, Mr Todd, also made some essential reflections about his position as a teacher, and he described reconsiderations about using digital games, where the teacher is more akin to a facilitator in action after experiencing the use of the game. The teacher recognised the students' positive attitudes and dedication during the lessons as motivation and wanted to continue with Minecraft in the subject of mathematics. The teacher's new insights into the possibilities using this particular digital game led me to the concept of the 'breakthrough adopter' in an attempt to

explain the expansive learning process found in the teacher's activity system. Thus, the possibilities offered by Minecraft address a rethinking of the role of the teacher, but it is up to the teacher to decide whether any transition from teacher to facilitator should occur.

For the fourth, in relation to the overarching question, the object in the intervention has been changing, especially when it comes to the students who created the new object 'fooling around', where their motive was then to finish the tasks as fast as they could so they could do other things. When working with such a commercial digital game, it may be reasonable to keep in mind that there is a possibility that the outcome may be not occur as planned and that the object can be transformed into something unexpected. It must be clarified at the beginning of a study—in an attempt to strengthen its resistance—that the study must be invulnerable to such an unexpected turn and must survive. I think this condition should be required in start-up phases and should furthermore awaken enough curiosity to be explored further. Working with a digital game using CHAT, this research offers the potential to work with something new that is changing rapidly. Students' interest in the game could fall because of a newer game, and the game itself may have to be upgraded. There is a reasonable chance that something unpredictable could happen.

I do not suggest that such findings as discussed above be required in similar studies, but they show an example of what may be expected. The contribution from the articles emphasises different parts of the research. The multi-voiced approach also gives attention to the fact that members of the community have their own understanding of the object. Further, I will follow the object using the third generation of the activity system (Engeström, 2015; Engeström & Sannino, 2010; Virkkunen & Newnham, 2013) to illuminate how it has changed through the collaboration.

5.2.2. Tracing the object of the intervention

In this section, I will be using the third generation of the activity system (Engeström, 2015; Engeström & Sannino, 2010; Virkkunen & Newnham, 2013) to show how the detected activity systems from this research are involved in the construction of a shared object. According to CHAT, an activity system is built around its object (Engeström, 2016), thus making the object of essential importance and interesting to pursue to gain

more information about what actually happened in the intervention. An example of the importance of understanding the changing object is shown in the study by Lund and Hauge (2011a).

The activity systems presented below in Figures 9, 10 and 11 are based on the earlier presented general model of an activity system, adapted from Engeström (1999a, 2015, 2016) and shown in chapter 3 in Figure 2.

Figure 9 presents the researcher's activity system in interactions with the principal's activity system. The dialogue between the principal and researcher has been, according to CHAT, a culturally evolved tool based in previous experiences that has contributed to the construction of a shared object. The objects, as shown in the round figures, overlap each other, showing the shared object as it has evolved during the dialogue.

In article 3, the principal's dilemma that appeared during the first phase about his interest in collaboration and teachers' shortage of time is outlined in Figure 2. Therefore, as I see it, our construction of the shared object never actually ended, but was somehow interrupted or saved by Mr Todd, the first teacher. This is in line with what may be expected concerning the achievement of a shared object (Engeström, 2016), and it was especially visible between the principal and me.

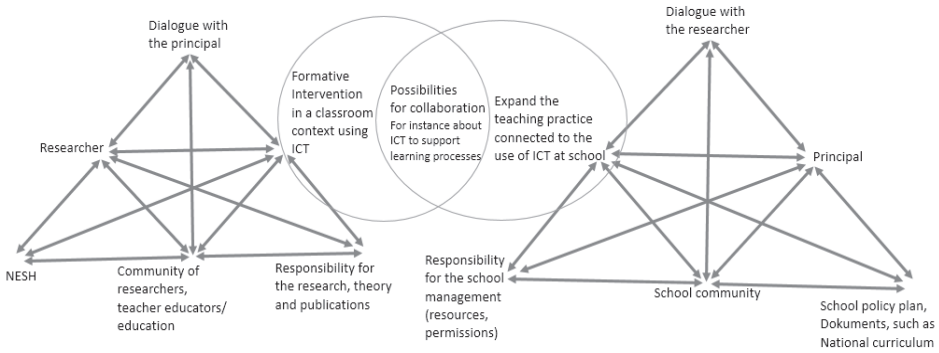

Figure 9. Researcher's activity system and principal's activity system, and the construction of their shared object (adapted from Engeström, 1999a, 2015, 2016)

However, the collaboration as a possibility was something we did share, and it contributed to resolving our dilemmas. Mine dilemma was about how to realise classroom research using ICT, where the need was defined by the teachers and the

principal's was about expanding the school's teaching practice using ICT. The dialogue between the principal and me, presented in article 3, reveals the contradictions.

During the initial phase of this intervention, the teacher, Mr Todd, formed a concretised purpose for a collaboration. He had an actual need to expand his teaching practice because he was worried about students' interest in the subject of mathematics. He described that their motivation was decreasing and that it was important to do something about this. The teacher's object is shown in Figure 10 below. The round

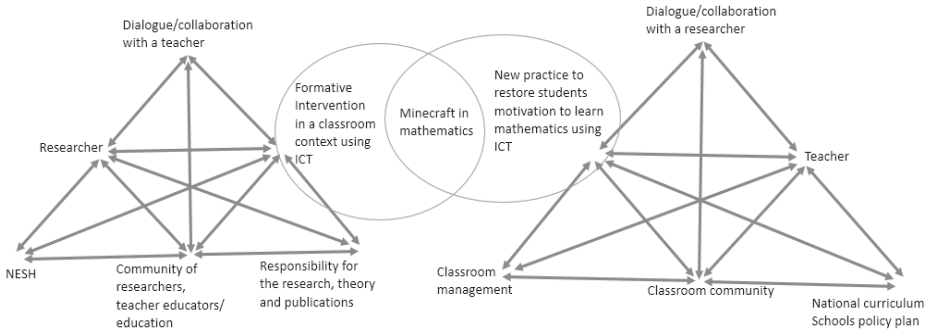

Figure 10. Researcher's activity system and teacher's activity system, and the construction of their shared object (Adapted from Engeström, 1999a, 2015, 2016)

figures, where they overlap, show the clarified object, constructed in collaboration between the teacher and me; it defines the main purpose of the intervention and it was constructed during our dialogue in the initial phase. This object was presented for the students before we started our lessons using Minecraft. Mr Todd's experiences about exploring a new—to him—educational tool are described in article 2. In his activity system, some changes were made in every constituent in the model, as shown in Figure 2 in article 2. He did interpret the students' activity as motivation, and he reconsidered the position of a teacher when it comes to the use of Minecraft as a new educational tool. He stated that such an educational tool provides new challenges for teachers.

After some lessons, it was possible to detect students' motives working with Minecraft. In article 1, the observed motivation was explored further, and variation between the students was found. It was especially clear that Group A developed their own object, 'fooling around', as depicted in Figure 11. The students in Group B seemed to have adopted the overall object as it was explained by the teacher and me. They

wanted to continue to work with the tasks in mathematics even though the lesson was finished. The object regarding the lessons is problematized in article 1. An interesting discussion occurred about the object and the understanding of how the object developed among the students. One student expressed interest from Group A especially clearly. They developed an understanding, a norm, in the classroom community that when they are finished with their task, then they can do whatever they want. This notion was connected to Minecraft and not to the books. This shows that such an analysis using activity systems can give the notion that participants' various motives can occur simultaneously. Furthermore, when looking at the students' processes of internalisation and externalisation (Engeström, 1999a), the students achieved enough competence to be able to suggest tasks for the future of learning, not only in mathematics, but also in other subjects.

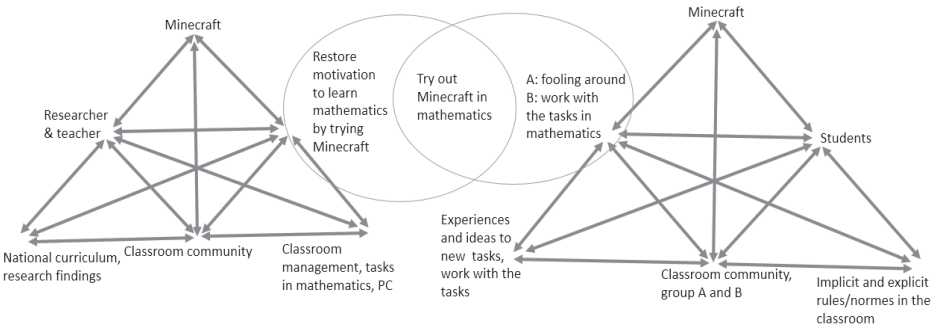

Figure 11. Researcher's and teacher's activity systems combined, and the students' activity system with the construction of the new object from Group A (adapted from Engeström, 1999a, 2015, 2016)

In summary, the object has been transformed and interpreted during the different phases, various activities and several participants in relation to this case study and it can be traced across the associated articles. The teacher's object from joining this collaboration is outlined in all the articles. The researcher's object is outlined in article 3. Especially in article 3, it is possible to trace how the researcher and teacher's objects meet. In article 1, we meet students and their transformation of the object through the insight into students' motives and dedication to work with the tasks in mathematics. Nevertheless, the teacher expresses in article 2 that the goal has been achieved and that

he has developed an understanding of what is needed from a teacher using a digital game as an educational tool.

5.2.3. Tracing the contribution and challenges of using CHAT

CHAT is according to Nussbaumer (2012) adaptable and applicable to many disciplines and has during the last two decades met interest in the field of educational research. One reason for this may be that the theory is recognised because of its focus on *collaborative aspects* of learning, accounting for complex situations. A classroom context with everything that is happening, including planning activities, is such a complex situation. In this thesis, this collaborative aspect has been emphasised in various ways and is represented in the three articles.

In the third article, the collaboration can be described as a fruitful collaboration between the researcher and the practitioners, as the achievement of activities in the real-life context was realised. Furthermore, this collaboration has made it possible to trace the mapping of the various contradictions that emerged during the study. When the participants did succeed in overcoming the contradictions, the next steps could be realised. In this way, the research presented in this thesis could be helpful to show how a project could move forward despite obstacles that may occur in particular periods in a study. In article 2, the collaborative aspect did not receive much attention and it is not presented as something essential because the article is driven by another focus, as stated in the research question. Nevertheless, the importance of a collaborative aspect is brought into being by the teacher, Mr Todd, expressing that the researcher has been a resource and that he, describing himself as a traditionalistic teacher, needed the support of another competent adult to work on a project like this. In article 1, the collaborative aspect manifested itself in different ways. It showed itself as a collaboration between students completing tasks and other activities that are not necessarily connected to the given tasks in mathematics. Furthermore, the collaboration is concerned with students sharing their experiences with each other and the researcher about the use of Minecraft in mathematics, as well as suggestions that they construct together during the focus group interviews. The collaborative aspect is also connected to the dialogues between the researcher and the teacher during lessons about the activity they are experiencing.

It is concluded in article 3 that the collaboration and the continuity of the dialogue have been fruitful. The further activity in the intervention is documented in articles 1 and 2. With a foundation in CHAT, this thesis addresses collaboration as something essential that manifests itself in the intervention, as shown in the articles.

The concepts of an *activity system* and *the third generation of activity system* have helped to uncover the distinction between the object as presented for the students, which was the purpose of the intervention expressed by the teacher and me, and the actual outcome that is traced from several empirical sources and shown in article 1. Informed by the concept of an activity system, it has been possible to illuminate students' involvement in and influence on the intervention as it progressed. Their collaboration had an impact on the tasks, on planning and on shared experiences. The students' positivity is clear in article 1, and I point out that such positivity should not be taken for granted. It facilitates the emergence of developmental processes. The teacher also shows a kind of interest that may be understood as positivity. This can be anchored to what he expresses about his observations. In articles 1 and 2, he states that students are motivated and that it is nice to see. He talks positively about the collaboration with the researcher and that he is open to such projects in his classroom. The use of an interesting artefact as an educational tool can have such an impact on this collaboration.

The impact of *nonhuman actants* has a potential to be explored more in connection to the understanding of *cultural artefacts*. This may be challenging and even bold, but new technology, including such popular games as Minecraft, develops fast and it should be continuously questioned. CHAT helped me to explore and analyse the experience gained from Minecraft within this case study; thus, it is given prominent importance in this thesis. The concept of *mediating artefacts* had an important impact on the understanding of Minecraft as an educational tool. A challenging understanding of Minecraft could be presented with the help of Clarke (Clarke, 2015; Clarke et al., 2018). As mentioned earlier, one of the important reasons for applying situational analysis was that this method is concerned with mapping the relation among various elements in a research situation. This also includes nonhuman elements, such as digital technology. For instance, in this study, the nonhuman elements could be Minecraft or the e-mails. However, it must be noted that Engeström does not understand nonhuman elements as 'actants', as Clarke does (2015, pp. 91–95), but rather places a strong

emphasis on the role of artefacts in mediating activity among humans (Blackler, 2009, p. 31). Thus, humans use culturally evolved artefacts as tools to reach their goals. This approach to digital technology has been visible during this study. Virkkunen and Newnham (2013, p. 39) express, 'Tools are cultural mediators that are used for changing the external world.' This refers to the principle of 'double stimulation' (Engeström, 2015, 2016; Sannino, 2015) mentioned earlier. Situational analysis has helped me to discover the importance of various elements in the research process when sitting on the 'transparent roof' (Postholm & Moen, 2011, p. 399) analysing the research situation itself. That said, a further understanding of Minecraft or e-mails has been as mediating artefacts that were necessary means for the continuity of the different phases of the study, including the activity in the classroom, and not that they had their own agency (Clarke, 2015, p. 92).

In CHAT, the participants use artefacts that are considered necessary for learning. The understanding is that the artefacts work only when they are used by the participant in a context through their work (Blackler, 2009). The artefacts do not work by themselves. This view is challenged by Clarke and her colleagues (Clarke, 2015; Clarke et al., 2018). Nonhuman actants have a serious and important position in situational analysis that suggested to be agentic. In this thesis, the nonhuman actants could be described as the technology used with its own agency and as discourses that could be detected and analysed. Clarke calls such a procedure 'helping silences to speak' (Clarke, 2015, pp. 105–108). She expresses also that 'adequate analyses of situations being researched must include the nonhuman explicitly and in considerable detail' (Clarke, 2015, p. 92). Here, I identify the possibility of another interpretation to challenge the interpretation using CHAT. The visible positivity of the students during the intervention could be suggested to be a consequence of contextual elements, that is, from the digital game Minecraft, which is not only an educational tool waiting to be used by the participants, but is somehow constitutive of the situation itself. There are other contextual elements to be detected and analysed than the digital game in this research, for instance, the computers or the material classroom. However, what I want to illuminate is that the understanding, especially regarding ICT, could be different by recognising nonhuman actants as agents with contextual power. Besides the fact that

this may draw attention to a more postmodern turn,[24] contrasting the focus about participants' activity using cultural artefacts and a discourse analysis about nonhuman actants can evoke more reflexivity about interpretations made (Alvesson & Sköldberg, 2009). More research should be done to follow and problematize the gap between the understanding of cultural artefacts and nonhuman actants and the implications or consequences this may have for the field of educational research regarding the understanding of ICT in connection to various subjects, students, teachers and research contexts. There is an inherent potential to explore digital games as *'tertiary artefacts'* (Cole, 2005, p. 91), as it is explained in the research conducted by Cole (2005). Regarding this, one interesting question arises about how digital games can be qualified as 'tertiary artefacts' compared to what constitutes a relatively autonomous imagined world (Wartofsky, 1979, p. 208) as a tertiary artefact.

5.3. Contributions, limitations and concluding remarks about further research

Largely, the methodological contribution of this thesis relates to approaching the interventions, with a special focus on an analysis of the initial phase of collaboration, as shown in article 3. Article 3 pointed out the need for research that aims to clarify the importance of the initial phase in a formative Change Laboratory intervention. Based on research from the field of education, I tried to map the initial phases of a collaboration in the context of the whole intervention. The initial collaboration has a serious impact on the further development of a study, and it deserves more research and to be incorporated into the overarching thinking concerning formative Change Laboratory interventions and in methodological choices, such as in case studies. Attention, both methodological and theoretical, should be directed as early as possible towards collaboration and dialogue when planning an intervention. For instance, dialogue may exist without further collaboration, as the contradictions in this study may indicate if they were not solved. However, if we turn it around to make a rhetorical point saying 'a collaboration without dialogue', it will not make sense. From a logical viewpoint, a fruitful dialogue must be established as an essential basis for collaboration. This study

[24] Alvesson and Skõldberg (2009, p. 76) say that Clarke is pulling grounded theory around the postmodern turn and is inspired by discourse analysis.

shows that effort must be made at the beginning of a study to keep the continuity of a dialogue.

Various activities were achieved in one single classroom during this study. These achievements are not necessarily a strong base for making arguments about what could go wrong, and an initial phase has a clearly essential importance. Nevertheless, with the help of CHAT and the concept of contradictions, it is possible to trace some of the pitfalls and challenges that occurred during the transformative processes in this study that could have spoiled the various sequences of learning actions if they were not solved. From an analytical viewpoint, this thesis demonstrates the need for attention to be paid to what may be required already from the start when planning and making first attempts to communicate about an intervention study. Time is often an insufficient resource in schools, and for me, sensitivity to this has been connected to ethical considerations as a researcher. In connection to this, I will also call attention to the second teacher, Mr Marvin, who adopted the intervention and made it possible to continue. It was not possible for me to have access to the planned or informal meetings between Mr Todd and Mr Marvin. However, the object of the intervention has moved from Mr Todd and was received by Mr Marvin, in addition to my and the students' transmission of information. Mr Marvin's activity system was not explored, mainly because after his entrance into the intervention, the students' activity was in focus. However, now, from a retrospective viewpoint, following this up could be the next step for me to take.

Another weakness of this study is that learning outcomes from using Minecraft have not been followed sufficiently enough, despite the fact that outcomes were something with which the students were to some extent occupied. Learning outcomes are mentioned in article 1 in connection to game-based learning (Beavis et al., 2015) and especially in connection to the use of Minecraft in schools (Abrams, 2017; Niemeyer & Gerber, 2015). Nevertheless, 'learning outcomes' had to share the space with 'play' (Huizinga, 1955; Jessen, 2011) and 'motivation' (Canossa et al., 2013; Plass et al., 2015; Sáez-López et al., 2015; Turkay et al., 2014), and they have not been the teacher's main concern, as he expresses in article 2.

In this study, the focus was also on involving students, who know best about being students nowadays (Nilsen, 2010). This is connected to the use of the commercial

digital game Minecraft, their competence and, especially, the ethical consideration of involving students in research and giving them a voice. The intervention gained many innovative ideas from the students for further development regarding the use of Minecraft. The experiences from all parts involved show that the students were positive and cooperative during the whole intervention. The contribution from this study is, as I see it, the involvement of students in the Change Laboratory, where the students are given active agency with the possibility of influencing the intervention and its development. They are not only a class that has to complete some tasks. Thus, it was possible to detect their motives and efforts. According to some researchers, most studies about digital games have been written about children, not with children (Beavis et al., 2015; Wernholm & Vigmo, 2015). The third generation of an activity system has been shown to be a necessary means of making it possible to include children in an intervention research such as this.

When it comes to students, this study did not address specifically any differences that might have arisen between girls and boys. The main reason is that Minecraft has gained popularity with both girls and boys, and the teacher's observations support this (Jarvoll, 2018b). In addition, the focus was concentrated on the differences between Groups A and B. However, the potential that lays in CHAT can be exploited to follow girls and boys concerning the use of digital games in school and in other contexts, as shown in the study conducted by Rizzo et al. (2012). Furthermore, the described study by Engerman et al. (2018) about how boys may be re-engaged in traditional classroom settings shows interesting potential and possibilities that have to be developed in future classroom research employing digital games and CHAT.

On several occasions, I have been asked and I have asked myself what makes this study a formative Change Laboratory intervention. A Change Laboratory takes into account the tasks being carried out in a context. For this reason, it has been important to show how an initial collaboration can be brought into being. From this project, I have experienced that an intervention needs time to develop before it can be described as a formative Change Laboratory intervention. My aim in article 3 has been to address this point by showing how a timeline can be depicted before a project can be referred to as a project and meet the requirements regarding being a formative intervention. In addition, I have outlined earlier differences between a formative intervention and two related

approaches, action research and design research, which have actually been processes that are not quite visible in the short text, but have led me to understand this intervention as a formative intervention. The notion of activity has been a support. One single action, trying a digital game in one lesson, could not contribute to expansive learning, but simply to a single experience with a start and an end. The collective reproduction of seemingly similar actions that repeat without a predetermined endpoint describes what activity means in CHAT (Engeström, 2016; Leontjev, 2002). After many sessions trying out different tasks and solutions, even when another teacher joined this class, the activity with Minecraft continued. Despite enjoying being with the class, I started to worry about what would happen with their activity when my contribution to the project ends. I received an answer to this question. Unfortunately, it has a methodological limitation. After an informal talk recently with a teacher who was not directly involved in the study but who had shown some interest earlier, I have been informed that students from the school now have the opportunity to work with Minecraft in the elective subject of Technology in practice.[25] The students are mixed when it comes to the class level; thus, some of the students who originally joined this intervention participate in this elective subject. In short, the researcher has left the school building, but the activity continues.

[25] The subject is known as 'Teknologi i praksis': https://www.udir.no/kl06/TPR1-01?lplang=http://data.udir.no/kl06/eng

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Appendices

The Norwegian text is translated to English by Semantix.no

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

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Our date: 6 May 2015 | Our ref: 42879 / 3 / KH | Your date: | Your ref:

FEEDBACK ON NOTIFICATION RE. PERSONAL DATA PROCESSING

We refer to your notification relating to the processing of personal data, received on 20 March 2015, applies to the following project:

42879	*Digital Natives and Learning Processes in Schools*
Executive Officer	*Nesna University College, c/o Head of Department*
Manager	*Agnieszka B. Jarvoll*

The Data Protection Officer has considered this project and has found that the processing of personal data should be reported in accordance with Section 31 of the Norwegian Personal Data Act. Such processing complies with the provisions contained in the Norwegian Personal Data Act.

The Data Protection Officer's assessment is conditional on the fact that the project should be undertaken in line with the information provided on the notification form, correspondence with the Data Protection Officer and the Data Protection Officer's comments, as well as the Norwegian Personal Data Act and the Norwegian Act on Personal Health Data Filing Systems and its appurtenant regulations. The processing of personal data may be initiated.

You should be aware that further notification should be submitted if the processing differs from the information on which the Data Protection Officer's assessment is based. Change reports shall be submitted on a separate form, http://www.nsd.uib.no/personvern/meldeplikt/skjema.html. Notification shall also be provided after three years if the project is still in progress. Notification shall be submitted in writing to the Data Protection Officer.

The Data Protection Officer has entered information about the project on a public database, http://pvo.nsd.no/prosjekt.

When the project ends, on 1 August 2018, the Data Protection Officer will submit an enquiry relating to the status of the processing of personal data.

Yours sincerely

Katrine Utaaker Segadal

Kjersti Haugstvedt

Contact: Kjersti Haugstvedt tel. 55 58 29 53 Enc.:
Project Assessment

Data Protection Officer for Research

Project Assessment -
Comments

Project no: 42879

The Data Protection Officer is operating on the premise that the project has been cleared with the municipality/school management.

The study shall be undertaken as an action research project which will involve using the computer game, Minecraft, for teaching mathematics. Data will be collected by using individual and group interviews, as well as observing the game being played.

The information provided about the study has been suitably prepared. Written consent from the parents shall be obtained. We are operating on the premises that the pupils shall also be informed about the project arrangements.

We are operating on the premise that teacher confidentiality shall not preclude the processing of data.

The project will end on 1 August 2018. The data shall be anonymised by ensuring that neither direct or indirect personally identifiable data shall be disclosed.

Appendix 2:

Interview guide for pupils about using the computer game, Minecraft, for teaching mathematics

Note: the questions have been asked in random order during the interviews depending on what seemed to be most suitable at the time. Additionally, some questions have been changed in this interview guide in an attempt to adjust the interviews to whatever occurred during the specific lessons regarding focus group interviews.

1) Single semi-structured interviews. Prior to teaching

- What do you think about playing Minecraft at school?
- Did you know how to play Minecraft before?
  - Can you tell me a bit about Minecraft? (What happens? What can you do?)
  - How do you usually play at home? (Play after school? Alone or with others?)
  - Do you plan when you are going to play?
- Do you like playing other computer games? (Which games do you like playing? What are they about?)
- Why do you think children like computer games? (Why do you play computer games? If you were going to explain to an adult why children play computer games, what would you say?)

2) Short conversations during lessons, some were recoded using Bandicam software

- How are you getting on? (Is the maths task OK?)
- Can you tell me a bit about what you are working on? What have you done so far?)
- What's it like playing Minecraft in your maths class?
  (Can you tell me a bit about whether or not it is interesting, appealing, fun, boring, difficult, easy, just different?) (- Do you recognise the tasks from your maths book?)

3) Focus group interviews after lessons

- What was it like playing Minecraft today? (Was it what you expected?)
(What was good? What was not so good? What was your maths task like? Was it difficult/easy? Could we have done anything differently?)
- How do you think we could continue working with Minecraft? (What could we work on next time, for example?)
- What have you learnt? (What is most important? Have you learnt anything which has nothing to do with maths?)
- What's it like to use Minecraft for learning maths? (Can you tell me a bit about why it is better/not better? How?)
- Would you like to work this way in your maths classes later on? (Can you have too much Minecraft?)
- How do you like learning maths otherwise? (How do you think you learn best?

Reading books by yourself, listening to the teacher, being out and doing different things?)
- How you think we adults got on when playing Minecraft?
- Would you like to play more/less Minecraft at home too? (- What's it like working on something at school that you have been partly working on during your leisure time?)

Appendix 3:

Interview guide for teachers about using the computer game, Minecraft, for teaching mathematics

Note. the interview conducted during the autumn term of 2015 was adapted to suit the change of teachers in January 2016.
During this interview the questions were asked in a different order that was adjusted to accommodate what was most suitable at the time.

1) Conversations during classes, some of which were recorded on tape

- How are you doing? - Is the maths task OK?
- Can you see anything that could have been done differently?
- Has anything in particular stood out today?

2) Interviews after autumn 2015. Experiences to date?

- How would you describe your class? (Who are they? How have they reacted to playing Minecraft?)
- What have you experienced? (Was it what you expected? Is there anything else we should have done? What do you think about our working methods?)
- Do you think that your pupils have learnt anything? (What is most important? Have they learnt anything which has nothing to do with maths? (What was good? What was not so good? What was the maths task given to your pupils like? Was it difficult/easy? (Difference between the groups?)
- What should we adjust/change for the spring term? (What should we place more emphasis on in order to develop our working methods? Adapt better for the class?)
- What should we work on after Christmas? Topics?
- Do you think that your pupils would like to learn maths with the help of Minecraft later on? - What do you think about your pupils' own suggestions?
- Are there any limits in respect of how much we can use Minecraft in schools? What might any such limits be?
- How do you think we adults got on when playing Minecraft? What do you think is required from the teacher?
- What should the transition to a new teacher be like? How would such a transition be in respect of sharing experiences?

Appendix 4: Tasks in mathematics using Minecraft

What are we going to do today? Week 22, 2015

- **We are going to work in groups. Each group will consist of two or three pupils. One pupil will be a super-user and the other/others will be super-students.**
- **All the groups will solve challenges on a sheet to the best of their ability.**
- **The main task of the super-students will be to learn about Minecraft.**
- **The main task of the super-users will be to teach the super-students about Minecraft.**
- **We have decided that a Minecraft block will be 1x1x1 m.**

Challenges for the groups:

1) **Working with a circumference, area and mirrors and creating two houses with rooms!**
    a. Start by creating a surface with an area of $64m^2$
    b. Build walls with an area of $24m^2$ or $16m^2$
    c. What is the external circumference? ANSWER:
    d. What is the internal circumference? ANSWER:
    e. Create a room which is $4m^2$ or $9m^2$. The walls of the room should be as high as the outer walls.
    f. How large is the second room? ANSWER:
    g. We will create a house which is a mirror image. There should be a total of $16m^2$ between the two buildings.
    h. How many metres away is the mirrored house from the first house? ANSWER:

2) **Working on volume!**
    a. Create a post outside the first house which is 3x3x4 m.
    b. What is the volume of the post? ANSWER:
    c. Create a sculpture on top of the post which is at least 4 metres high, and estimate what the volume of the sculpture might be.

d. Create a sign with the name of the sculpture. Write in your group number as well.

3) **Finishing the houses!**
   a. Build the houses. Create roofs, doors, windows and stairs.
   b. Create a garden. You can also create a fence.

4) **Visit each other and show what you have created!**

Week 41, 2015

Class 6: Maths tasks in Minecraft associated with topics from Chap. 3

1)

In this task you are going to create a house in Minecraft where the floor and walls have patterns. You will choose the patterns yourself.

- The mosaic floor must have at least 20 x 20 blocks.

- The walls must be at least 6 blocks high and have patterns which repeat on each wall.

- Create a sloping roof which is symmetrical.

- Create a balcony! The size of the balcony must be F4 or larger. F1 is:

2) (Extra task)

Work in groups of two.

Pupil 1 will be given a picture which pupil 2 will not be able to see! This is very important!

Pupil 1 will give instructions to pupil 2 who will try to create an identical picture in Minecraft by following the instructions provided by pupil 1.

Pupil 1 will not be allowed to see the picture while is it being created in Minecraft until pupil 2 has finished!

Do the pictures look the same?

Answer: ……..

What is the reason for that?

Answer: ……..

……

Tasks for Week 44, 2015 (the pupils search for tasks in a Minecraft world)

Use the sheet to answer questions 1-4 in Minecraft.

Question 1: What will the calculation be?
Question 2: Provide a brief written explanation about how you have explained 5678 to each other.
Question 3: Provide a brief written explanation about the number you get after several attempts.
Question 4: What will the five-digit number be?

Hint!
You can find a secret message hidden somewhere in question 4! (.... and if you search even more you will find the answer to question 1!)

TASKS IN MINECRAFT:

1) **Fear of big numbers?**
   What is 350,000 x 4?
   It will be easier to work this out if you "forget" the four zeros.
   So you could try working out 35 x 4 first (hint! it's 140!). You can then add the four zeros. And hey presto, you will now have the answer! (**It's 1,400,000)**
   Now it's your turn! Create a calculation in the same way to get an answer of 5,500,000
   (This calculation will look like this: 1,100,000 x 5)

2) **Is 8 x 7 hard to remember?**
   Do you remember what 8 x 7 or 7 x 8 is? (Yep, it's 56!)
   If you turn the calculation round it will look like this: 56 = 7 x 8 and remove the calculation symbols.
   (the multiplication sign x and the total drawn =). What do you get then?
   Yes, something that is easy to remember: 5678! Genius!
   Explain this to each other in your own words!

3) **Magical numbers!**
   - Think of a number between 1 and 10
   - Multiply that number by 9.
   - Add together the digits in the number you get.
   - Subtract 5.

   The answer you get will be… 4!
   Try this twice using different numbers. What has happened? Explain it to each other!

4) **Using your head!**
   We want to get a five-digit number which does not contain a 0, and no numbers that are the same!
   And where:
   - The first number is the same as the number in a pair.
   - The second number is five minus the first number
   - The third number is twice as large as the first number
   - The fourth number is the third number plus three
   - The firth number is the difference between the first and fourth numbers.
   What will that five-digit number be? (answer: 23475)

Minecraft in Schools, Week 45, 2015

We are going to create a classroom in the classroom!

You will work together in groups of two or three and create a mini version of your classroom in Minecraft! Remember to take screenshots of your Minecraft classroom as you proceed!

1) You need to decide what size your blocks will be in Minecraft. You will need to think about the scale. For example, 1 metre in the classroom corresponds to 10 cm in Minecraft. If you decide that one block is 10 cm, 10 blocks will be 1 metre. The classroom in Minecraft would be pretty large. It would be smaller if you decided that one block in Minecraft would be 20 cm, or 25 cm.
Write your decision here:

1m in the classroom corresponds to _____ cm in Minecraft, and 1 block in

Minecraft is _____cm.

2) Measure the classroom!

a) Measure all the walls. How long are they in reality?

- Calculate how many Minecraft blocks long each wall would be and set up the blocks.

b) How high are the walls? (You will probably need to estimate the height here)

- Calculate how many Minecraft blocks high the walls will be. Set up the walls, BUT remember that there are also going to be doors and windows!

c) Measure the windows and doors. You will need to measure the width and height here.

- How many Minecraft blocks will there be for the height and width? Create the windows and doors.

3) **Measure the desks.**

   - How many Minecraft blocks can you use to create a desk?

   - How many desks is there space for? Create the desks.

4) **Measure the whiteboard**

   - How many Minecraft blocks can you use to create a whiteboard? Create the whiteboard.

5) **Is there anything else you can measure and create in your Minecraft classroom?**
6) **Take screenshots!**

Minecraft in Schools, **Week 2, 2016**
Remember to take screenshots! Last 5-10 mins: Brief review of the task in plenary

Fractions

Built a funny, colourful house!
Remember: one Minecraft block is a cube, with each side measuring 1 metre.

a) Start by creating a wall which is 8 metres long and 5 metres high, and where $\frac{5}{10}$ of the wall is yellow and the rest is blue. - What will the fraction be for the blue part of the wall? Answer:

- Can you write this fraction using smaller numbers? Answer:

b) The next wall is $\frac{2}{4}$ longer than the first wall. It is important that the two walls create a 90° corner. Build the wall. $\frac{50}{50}$ of this wall should be green.
- Master question: What percentage of the wall is green? Master answer:

c) Create a wall which is the same size as wall b, but $\frac{1}{4}$ of the wall should be red, $\frac{1}{4}$ purple and the rest light blue.
Super master question: What percentage of the wall is light blue?
Super master answer:

d) Create the last wall. It should be as large as the first wall you created, and have four different colours! You must decide the colours and how much of the wall will be covered in each colour. Write down the percentages for the different colours.

Colour 1…… covers ---------- of the wall

Colour 2…… covers ---------- of the wall

Colour 3…… covers ---------- of the wall

Colour 4…… covers ---------- of the wall

e) Create the roof!
$\frac{120}{240}$ should be dark grey $\frac{60}{240}$ should be light grey and the rest white.

- What percentage will the white part be? Answer:
- Can you write these fractions in smaller numbers? Answer:

f) Create a work of art outside the house $\frac{1}{10}$ of which should be in a new colour!

Minecraft in School, **Week 3, 2016.** *Area* *(with suggested answers)*

You are going to build a garage and imagine that the floor inside the garage will be 4 x 5 metres. one Minecraft block is a cube, with each side measuring 1 metre. The walls in the garage would be 1 m thick.

a) Build the floor, and calculate how many square metres the floor inside the garage will cover?
Answer:

b) You change your mind and want a bigger garage! However, the outside measurements must be less than 50 $m^{2.}$ Find out how large your garage can be. How many metres will the sides be?
Answer: (7x7 = 49 or 8x6 = 48)

c) What will the circumference of your garage be?
Answer: (28m, it might be interesting to discuss this problem together, i.e. that the circumference will be the same no matter what)

d) What will the inside area of the garage be?
Answer: ($25m^2$ or $24m^2$)

e. You are now going to build walls which are 4 metres high. Remember that you will also need a garage door. It should be 3 metres high, and *4 or 5 metres* wide.

- Calculate how many square metres each wall will be?
Answer: (options: 4x7, 4x6, 4x8)

- How many square metres will the garage door be?
Answer: (3x4 or 3x5)

f. Create the roof. You will need to decide if you are going to have a sloping roof, or a flat one. If you choose a sloping roof, you will need build on two of the walls.

h: Hey! You built your garage really fast and you have time to spare! You could plant some flowers or bushes around your garage.

Remember to take screenshots!
Last 5-10 mins: Brief review of the task in plenary

Week 6

The teacher has created his own tasks which were handed out to the pupils in class, but he doesn't want them to be published.

Week 24

The pupils find tasks about volume in a Minecraft world and solve them. Their answers are written down on a sheet. As previously requested by the pupils, these tasks are in English.

The tasks and the world have been downloaded in advance. Sources:

https://worlds.education.minecraft.net/node/133

https://worlds.education.minecraft.net/

https://worlds.education.minecraft.net/sites/default/files/worlds/134/material/lessonplan-volumes_134.pdf

Topic: what is the volume?

What is the volume? We are going to calculate the volume. Why is it important?

Volume is an integral part of mathematics, and it shows the "empty" space in a fixed object (sphere, cylinder, box, etc.). Another way of saying this is that volume means the contents of an object. We measure volume as a cubic measurement, e.g. as cubic millimetres/millilitres and cubic metres/litres, metres to the power of three.

(Review in advance, on the whiteboard)
Litres converted to cubic units:

1 litre = 1 dm^3
1,000 litres = 1 m^3

General formula for calculating volume:
Base area * height, i.e. basic surface multiplied by the height

Example of calculating volume:
Calculate the volume of a box which is 5 metres long, 4 metres wide and 3 metres high.

Calculation:
Base area = length * width
Base area = 5 metres * 4 metres = 20 m^2

Volume = base area * height
Volume = 20 m^2 * 3 m = 60 m^3

Answer: The volume of the box is 60 m^3 (cubic metres)

The inspiration for the various tasks has been obtained from several different sources:

Tjora, H. (2013). Mattemagi. Over 100 morsomme, magiske, praktiske og nyttige matematikkøvelser for trent og utrent [Maths Magic. Over 100 fun, magical, practical and useful mathematical exercises for experienced and inexperienced mathematicians] (13 ed.). Oslo: Kagge forlag.

Johnsen, A. L. (2011). *Mer moro med matte* [More Fun with Maths]. Oslo: Kagge forlag.

Bakke, B., & Bakke, I. N. (2012). *Grunntall 6a. Matematikk for barnetrinnet* [Basic Figures 6a. Mathematics for Primary Schools]. Drammen: Elektronisk Undervisningsforlag AS.

Bakke, B., & Bakke, I. N. (2012). *Grunntall 6b. Matematikk for barnetrinnet* [Basic Figures 6b. Mathematics for Primary Schools]. Drammen: Elektronisk Undervisningsforlag AS.

The Norwegian Centre for ICT in Education: Brundalen School uses Minecraft for building its school https://iktsenteret.no/ressurser/minecraft-gir-laeringskraft

Magnus Henrik Sandberg's resources page: Building the Classroom https://minecraftiskolen.wordpress.com

Mattemestring.no: Borrowed World "Builder" for working on some tasks. http://mattemestring.no/

MinecraftEdu World Library: Verden MFY Volumes, Part 1, of MakersFactory from http://services.minecraftedu.com/worlds/

Appendix 5: for the parents/guardians of Class 5 pupils
Research project on using the computer game, Minecraft, in schools

Can I interview your child?

In connection with my work on my doctorate at Nesna University College about how the use of digital teaching methods in schools can help to support pupils' learning processes, I would like to interview the pupils and record their voices on tape. In order to do this I need parental consent. Consent, and other information relating to my research project, have been reported to the Data Protection Officer for Research at the Norwegian Centre for Research Data. Project no.: 42879.

Why computer games?

The Norwegian Knowledge Promotion Reform emphasises that being able to use digital tools is one of five basic skills. These include computer games which are being introduced in schools for teaching purposes. There are many types of games and not all of them are suitable for teaching. Minecraft is a very popular game and is being used in different subjects at some schools. X School is keen to try it and I have been given the opportunity to follow the class's experiences. The class teacher and I will try using Minecraft for teaching mathematics during the spring, in Week 22, and we will continue using it during the next academic year. Various research projects have outlined the many advantages to be derived from using computer games. Some of the key findings are associated with pupil mastery and increased motivation to learn. Learning is a key aspect of this computer game. The pupils have to learn critical thinking, reflection, problem-solving and cooperation in order to actually advance in the game. The Norwegian Media Authority has reported that 94% of all children aged 9-16 play each day. In other words, there is considerable potential in this natural interest which schools can embrace. Children are highly competent in this field and often feel successful when they are able to show what they can do. This project will focus on the pupils' positive participation experiences and the fact that they are contributing towards research which they can also benefit from in other contexts in the future.

Implementation and voluntary participation

Teaching Minecraft will be part of the ordinary tuition provided in the class, but participation in the project as an informant is voluntary. Pupils will have the opportunity to withdraw at any time without having to explain why. Those pupils who participate will be anonymous and any personal data will be treated in confidence. I will be present in the classroom, along with the class teacher, and I will be making notes about my observations and recording game sequences. The only things that will be recorded are the voices of the children and what happens in the game. The interviews about the children's experiences with the game will be recorded both individually and in groups and they will be processed and stored by me. Parents/guardians can ask to see the interview guide if they wish. The data will be used in my research work and will include both written and verbal communications. I am planning to complete my research in 2018. After that the data will be anonymised and stored by me on an external storage unit so that I can follow up the topic at a later date if so required.

Appendix 5: for the parents/guardians of Class 5 pupils
Research project on using the computer game, Minecraft, in schools

I hope that you will think that it sounds exciting for the class to try using this computer game!

Parental permission for spring 2015 and the 2015-2016 academic year:

☐ **Yes, I/we consent to** (name of pupil) _____

being able to participate as an informant in connection with this research project.

Signature of parents/guardians:

_____

If you have any questions about my research project please contact me on agniebj@hinesna.no, or tel. +47 75 05 78 58

Yours sincerely, Agnieszka B. Jarvoll, Nesna University College

Appendix 6: Declaration of consent from the Rector in connection with the research project on the use of Minecraft in teaching during the spring of 2015 and 2015-2016 academic year.

In connection with my work on my doctorate at Nesna University College about how the use of digital teaching methods in schools can help to support pupils' learning processes, it may be necessary for me to talk to the rector and record our conversation on tape. In order to do this I need the rector's consent. Consent, and other information relating to my research project, have been notified to the Data Protection Officer for Research at the Norwegian Centre for Research Data. Project no. 42879.

Collaborative research project
With the help of the Class 5 teacher, I am planning to try out the computer game, Minecraft. This trial will constitute part of the class's ordinary maths teaching this spring and during the next academic year. This is a research and development project which could be described as being a research partnership where the parties jointly develop new practices in respect of using the game during teaching. I will be participating as one of the collaborative partners in the classroom, but the class teacher will be responsible for the teaching sessions. As we proceed the teacher and I will ensure that we engage in a continuous dialogue. This involves a requirement to make comments or explain what is happening. This type of method helps to provide insight into the learning processes of the pupils. It is also important for me to interview the teacher and the pupils about new experiences and perspectives.

Why computer games?
The Norwegian Knowledge Promotion Reform emphasises that being able to use digital tools is one of five basic skills. These include computer games which are being introduced in schools for teaching purposes. There are many types of games and not all of them are suitable for teaching. Minecraft is a very popular game and is being used in different subjects at some schools. Various research projects have outlined the many advantages to be derived from using computer games. Some of the key findings are associated with pupil mastery and increased motivation to learn. The pupils have to learn critical thinking, reflection, problem-solving and cooperation in order to actually advance in the game. The Norwegian Media Authority has reported that 94% of all children aged 9-16 play each day. In other words, there is considerable potential in this natural interest which schools can embrace. Children are highly competent in this field and often feel successful when they are able to show what they can do. This project will focus on the pupils' positive participation experiences and the fact they are contributing towards research which they can also benefit from in other contexts in the future.

Rector's consent
As the head of the school it could be interesting to attend a collaborative meeting or be available for interviews. Confidentiality and anonymity will be ensured in accordance with the normal procedures which apply to qualitative research. The rector's participation is voluntary and he will have the opportunity to listen to the

Appendix 6: Declaration of consent from the Rector in connection with the research project on the use of Minecraft in teaching during the spring of 2015 and 2015-2016 academic year.

recordings of interviews and he will be able to withdraw or correct anything that has been said if he so wishes. He will also have the opportunity to withdraw at any time without having to explain why. Out of respect to the rector's time, the duration of interviews and any collaborative meetings will be agreed. I will make notes about and/or record our collaborative meetings. The data will be used in my research work and will include both written and verbal communications. I am planning to complete my research in 2018. After that the data will be anonymised and stored by me on an external storage unit so that I can follow up the topic at a later date if so required.

Rector's consent
Yes, I consent to participating in conversations, meetings or interviews which can be recorded on tape.

Signature:

_____

If you have any questions about my research project please contact me on agniebj@hinesna.no. or tel. +47 75 05 78 58
Yours sincerely, Agnieszka B. Jarvoll, Nesna University College

Appendix 7: Declaration of consent from the teacher/teachers in connection with the research project on the use of Minecraft for teaching purposes

In connection with my work on my doctorate at Nesna University College about how the use of digital teaching methods in schools can help to support pupils' learning processes, I would like to interview the class teacher/teachers and record their voices on tape. In order to do this I need the teachers' consent. The teachers' consent, and other information relating to my research project, have been reported to the Data Protection Officer for Research at the Norwegian Centre for Research Data.

Collaborative research project
We will be trialling the computer game at the intermediate stage with the help of the class teachers. This teaching trial involving the use of Minecraft, will constitute part of the class's ordinary maths teaching this spring and during the next academic year. I will be participating as one of the collaborative partners in the classroom, but the class teacher will be responsible for the teaching sessions. As we proceed the teacher and I will ensure that we engage in a continuous dialogue. This involves a requirement to make comments or explain what is happening. This type of method helps to provide insight into the learning processes of the pupils. It is also important for me to interview the teacher about new experiences and perspectives.

Voluntary participation and data collection
Confidentiality and anonymity in respect of this research project will be ensured in accordance with the normal procedures which apply to qualitative research. Teacher participation as an informant in respect of this research project is voluntary. The teacher will have the opportunity to listen to the recordings of interviews and will be able to withdraw or correct anything that has been said if he/she so wishes. The teacher will also have the opportunity to withdraw at any time without having to explain why. As regards the teacher's time, the duration of the interviews and collaborative meetings will be arranged, and an explanation will be provided about their contribution during the course of the study. I will also be making notes and/or recording our collaborative meetings and I will record sequences of the game and the accompanying voices of the participants. The only things that will be recorded are the voices of the teacher and the children and what happens in the game.

The data will be used in my research work and will include both written and verbal communications. I am planning to complete my research in 2018. After that the data will be anonymised and stored by me on an external storage unit so that I can follow up the topic at a later date if so required.

Consent for the spring of 2015 and the 2015-2016 academic year:

☐ **Yes, I consent to participate as an informant.**
Teacher's signature:

_____

Articles

Article 1

Jarvoll, A. B. (2018a). “I’ll have everything in diamonds!”: Students’ Experiences With Minecraft at School. *Studia Paedagogica*, 23(4), 67–89. doi:10.5817/sp2018-4-4

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"I'LL HAVE EVERYTHING IN DIAMONDS!" STUDENTS' EXPERIENCES WITH MINECRAFT AT SCHOOL

AGNIESZKA B. JARVOLL

Abstract

The aim of this article is to highlight the experiences of 11–12-year-old students at a Norwegian primary school regarding their use of Minecraft in mathematics classes and explore the consequences for their motivation. The present research was carried out as a single case study. This implies an in-depth investigation of a contemporary phenomenon, an intervention, studied in its real-life context, the classroom. The object of the intervention in the participating class in 2015 and the spring of 2016 was to use Minecraft as an attempt to restore motivation for mathematics. The teacher found his students were motivated to work with Minecraft, but a question emerged about students' motivation to perform the given tasks. This study suggests that formative interventions in which the researcher is present in a school context implicates the possibilities for the study of externalisation processes. These processes provide an opportunity to obtain an understanding of what happens when a popular digital game from youth culture is applied to tasks in mathematics to achieve pedagogical goals.

Keywords

digital games, formative intervention, classroom research, case study, motivation

Introduction

"*I'll have everything in diamonds! A sword and everything! A pickaxe and a spade, and everything there is!*" shouted Edward, a 12-year-old student from a Norwegian primary school, after playing Minecraft. Statistics from the Norwegian Media Authority (2016, 2018) show that about 96–97% of boys and about 63–89% of girls aged 9–14 play digital games every day, and Minecraft is one of the most popular digital games among children in this age group. The Minecraft world consists of blocks that players manipulate. Players have unlimited resources in creative mode and can help each other to build something from their own imaginations (Gallagher, 2015). Indeed, Minecraft may be the most successful commercial game ever created (Bebbington & Vellino, 2015, p. 7).

Minecraft has also found its way into schools (Callaghan, 2016; Cipollone, Schiffer, & Moffat, 2014; Mail, 2015; Nebel, Schneider, & Rey, 2016; Sáez-López, Miller, Vázquez-Cano, & Domínguez-Garrido, 2015). Research shows that Minecraft is used as an educational tool in various countries and subjects and at different grade levels (Nebel et al., 2016, p. 357).

Statistics from the Norwegian Media Authority (2016, p. 82) show that 8% of primary school students have the opportunity to use digital games at school, but these statistics do not distinguish between Minecraft and other digital games.

It is therefore interesting to explore what can happen when a popular digital game, such as Minecraft, is transferred to a classroom setting and, as will be outlined, used in mathematics to restore class motivation. This leads to the following research questions: How do students experience the use of Minecraft in their classroom and what are the consequences for their motivation?

A formative intervention (Engeström, 2015, pp. xxx–xxxii) was conducted in 2015 and the spring of 2016. The Change Laboratory process (Virkkunen & Newnham, 2013, pp. 12–13) was used to organise the intervention and is typically applied in the context of an activity system, for instance a classroom facing a transformation (Engeström & Sannino, 2010) such as the introduction of a new educational tool.

This approach may provide the opportunity to understand students' experiences and include them in further intervention processes. This is important because it must be remembered that students have the most experience with being students (Nilsen, 2010, p. 24) and little attention has been paid to their voices in research about game-based learning (Beavis, Muspratt, & Thompson, 2015).

The present research did not seek to evaluate the intervention but rather to investigate closely the students' experiences. The teacher's understanding of motivation is also considered in this dialectical approach.

In the following sections, Minecraft will be described and the study's context outlined. Then, the study's theoretical framework will be presented before the methodological approach is introduced. Finally, the study concludes with an analysis of the research findings, a discussion, and a conclusion.

Minecraft description

Owned by Microsoft but created by Mojang, Minecraft is a popular digital game (Abrams, 2017; Beavis et al., 2015; Nebel et al., 2016; Willett, 2016) that has, according to Marklund, Backlund, and Johannesson (2013, p. 308), received much acclaim. The game is innovative and features a player-driven narrative that differs from other games in that it does not have traditional goals including players collecting points or reaching a different level. In Minecraft,[1] players can collaborate and create stories with characters because the Minecraft world "provides participants with the space to do so" (Cipollone et al., 2014, p. 5). The game enables players to design the game themselves, choosing whether they want to play independently in single-player mode or with others in multiplayer mode (Niemeyer & Gerber, 2015).

From a constructionist perspective, Minecraft can be viewed as an educational tool whereby meaningful interactions contribute to knowledge building (Cipollone et al., 2014, p. 10). The earth, the vegetation, and the mountains are made of blocks that can be engineered collaboratively in various ways. Players can create their own goals using different tools, such as a pickaxe to dig or a torch to light up a labyrinth. In creative mode, the players have unlimited resources if they want to build advanced structures, such as landscapes and buildings, or to rebuild visual compositions from history or mathematics (Gallagher, 2015). Because of the possibilities mentioned above, Minecraft is known as a sandbox game (Canossa, Martinez, & Togelius, 2013; Mail, 2015; Niemeyer & Gerber, 2015) that can be modified to suit curricula (Gallagher, 2015, p. xi).

Moreover, according to the Norwegian Media Authority (2018), the game appeals to boys and girls, which is not the case with most other digital games. In a survey conducted by Beavis et al. (2015) of 270 students aged 9–14, Minecraft was the only game nominated by both genders as a favourite among numerous digital games (Beavis et al., 2015, p. 27).

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[1] Or Minecraft: Education Edition, which is made especially for schools. See https://education.minecraft.net/.

Related research

Recently, researchers have been occupied with what implications can be drawn from using Minecraft for future learning (Abrams, 2017; Niemeyer & Gerber, 2015). Some research has concluded that there is not necessarily any improvement in academic results after implementing Minecraft in schools (Sáez-López et al., 2015, p. 125) despite the advantages highlighted in contemporary research on motivation (Canossa et al., 2013; Plass, Homer, & Kinzer, 2015; Sáez-López et al., 2015). Motivation is defined as both the reason for behaving a certain way and the desire to do something. Motivation is divided into extrinsic (external) and intrinsic (internal) motivation, with a special focus on the latter in recent research (Canossa et al., 2013; Plass et al., 2015; Turkay, Hoffman, Kinzer, Chantes, & Vicari, 2014). It has also been emphasised that students may be intrinsically motivated to play but not necessarily to learn (Jessen, 2011; Plass et al., 2015). Students can find ways to complete their game without learning the educational content, the reason being that "to play", according to Jessen (2011, p. 159), is not a means but an end in itself. He connected this assumption to a possible understanding of the motivation to play games. He drew on Huizinga (1955), among others, to express that play is, in and of itself, a meaningful human activity that we practise for the simple joy of it (Jessen, 2011, pp. 158–159). Another explanation for the assumption that games can but do not necessarily motivate learning is connected to the idea that learning content and game mechanics are not always linked tightly enough (Plass et al., 2015, p. 269). In their review, Plass et al. discussed the design elements of games that facilitate learning, such as motivation and affective elements, summarising that constructs related to motivation often include affective components, such as emotions and attitudes (Plass et al., 2015, pp. 270–272). This finding was investigated further by Abrams (2017), who presented the case of 11-year-old Anita to explore how feelings and imagination may influence creation and play within a space such as Minecraft. The study illuminated the importance of emotions when working in the Minecraft world that should not be dismissed as supplementary resources to motivate and engage students (Abrams, 2017, pp. 505–506). Another research study connecting emotions with Minecraft involved a survey distributed by Canossa et al. (2013) to participants aged 12–49 from 21 different countries. Their research indicated that the greater a player's dedication, the more he or she used and crafted objects made with diamonds, the stronger his or her curiosity was, and the greater his or her use of stone objects was. Their survey showed that curiosity, as a part of intrinsic motivation (Reiss, 2012), was evident among Minecraft players. Canossa et al. defined curiosity based on Reiss (2012) as the universal desire for intellectual activity, learning, and creating. They also explained

that Minecraft affords great freedom for expressing curiosity. This is also in line with Cipollone et al.'s (2014, p. 5) understanding of Minecraft, outlined above.

The aforementioned research was selected because it problematised various aspects of how digital games, and Minecraft in particular, can be understood in connection with motivation, play, and emotions and emphasised learning. Furthermore, the selected research influenced me, a qualitative researcher, and offered ideas about what topics have been given attention recently. Therefore, in consideration of this research, while proceeding with my study I have been open to the fact that my research could contribute to other perspectives.

The context and aim of the intervention

From the collaborative network of schools associated with my university, one school was purposefully selected (Creswell, 2013, p. 156) because of the head teacher's expressed interest in developing the use of information and communication technology (ICT) at his school. The participating school, with approximately 300 students, is in northern Norway and offers education from first to tenth grade. The head teacher at this school informed the teachers of the possibilities regarding collaboration in a research project. The teacher who joined the research project has about 30 years of experience as a primary school teacher. He expressed that the books they were using in mathematics were dissatisfying for his students and decreasing their motivation. After conducting an informal study in his class, he realised about 20 of his students were eager to play Minecraft for fun in their leisure time. At the beginning of January 2015, the teacher clarified his reason for collaborating in this research, outlined as an intervention. He selected Minecraft as our entry to working with both ICT and mathematics. He wanted to restore students' motivation by trying a new educational tool, Minecraft, to teach mathematics.

The participating class had 27 students, 11 girls and 16 boys, aged 11 and 12. The intervention started in January 2015, when they entered the fifth grade, and it continued through the spring of 2016. For practical reasons, teachers in several subjects divided the class into two groups; this was also the case during the intervention. Group A, with 16 students, performed well at mathematics. In the smaller Group B, the students needed a peaceful working environment with more support and attention. Group A studied mathematics on Mondays and Group B on Tuesdays. One ICT teacher informed me that, because of a lack of access and time, Minecraft had not previously been an option as an educational tool at this school.

In week 22 during the spring of 2015, the teacher and I conducted an introductory session where we tried some mathematics tasks and observed how well the students knew Minecraft. In week 29, we had a session without Minecraft where I conducted participant observations. During 2015–2016, we had sessions with both groups during weeks 41, 44, 45, 2, 3, and 6 as well as a follow-up session in week 24. All mathematics tasks were prepared according to the overarching national curriculum.[2] The tasks focused on problem solving, cooperation, creativity, orality, engagement, differentiation, and the understanding of such mathematical concepts as area, volume, perimeter, scale, fraction, reflection of patterns, and parallels. The teacher and I made use of the creative mode in Minecraft with unlimited resources. Figure 1 shows one given task during week 45 where students had to rebuild their classroom in Minecraft.[3] Our learning objectives[4] connected to this task were concerned with measurement, scale, collaboration, and orality.[5] In pairs, the students measured the classroom, decided how big the blocks should be, and then rebuilt the classroom in Minecraft. They had to determine whether one block should correspond to one meter or be smaller. If the blocks were too small, for instance 5 centimetres, they had much more work to do. Students could see one another's solutions in multiplayer mode to understand the consequences of different choices (see Figure 1). Figure 1 shows that pairs in Group A were working near one another. The classroom towards the front, being made by one pair, will be much smaller than the other classroom.

2 The Knowledge Promotion, *Kunnskapsløftet* (LK06).

3 The inspiration for this task came from: https://iktsenteret.no/ressurser/minecraft-gir-laeringskraft, https://minecraftiskolen.wordpress.com.

4 According to the national curriculum, we were working with digital competence.

5 The ability to express oneself orally is one of five basic skills described in the national curriculum.

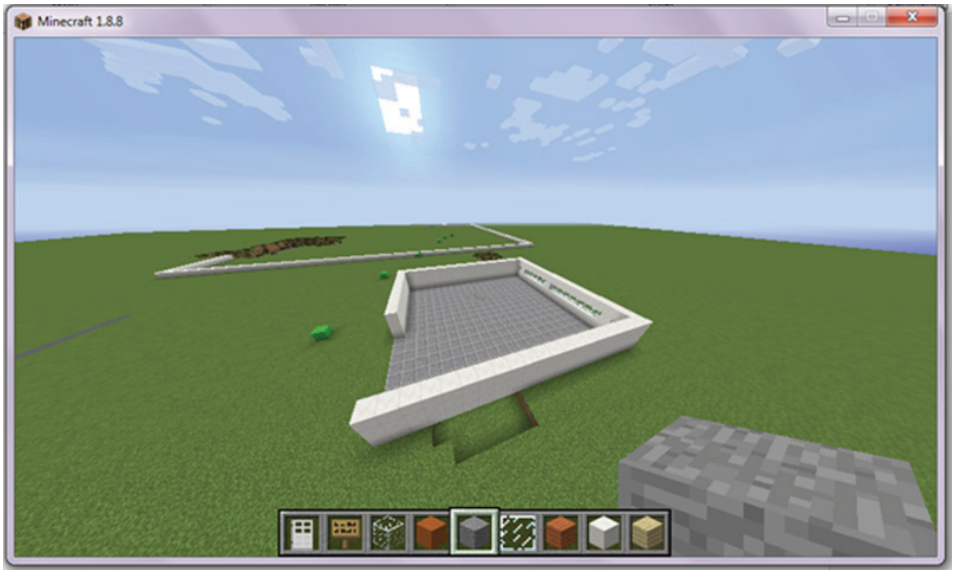

Figure 1. Build your classroom task (screenshot from week 45, Group A)

The teacher wanted to work with the mathematics tasks according to ideas about deeper complex learning using digital tools. Such a focus included reflections on such matters as the choice of block size mentioned in the task presented above and an evaluation of this choice in collaboration. We were inspired by a study by Jahnke, Nordqvist, and Olsson (2014), the findings of which show different components of deeper learning when it comes to group learning.

Research and theoretical framework

Cultural-historical activity theory (CHAT; Engeström, 1999, 2015), which implies that formative interventions contribute to a change in practice through expansive learning, was selected as the theoretical framework for this study because it supports an understanding that games are dynamic and players and conditions change (Plass et al., 2015, p. 273). An artefact, such as Minecraft, can facilitate actions between students that are cooperative (Engeström, 2015). According to Leontjev (2002), human activities exist in the form of actions or a chain of actions. Leaning on Leontjev, Engeström explained that the object of an activity is its true motive (Engeström, 2015, p. 54), meaning an activity is realised by goal-directed actions, as in this outlined intervention with solving various tasks in mathematics.

CHAT is often used as an analytical tool to contribute to knowledge about a situation both before and after a formative intervention. As a tool for development, it is called the Change Laboratory (Virkkunen & Newnham, 2013), based on the experiences of Engeström and his colleagues with developmental work research (Engeström & Sannino, 2010; Virkkunen & Newnham, 2013).

As claimed by Engeström and Sannino (2010, p. 5), expansive learning typically calls for formative interventions based on Vygotsky's principle of double stimulation in which a neutral external artefact is filled with meaning, increasing the chance of solving a problem. Expansive learning is also the process of resolving contradictions, including dilemmas or conflicts (Engeström, 2015, p. xxiii) embedded in the lives of the participants, whether students or teachers. When a contradiction is resolved, a new form of activity emerges, which can be understood as a solution. In addition, a new practice has been experienced among participants. As presented in the context of the current study, the teacher's contradiction was that the mathematics books were not good enough for his students and their motivation for mathematics was decreasing. He expressed a need for change. His new solution was to try another educational tool, an artefact, to obtain his object: restoring students' motivation for mathematics. Minecraft was also a new experience for him.

There is a crucial difference between *objects* and *outcomes*. Objects are carriers of motives, meaning they are foci of attention, volition, effort, and meaning. People, through their activities, are constantly changing and creating new objects. In addition, new objects can be the unintended consequences of activities (Engeström, 2015, p. xvi). The outcome, however, is the actual product (experience) of the action taken with the help of tools (Engeström & Sannino, 2010, p. 6). Furthermore, participants can redesign the tools (Virkkunen & Newnham, 2013). Two important processes explain this activity. The internalisation process entails the reproduction of a culture, including an artefact, and the externalisation process is about how artefacts can be used innovatively (Engeström, 1999; Postholm, 2015). Engeström crystallises all this in his expansive cycle model (Engeström, 1999, pp. 33–34), depicted in Figure 2. According to Engeström, this circular process of development linked to Vygotsky's (1978) zone of proximal development can also occur at the level of collective activity (Engeström, 1999, pp. 33–34). Any activity begins with an emphasis on internalisation, for instance training, to become more competent in an activity as it is carried out. Externalisation first occurs as discrete individual innovations. As the activity becomes more demanding, the search for solutions increases, accompanied by the growing process of externalisation, which will reach its peak when a new model for the activity is applied (Engeström, 1999, p. 34).

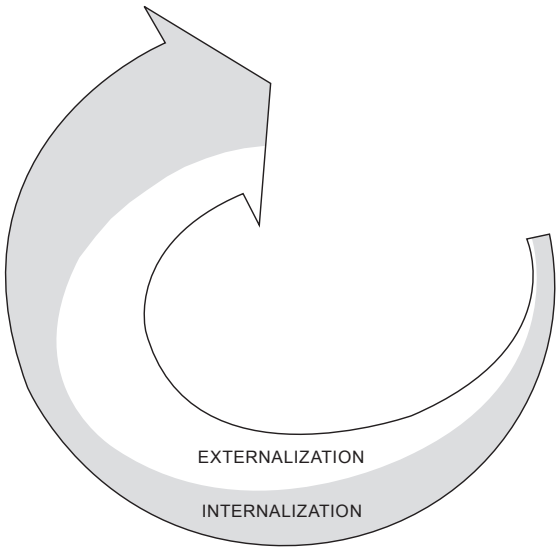

Figure 2. The expansive cycle (Engeström, 1999, p. 34)

Methodology

The research was conducted as a single case study (Yin, 2014), which implies an in-depth investigation of a contemporary phenomenon, in this case an intervention in its real-life context (Creswell, 2013; Yin, 2014), the classroom. The emic perspective (Fetterman, 2010) of the processes and intracultural diversity among the students involved have been important to understanding their actions. CHAT also propounds this view with the explanation that CHAT is a dialectical theory in which a new concept is transformed step by step into a new form of practice by participants (Engeström & Sannino, 2010, pp. 4–5) and where the dialogue is accompanied by an activity during an interaction (Postholm, 2010). The nature of this understanding classifies this study under the social constructivist approach (Creswell, 2013; Postholm, 2010), with the epistemological assumption that researchers can acquire knowledge through participants' subjective experience of collaborating in their context (Creswell, 2013, pp. 20–21).

A formative Change Laboratory intervention (Virkkunen & Newnham, 2013) was the method by which developmental processes were approached. This strategy anchored the intervention in the school context as it can be applied to case study research (Yin, 2014, p. 4). This kind of work takes about 5 to 12 Change Laboratory sessions, usually with a follow-up session (Virkkunen & Newnham, 2013, p. 15). The number of sessions that were used in this study's intervention is noted above.

Data collection

A major strength of case study research, according to Yin (2014), is the opportunity to use multiple sources of evidence. Consequently, I collected different data types to develop converging lines of inquiry. Thus, the case study findings build on several sources of information that support the study's construct validity (Yin, 2014, pp. 118–121).

The relevant data corpus, described in Table 1, consists of transcriptions of eight semi-structured interviews with individual students conducted early in the autumn term, eight focus group interviews after the lessons, conversations from weeks 2 and 3 with the teacher during lessons, and participant observations from the classroom. During my process of analysis, screenshots were used to support my observations (Creswell, 2013, p. 160). These screenshots of student products exemplify how they solved tasks (Virkkunen & Newnham, 2013, pp. 15–16), and the teacher and I jointly evaluated them during the intervention. The screenshots served, then, as physical artefacts, that is, printouts (Yin, 2014, p. 117), both in the collaboration with the teacher and later in my process of analysis.

Table 1
Data corpus

Data types	Source
Recordings of eight single semi-structured interviews	Week 40, 2015, four students from each group. From 5 to 15 minutes.
Recordings of eight focus group interviews	Weeks 44, 45 (2015), 2 and 24 (2016). Four interviews from each group with four students in each interview. From 15:32 to 28:00 minutes.
Recordings of four conversations with the teacher during lessons	Weeks 2 and 3 (2016), total 22:34 minutes.
Notes from participant observations	Notes from 23.5 hours in the classroom (2015–2016).
Physical artefacts	133 screenshots from student tasks, weeks 44, 45, 2, 3, and 6 (2015–2016).

Furthermore, my conversations with the teacher during lessons involved sharing our direct observations (Yin, 2014, p. 106). This kind of immediacy, especially when recorded, enables access to action in real time.

I received permission to interview 20 of 27 students from their parents. They received a letter to sign with information about the project and the proposed interviews. Both the students and their parents were informed that the study would be anonymised, students could withdraw from the research

project at any time, and they could listen to the recordings. Data collection and storage followed the requirements for personal data (NESH, 2016).

Individual interviews obtained students' individual understandings (Kvale & Brinkmann, 2015; Yin, 2014) of Minecraft and other digital games, their attitudes towards mathematics in school, and their expectations from the intervention. Focus group interviews were conducted to understand the range of their experiences (Kvale & Brinkmann, 2015; Yin, 2014) with the lessons and their suggestions for other tasks in future.

In both kinds of interviews, I asked the students about their classroom experiences, which enabled me to confirm my understanding of my observations and access their views. I also applied this strategy during conversations with the teacher (Yin, 2014, p. 117). Such methodological triangulation can be used to confirm interpretations, but it was even more valuable for me to gather additional observations and interpretations (Stake, 1995, pp. 114–115). This kind of procedure also strengthens the study's trustworthiness (Postholm & Smith, 2017, p. 89).

Data analysis

The constant comparative method of analysis (Corbin & Strauss, 2008) was selected to analyse my transcripts of interviews, conversations with the teacher, and observation notes. This method of analysis can be used in qualitative studies other than the grounded theory approach (Postholm, 2010, p. 87), such as case study research (Yin, 2014, p. 138). Furthermore, this method acknowledged the researcher's presence and is in line with the social constructivist approach. I experienced being part of the construction of data material (Charmaz, 2014), for instance when the teacher and I discussed our observations in the classroom. Our shared experience or the knowledge we gained was created through collaboration. This acknowledgement of the researcher's presence is also emphasised in Change Laboratory interventions (Virkkunen & Newnham, 2013).

The data from the interviews were structured and reduced through the processes of coding and categorising according to the constant comparative method of analysis (Corbin & Strauss, 2008). The process of coding involved aggregating the text into smaller categories (Creswell, 2013, p. 184). This means I made a list of codes after I had opened the data up to all potentials and possibilities (Corbin & Strauss, 2008, p. 160), considering possible meanings during reading. Then, I reduced the number of codes by searching for similarities and differences among the emerging categories, constantly comparing them until I had three main categories. These will be outlined below.

Observation notes and conversations with the teacher became complementary data to support the categories that emerged during the analysis. Screenshots supplemented displays of task outcomes.

From the beginning of the intervention, students expressed positivity about using Minecraft when we had lessons and during interviews. This positivity was such a natural part of the intervention that it could be taken for granted. During the analysis, I called this positivity "positive attitude". This attitude can be defined as a general viewpoint on the intervention, as well as positive expressions about Minecraft (Abrams, 2017), and it was defined as the core category. This is followed up in the discussion section. This core category was supported by the following main categories: *motivation and fooling around*, *tasks*, and *learning*.

Expressions such as *fun* or *funny* and emotions such as joy and dedication appeared in the classroom and the interviews. During conversations, the teacher connected these expressions and emotions to motivation. This understanding of motivation is also in line with previous research (Abrams, 2017; Plass et al., 2015). Based on his experience with this class, the teacher could uncover changes in motivation, something on which I relied. I had, as mentioned earlier, one mathematics lesson without Minecraft, that is, without a strong basis for questioning the teacher's understanding of motivation in his class. As will be shown, however, this motivation was double-sided. That is why this category was named "motivation and fooling around".

The *tasks* category concerned experiences with the completed tasks and suggestions about the future use of Minecraft at school regarding mathematics and other subjects and other ideas that emerged. The *learning* category included learning outcomes students may have experienced when working with the tasks.

The main categories outlined above will guide the following text. Going through the transcripts from the interviews, some parts illustrate the variation in students' understandings and experiences especially clearly and exemplify the main categories outlined above particularly coherently. Excerpts from these parts were chosen for presentation. They do not represent all students, but they reflect differences between Group A and Group B.

Findings

Motivation and fooling around

As I observed, the students expressed positivity on mornings when the computers were turned on for work. With excited faces, they wanted to get to the computers as fast as they could, but when told to wait, they listened patiently—more or less—to what the teacher and I had to say.

Observations from the lessons revealed that students from Group B wanted to continue with their tasks even when the lessons were finished. Students in Group A were in a hurry to finish their tasks and then play Minecraft. Sometimes they did their tasks, but simultaneously also did something else in the Minecraft world. It quickly seemed to me that the received tasks were of secondary importance. During one lesson, when students in Group B were working with the tasks, the teacher and I summarised what was going on. The teacher said:

> *Well, there are many students in the other group (A) who like this (task) but were too busy to do what they wanted to do. But here (in Group B), it seems that the disciplinary aspect is more fun through the use of Minecraft. At first, you'd think that the opposite was the case. So that's why I think it was very surprising that it's worked so well. It's very enjoyable to see.*

The teacher and I observed that the working process was different in Group B. Students worked in a more dedicated manner, showing how they managed to solve the tasks using Minecraft. The teacher was surprised that this group was more interested in working with the tasks. The main argument for splitting this class into groups was that Group B needed more support, but according to the teacher they managed well on their own during these lessons. A screenshot from two students in Group A (Figure 3) and one from two students in Group B (Figure 4) exemplify the differences in their efforts on the tasks.

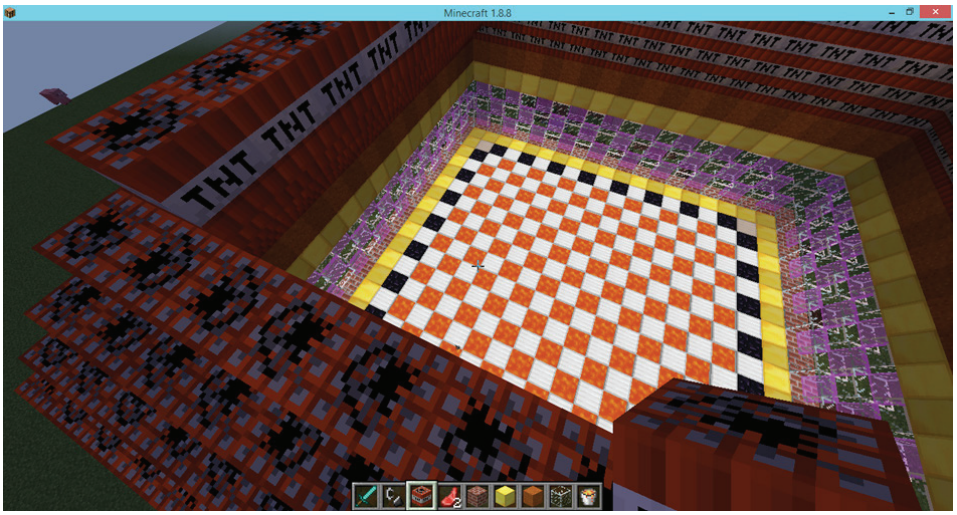

Figure 3. Screenshot from two students in Group A (week 45)

Figure 4. Screenshot from two students in Group B (week 45)

These two students from Group A built their classroom with TNT blocks and blew it up after they took their screenshot. The two students from Group B were busy ensuring all the details were right. They proudly showed the teacher and me their classroom construction, and one asked if they could show their classroom to the rest of the group. This question surprised the teacher because he thought of this boy as a highly modest student. Later, the teacher expressed more about his reflections connected to our observations of this group:

> *Again, I think that this group does more of what they're supposed to. They're not fooling around so much. They cooperate better, too. Many of them, those who usually have challenges, are doing very well with this working method. This is something they're good at and can use for schoolwork. I think that it must be motivation. The other group should have the prerequisites to do more difficult tasks, but obviously not. It's funny that those who usually aren't working so much during the lessons are very active.*

From our observations, we decided that Minecraft was a reasonably good choice of educational tool for Group B. Such emotions as pride and the feeling of mastering the game in connection with schoolwork (Plass et al., 2015) were observed during the lessons. Based on an understanding of the research presented above and the teacher's reflections, Group B showed motivation to solve mathematics tasks using Minecraft.

During one focus group interview, Simon from Group A was quite convinced it was much more fun to work in Minecraft than with the book. He said: "*Somehow, I don't see this as a class in mathematics.*" The excerpt below relays the conversation in Group A when students were asked how they could work with Minecraft:

> Simon: *I haven't really learned anything new in mathematics. We've worked with things I already knew, but it's more fun.*
> Lotte: *It makes it easier to learn if it's more fun.*
> Jonas: *We can use fractions to make weapons.*
> ABJ: *How?*
> Jonas: *The sword. You have four diamonds and* (…) *then you can have two swords. Four divided by two will be two.*
> ABJ: *I didn't know that. But your tasks were about fractions. How did they work?*
> Simon: *They were okay, but it was a little bit difficult when we didn't think to read the whole task before we started.*
> Emilie: *I did.*
> ABJ: *So you* (Simon) *were in a hurry?*
> Simon: *Yes, we planned to do it fast.*
> ABJ: *Why?*
> Simon: *Because then we could just fool around.*
> Jonas: *We could hang some zombies!*

Lotte noticed the connection between fun and learning. However, Simon was unsure of whether he was learning and did not read the tasks properly. He instead emphasised the fun of playing (Jessen, 2011). Jonas argued about fractions when he wanted to play Minecraft. Their main motives were, then, not to work with mathematics tasks but to get through them quickly and then do anything else more meaningful, such as hang zombies. Engeström (2015, p. xvi) clarified this kind of issue by stating that objects are carriers of motives. Through their activity during this intervention, they created a new object: fooling around. Fooling around was also a term the teacher used when he described their activity when they were doing anything but solving the tasks, and Simon confirmed this object in our conversation above. The fun of playing may be the reason for their explanations above. As emphasised earlier, "to play" can be an end and not a means (Jessen, 2011), but it is also possible that the content of the tasks had an unclear link to the game mechanics (Plass et al., 2015).

In an interview with Group A on Monday of week 24, Simon said that he had a confession to make.

Simon: *Okay, I'll just confess.*
ABJ: *Yes?*
Simon: *Bendik and I were doing some stuff behind room one, when no one else was there, and we made a crafting table of planks and we made swords. We gave one sword…*
Lotte: *An axe!*
Simon: *So an axe, to Lotte. And we had lots of fun there!*
ABJ: *So you were in a completely different place?*
Simon: *Yes. You can break those three planks and you can make a crafting table and then you can make sticks and…*
Lotte: *Four planks!*
ABJ: *And the teacher didn't know anything about it?*
(Laughing)
ABJ: *He didn't catch you?*
Simon: *No, on crowds, the tags don't show!*
ABJ: *Yes, you fooled us!*
Lotte: *Yes!*
Simon: *We just didn't find any stones, and then we couldn't mine iron and gold.*
ABJ: *But you also did the tasks?*
Simon: *Yes.*

Again, Group A students showed they have an alternative object in their mathematics lessons. They did the tasks, but that was not what they were eager to discuss. Their attention was on the crafting table, where they could make weapons for other students. This kind of additional and creative activity (Abrams, 2017; Canossa et al., 2013) also allowed them to express satisfaction with fooling the teacher and me. It seemed a fair thing to do, as they had completed the tasks. However, they showed openness and pride in telling me this. Indeed, various emotions appeared during this interview, awakening attention about the overall Minecraft experience (Abrams, 2017). When I asked Jonas from this group if there was too much Minecraft in mathematics, he and the three others clearly said, "No." This answer was given after the last lesson in week 24.

Tasks

Students from Group A were convinced about the benefit of using Minecraft in English.

Ulf: *I think that it would've been better to have Minecraft in English lessons.*
Jesper: *Yes, if you choose to set the language as English, you'll learn more English.*
Jonas: *You see the pictures and you have to think. I had to, about what it means and so on.*
ABJ: *So if you received tasks in English …*

Jonas: *Yes, like, "build an elephant", so you have to know what it means.*
ABJ: *Wouldn't it take a terribly long time to build an elephant?*
Jesper and Jonas: *No.*
Jonas: *You only need to make a head.*
Jesper: *Use grey blocks.*
Jonas: *It doesn't have to be very big.*
Martin: *It can be a block here, one block there, one block there, and there, there, there.*
Jonas: *And build it upwards; it would've been awesome!*

Students explained how English could be used because they know how Minecraft works and could transfer their experience to the school context. They had an understanding of the issue (Engeström, 1999, p. 33).

When I asked Group B what they wanted to do during their lessons, they suggested playing together in multiplayer mode.[6]

Melody: *We can build a city together.*
Edward: *But then everybody needs a username.*
ABJ: *Some of you have one.*
Edward: *I don't remember my password.*
Teo: *Oh, I have an idea!*
Melody: *People who don't have a username can join someone else.*
Teo: *If we got Minecraft all the time in school and got homework with Minecraft, then we could play at home together. We could get tasks and do them together.*
ABJ: *So your idea is to get homework in Minecraft? We can think about that.*
Edward: *You can make a school account and give us usernames.*
Ella: *Yes, you can make them.*
Teo: *Yes, but it costs money, so you must talk to the head teacher.*
Edward: *You can buy it on sale. It's a super deal on Halloween!*

Group B students were preoccupied with solving the problem of gaining access to the game for everybody and the fact that it should be possible to work together in a single game when doing homework. Based on their experience, they suggested redesigning what we had established, including the idea that everybody should have a username. Their internalisation process had advanced from their leisure time to the school context. Their focus was on the opportunities that appeared, particularly how they could be resolved. According to Engeström (1999), they had reached the externalisation process when designing new possibilities for this intervention. In week 45, we tried

[6] In multiplayer mode, students can play in the same game/save and cooperate.

their suggestion, but our success was limited, especially with Group A. Several students used TNT[7] to blow up their own and other students' classrooms. In Figure 1, a hole is clearly visible. The following dialogue highlighted this event.

> ABJ: *Do you mean that it was more fun to be in the same save?*
> Ada: *Yes, very.*
> Emilie: *Yes, but boring when they had to blow things up.*
> ABJ: *Did anybody really do that?*
> Emilie: *Yes, they blew up the city.*
> Lotte: *It's a little bit fun to blow things up!*
> Ada: *They can do it on their own server!*
> Melody: *And not at school!*

Learning

Students were asked if they thought they were learning mathematics with Minecraft. Students from Group B had the following answers.

> Ella: *Yes, I'm learning a little.*
> Mads: *Things we have to learn.*
> June: *Not really … or just a little bit.*
> ABJ. *Yes, what makes you feel that you aren't learning?*
> June: *I don't know; I'm not learning mathematics this way. When we do these tasks, we're just building; it doesn't feel like we're doing tasks.*

Bendik, from Group A, joined this interview because one student had to leave. His reaction to June's words can be traced to others in his group.

> *I was going to say … Minecraft is a slower way of learning, but much more fun. I'd rather have a whole day playing Minecraft than one hour with mathematics, especially when I'm finished with the tasks. Instead of doing the tasks for the next week, you can do what you want in Minecraft.*

Bendik turned the focus from the uncertain learning outcome that started to emerge when June was talking about the possibilities connected to play and again clarified his group's object – he finished the tasks and then he did something more meaningful for him. Tasks belonged to work at school, and he was not interested in doing more of the tasks than the minimum. The focus on play indicates more intrinsic motivation than working with the tasks (Jessen, 2011; Plass et al., 2015). Bendik's last sentence shows his understanding of Minecraft as an arena of freedom with possibilities for a curious mind (Canossa et al., 2013).

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[7] Special TNT blocks can be used to blow up constructions.

Discussion

This case study dealt with the following research questions: How do students experience the use of Minecraft in their classroom and what are the consequences for their motivation?

Students experienced positivity, showing a positive attitude throughout the intervention. However, it seemed that groups A and B had different motives when working with tasks. Consequently, the experienced outcome in terms of motivation was two-sided: in Group A, motivation appeared when students played or talked about playing Minecraft, but in Group B, motivation appeared for tasks in mathematics and students worked dedicatedly to complete them in Minecraft. The teacher expressed surprise at this finding, as he had expected the opposite. This finding contributes to an understanding that variation may be present among students in a class, despite displays of overall positivity. According to CHAT, it is important to distinguish between the expressed object and the actual outcome as well as to accept that a new, unplanned object may be created (Engeström, 2015). It became clear as the intervention progressed that students in Group A had created their own new object: fooling around, as evidenced through both interviews with the students and observations with the teacher. Fooling around involves doing something other than the task at hand, that is, playing, such as "*hang[ing] some zombies*", as noted by Jonas in Group A.

Students from Group A were more eager to discuss what they had been doing other than the tasks, which seemed more meaningful and enjoyable; this can be anchored to Jessen's (2011) explanation of the joy of playing games, informed by Huizinga (1955), who argued that play is considered a fundamental human activity. Furthermore, according to the students' experiences, Minecraft is fun but they were unsure of whether they were learning. This was the case for both groups, but it was more apparent with Group A. Students' doubt in this matter is supported by Sáez-López et al. (2015, p. 125), who did not identify significant improvement in academic results using Minecraft in their study but concluded that Minecraft is fun. Leaning on Plass et al. (2015), the game mechanics in Minecraft must be investigated closely in connection to different subjects and various students in school to gain a more complete view of this digital game's potential when it comes to learning.

Students did not seem to get tired of Minecraft, despite having had this game incorporated into many lessons. In the introductory part of this article, Edward expressed, "*I'll have everything in diamonds!*" This kind of emotional involvement is understood by Canossa et al. (2013) as a part of intrinsic motivation (Reiss, 2012) where learners can discover knowledge as they play (Turkay et al., 2014). Canossa et al. (2013) suggest that emotional involvement

indicates a special dedication to Minecraft that they detected in their survey but did not discuss in relation to the age range of their participants. The present qualitative study gives information about a particular group of students aged 11–12; thus, the research contributed to these students' experiences localised in the classroom as a part of school research. Excerpts from several interviews show curiosity (Reiss, 2012) and a desire to create, which is in line with Canossa et al.'s (2013) findings. Students made a crafting table, made axes and swords, and experimented with different types of materials and blowing up buildings. They showed involvement in describing possibilities and creative solutions, demonstrating affective expressions about working with Minecraft. Similar findings are described by Abrams (2017). She was engaged with how 11-year-old Anita experienced Minecraft. The description of Anita's experiences did not include other girls or boys her age but emphasised the impact of various emotions on her overall meaning-making experience. In the present study, attention was drawn to interactions among students and their dialogue with me during interviews about Minecraft. The uncovered emotions provide an important understanding of students' attitudes; however, this understanding has a collaborative dimension that must be considered for future learning (Niemeyer & Gerber, 2015, pp. 224–225). In other words, this case study contributes with a focus on dialogue and cooperation that exploits the possibility of using Minecraft for knowledge building (Cipollone et al., 2014, p. 10).

Finally, it is interesting to understand what the students experienced themselves. If we take a popular digital game such as Minecraft from youth culture and incorporate it into the school context to increase motivation with the idea that it will work, we will be taking this idea for granted. Why would students perceive this idea positively and think it fair that adults suddenly decide what they should do in the digital arena? According to Jessen (2011), children are good at revealing pedagogical objects in combination with digital games and see any work in the school context as a duty. Jessen argues that, from an educational perspective, this is about the interpretation of play (Jessen, 2011, p. 154). If the understanding is that when we play we are not working and not learning and that games are made for playing, we have a mismatch. Leaning on Engeström (2015), a contradiction is created when we use a commercial digital game in a school context. This was especially evident in Group A, where fooling around was their solution.

Formative Change Laboratory interventions as a dialogical approach are concerned with the study of externalisation processes (Engeström, 1999). As the intervention proceeded, it was possible to detect how students engaged in this new activity, fooling around, as part of an externalisation process. This shows what students did or experienced when a teacher exploited a popular game to reach pedagogical goals, and motivation in relation to both

positive emotions and mathematics tasks can appear in the same class. Motivation in connection to digital games is seen as a highly complex subject by researchers and needs to be explored more in a classroom context in addition to through surveys, such as those conducted by Canossa et al. (2013), Sáez-López et al. (2015), and Beavis et al. (2015).

Conclusion

The aim of this article was to highlight the experiences of 11–12-year-old students from a Norwegian primary school regarding their use of Minecraft in mathematics and explore the consequences for their motivation. The use of Minecraft in the classroom has gained popularity; the students showed overall positivity. I have argued that this positivity should not be taken for granted. Nevertheless, such a positive attitude has been useful to enhance the classroom context and gain more knowledge about this specific commercial digital game. That said, in this study, CHAT offered meaningful lenses through which students' actions and motives (Engeström, 2015) in connection to Minecraft could be better understood. Minecraft offers space for students to discover possibilities in collaboration, and while not everything may be according to the curriculum, it still may be a meaningful discovery of knowledge for both boys and girls. In further research, it would be interesting to explore boys' and girls' motives to play this particular game, particularly with a focus on their age. Such research could affect how teachers choose other games as educational tools or how to work with the curriculum regarding game mechanics. I hope this text has provided readers with a sufficiently vicarious experience to contribute to related work in the future.

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Article 2

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Article 3

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Exploring initial collaboration in an intervention: Creating a meeting place between educational research and educational practice

Agnieszka B. Jarvoll

ABSTRACT

In the field of education, researchers have focused on the importance of achieving a common understanding of school development and change of practice in collaborations with practitioners. In an attempt to contribute to this research, a formative Change Laboratory intervention is suggested as an interface between the researcher's world and the practitioner's world to facilitate collaboration between the two.

The case study, conducted in one mathematics class in a primary school with 27 students and two teachers, was informed by the following research question: How does initial collaboration between a researcher and practitioners create a meeting place, and what implications can be drawn from this?

The teachers' motive for joining the intervention was to expand their practice of using the digital game Minecraft. The collaboration lasted 1.5 years.

The findings show that e-mail correspondence seems to play a crucial role in the continuation and expansion of dialogue towards achieving an object-oriented activity.

Keywords: *Change Laboratory, activity theory, case study, classroom research, dialogue.*

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SAMMENDRAG

Innenfor utdanningsfeltet har forskere hatt fokus på viktigheten av en felles forståelse, i samarbeid med praktikere i skolen, av skoleutvikling og endring av praksis. Som et bidrag til denne type forskning er formativ intervensjonsforskning tatt i bruk for å forsøke å binde sammen forskerens og lærerens verden og legge til rette for samarbeid.

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Kasusstudien som presenteres er gjennomført i en klasse i grunnskolen med 27 elever og to lærere som jobbet med matematikk. Følgende problemstilling er blitt fulgt opp: Hvordan bidrar et begynnende samarbeid mellom forskeren og praktikeren til å skape et møtested, og hvilke implikasjoner kan trekkes ut fra dette?

Læreres motiv for å delta i intervensjonen var å utvikle egen praksis ved bruk av dataspillet Minecraft. Samarbeidet med lærerne og forskeren varte i 1.5 år.

Funn viser at korrespondansen gjennom e-post har spilt en avgjørende rolle for kontinuiteten og utviklingen av en dialog som resulterte i målorientert handling, altså aktivitet i matematikk-klasserommet med bruk av Minecraft som hjelpemiddel.

Nøkkelord: *formativ intervensjonsforskning, aktivitetsteori, kasusstudie, klasseromsforskning, dialog*

Introduction

On 11 November 2014, a teacher from a primary school sent me an e-mail after he was told that I was interested in collaborating in an intervention study using technological tools. He wrote, 'This is interesting. I am open to everything, primarily the use of digital programmes in the classroom. Students are very oriented towards Minecraft.[1] If we can begin there, then we have a start'.

Many researchers have focused on the importance of achieving a common understanding of school development and change of practice in collaborations between researchers and practitioners in the field of education (Biesta, 2007; Engeström & Toiviainen, 2011; Postholm, 2008; Quartz et al., 2017; Thorgeirsdottir, 2018; Zeichner, Payne, & Brayko, 2014). It has been argued that a fundamental shift is needed where the focus can be on substantive transformations in the current system (Zeichner et al., 2014). In addition, there is a need for a meeting place where researchers and practitioners can collaborate to provide a coherent understanding of the field of education (Rønbeck & Germeten, 2014, pp. 22–26) and its development (Postholm & Moen, 2011). This meeting place can support teacher education and practice, and it is suggested that Cultural Historical Activity Theory (CHAT) (Engeström, 2015, 2016; Virkkunen & Newnham, 2013) offers conceptual tools that combine the necessary sources of expertise (Botha, 2017; Zeichner et al., 2014).

Various developmental studies using CHAT have addressed the importance of collaborative activity in such a meeting place (Botha, 2017; Engeström & Toiviainen, 2011; Postholm, 2008; Thorgeirsdottir, 2018). However, a search in Oria, with access to many databases with peer-reviewed journals, shows that few studies have focused on how such a meeting place could be developed at the beginning of a collaboration. Collaboration can emerge through dialogue (Sannino, Engeström, & Lahikainen,

1. Minecraft is one of the most popular digital games for children between the ages of 9 and 14 years, according to the Norwegian Media Authority (2018).

2016), and dialogical processes appear to connect ongoing communication and future-oriented actions (Sannino, 2008; Sannino et al., 2016).

In some studies, a meeting place[2] is described as being part of the initial phase of collaboration between practitioners and researchers (Engeström & Toiviainen, 2011; Postholm, 2008), and it includes project talk that is only considered in studies if it facilitates or prevents the continuity of the work (Engeström & Toiviainen, 2011, p. 40). Moreover, the meeting place, as part of an initial phase in developmental school research, is considered important, and it is addressed in a variety of models (Engeström & Toiviainen, 2011; Thorgeirsdottir, 2018; Virkkunen & Newnham, 2013) within the context of a whole study. However, the focus has not been on how this initial collaboration contributes to the development of a meeting place.

This leads to the following research question: *How does initial collaboration between a researcher and practitioners create a meeting place, and what implications can be drawn from this?*

To answer this question, I used a formative Change Laboratory intervention as an interface between the researcher's world and the practitioner's world to facilitate better dialogue between the researcher and the practitioners (Virkkunen & Newnham, 2013, p. 12).

Thus, in this article, I will first present the context of the intervention study before describing the theoretical framework and methodological approach. Finally, I will discuss the research findings and present a model of expansive dialogue and a conclusion.

Study context

The hosting school was purposefully selected (Creswell, 2013, p. 156) from a network of collaborating schools that were connected to my institution of higher education. The school is located in northern Norway, and it offers compulsory schooling. The school has approximately 70 employees and 300 students from both Norwegian and immigrant families.

The principal was interested in the possibility of collaboration. He expressed that collaboration with institutions of higher education was highlighted in the school's policy plan and that it was interesting to expand the teaching practice connected to the use of information and communication technology (ICT) at his school. He

2. In this article, 'meeting place' refers to a fostered and developed common ground for a practical object-oriented activity. 'Third space' or 'boundary zones' are concepts used in CHAT. As I understand it, the former has met some criticism, never to be fully achievable because of traditional knowledge hierarchies (Zeichner et al., 2014). Meanwhile, the latter is based on 'horizontal expertise', characterised by already-defined processes, and it may be used to describe or analyse an established collaborative constellation (Engeström & Sannino, 2010).

clarified that he was unable to allocate extra resources, such as time, to any participating teacher. However, he did take responsibility for informing the teachers about a possible collaboration.

The first teacher, Mr Todd, who participated with me, noted that students' motivation for mathematics was decreasing and the books they were using were unsatisfying. After conducting an informal study in his class with 11 girls and 16 boys, ages 11 and 12, he realised that about 20 of his students were eager to play Minecraft. The teacher and I learned that Minecraft has lately found its way into schools in various countries and at different class levels (Callaghan, 2016; Cipollone, Schiffer, & Moffat, 2014; Mail, 2015; Nebel, Schneider, & Rey, 2016; Sáez-López, Miller, Vázquez-Cano, & Domínguez-Garrido, 2015). Furthermore, it shows advantages highlighted in contemporary research in connection to motivation (Abrams, 2017; Canossa, Martinez, & Togelius, 2013; Sáez-López et al., 2015). Because the teacher selected Minecraft as our entry to working both with ICT and with mathematics to restore students' motivation, the teacher and I had the opportunity to investigate students' experiences with Minecraft closely as an educational tool (Jarvoll, 2018).

Due to accessibility issues related to the use of computers and busy school days, Minecraft had not been used as an alternative educational tool at this school. With the principal's permission, the game was installed by an ICT-responsible teacher during the spring term in 2015.

As Mr Todd was offered and he did accept a position as a principal at another school, a second teacher, Mr Marvin, participated in the last half-year of the intervention.

The intervention lasted from the spring term in 2015 to the spring term in 2016. One introductory session was conducted in week 22 in spring 2015, and one session without Minecraft was conducted during week 39 in autumn. Then, sessions were conducted during weeks 41, 44 and 45 in 2015 and weeks 2, 3 and 6 in 2016, with a follow-up session in week 24. However, as will be shown, the initiative for this collaboration started earlier.

CHAT as a theoretical framework

CHAT (Engeström, 2015, 2016) is a dialectical theory (Engeström, 2016, p. 42) that builds on the idea that, to grasp the essence of any learning activity, the logic of its development must be reproduced theoretically. This thinking appeals to the intervention study presented in this article because, as will be shown later, it addresses the idea that abstraction captures the smallest and simplest unit of the whole study.

CHAT is often used as an analytical tool, but it is also a tool for further development, alluded to as a Change Laboratory (Aas, 2011, p. 275). A Change Laboratory is based on Engeström's experiences of Developmental Work Research

(Aas, 2011, p. 279), typically conducted in an activity system, such as a class, that is facing transformation (Engeström & Sannino, 2010, p. 15) and experiencing a new practice using a digital game as a new educational tool. It is designed so the participants meet tasks that call for expansive learning actions. Expansive learning is the process of working out and resolving contradictions that may evolve in the activity to be transformed. According to Engeström and Sannino (2011, p. 375), contradictions have several types of discursive manifestations, including dilemmas, conflicts or double binds. They define dilemmas as expressions or exchanges of incompatible evaluations, where a reformulation of the situation can contribute to a resolution. Conflicts can be expressed as a rejection using the word 'no' in a situation, and they can be resolved by finding a compromise. Double binds are explained as a pressing need to do something and, at the same time, a perceived impossibility of action. A practical transformation may be the solution.

Furthermore, Engeström (2016, p. 9) emphasised expansiveness as something primarily in material and cultural terms inherent to the potential of learning to produce new material objects, practices and patterns of activity. This is connected to dialectical processes, meaning that opposing forces in a system require one another, through their interplay, to form the basis of the development of the system. However, as Sannino et al. (2016, p. 260) conclude, talk and words alone do not make a difference. Development of the object is grounded in practical actions (Sanninno, 2008, p. 237), meaning that besides being discursive or conversational, productive activities are material, object-oriented and collective.

According to Virkkunen and Newnham (2013, p. 12), a Change Laboratory intervention can be seen as a dialogue and a process of co-production between the representatives of the worlds of research and practice. In total, five to 12 Change Laboratory sessions are needed to analyse and specify the challenges of developing a new practice. Previously, I noted the number of sessions that were used in this study's intervention.

A Change Laboratory focuses on opening people up to new perspectives, and it calls for motivation and flexibility; thus, participation should be voluntary for practitioners. This brings us to the role of the researcher.

The researcher in formative Change Laboratory interventions

In qualitative studies, it is important to clarify the researcher's role (Charmaz, 2014; Engeström, 2016; Stake, 1995; Virkkunen & Newnham, 2013). In Change Laboratory, the researcher aims to initiate, motivate, analyse, reflect and contribute to decision making and information dissemination (Engeström & Sannino, 2010; Virkkunen & Newnham, 2013); thus, the researcher must be flexible and open to change and be supportive when needed in the developmental process (Aas, 2011, p. 281). Lack of time can prevent a project from proceeding, and it was found to be problem-

atic for teachers in the initial phase of a study conducted by Postholm (2008). This study described what collaboration between the researcher and teachers means for the progress of the project. When teachers found the project useful, they no longer struggled to find time. This study showed that teachers wanted to reflect together, and they were interested in improving their teaching methods, enabling the project to move forward.

The Change Laboratory processes should not primarily proceed at the verbal level as rhetorical processes, but as an object-oriented inquiry, such as an expressed wish from a teacher to explore educational tools. The researcher can use a variety of discursive tools and probes to support the dialectic movement of suggestions. Virkkunen and Newnham (2013, p. 39) express, 'Tools are cultural mediators that are used for changing the external world'. This refers to a principle in formative interventions known as 'double stimulation' (Engeström, 2016, p. 43). By using mediating artifacts in the empirical reality, for instance, the use of ICT, the researcher can combine various suggestions into a functional whole (Virkkunen & Newnham, 2013, p. 113). However, according to Engeström and Sannino (2010), researchers must remember that in formative interventions, the participants own the process and the outcome.

The researcher is also responsible for collecting the empirical data, and the research findings will be shared with others who have a mutual interest in the study and its results. The researcher's role is to provide readers with the necessary vicarious experiences that are interesting enough from which to learn (Creswell, 2013, p. 200). Such a naturalistic generalisation (Stake, 1995) relates to the readers' experiences.

As outlined above, the researcher must focus on tasks that can be challenging (Aas, 2011, p. 282). Postholm (2015) met that challenge by showing how expansive learning and collaboration between the researcher and a teacher, with their overarching reflections, can be connected in the research and development process, where the researcher's task is especially visible. This overview of research connected to expansive learning in CHAT (Engeström, 2015) is crystallised in a model for research and development known as the R&D model (Postholm & Moen, 2011, p. 399). In this model, the researcher's plateau is clearly defined as a 'transparent roof', where he/she is no longer in contact with the practitioners but has an overview of the conducted developmental work. The researcher tries to reveal all the processes essential to the developmental work. In the present study, this task brought me to apply Situational Analysis (Clarke, 2015), a choice that will be explained in the following section.

Methodology

The study described in this article was conducted in a real-life context (Creswell, 2013; Yin, 2014) as a collaboration between two teachers from a primary school in

Norway and a researcher (me). For this reason, the research was conducted as a single case study design (Yin, 2014). This implies an in-depth investigation of a contemporary phenomenon, specified as the intervention, in a single primary school classroom. As indicated by Stake (1995, pp. 85–86), single case studies do not serve as a strong basis for generalising a study's findings to a population of wider cases. Nevertheless, case studies are generalizable to theoretical propositions (Yin, 2014, p. 21), meaning a study's theoretical framework can be used to establish a logic (i.e., an analytical generalisation) that could be applicable to other situations (Yin, 2014, p. 237) and to conduct naturalistic generalisations, as previously mentioned.

As outlined earlier, a Change Laboratory builds on a dialectical view where changing and developing a human activity are primarily seen as processes and relationships of interaction (Virkkunen & Newnham, 2013, pp. 29–30). This viewpoint is also the perspective taken in this study, thus positioning it under the social constructivist approach (Creswell, 2013), which is based on the epistemological assumption that knowledge can be acquired through the participants' subjective experience, in their real-life context and in dialogue with the researcher (Creswell, 2013, pp. 20–21).

The analysis and data selection methods

The research question focuses on the intervention itself and on the intervention participants. To address the research question, I used two related analysis methods. First, Situational Analysis was used. Clarke (2015) developed Situational Analysis as her contribution to Grounded Theory. Situational Analysis is applied to analyse the research situation itself (Clarke, 2015, p. 99). This method guided me to analyse further the e-mail correspondence in this study, where I used the Constant Comparative Method of analysis (Strauss & Corbin, 1998), which is more directed at social processes and human actions in the area of inquiry (Clarke, 2015, p. 133). Sitting on a 'transparent roof' (Postholm & Moen, 2011, p. 399) in an attempt to answer the research question, I claim that a researcher's plateau refers to all the elements found in the intervention. Situational Analysis is relevant to this intervention study because it acknowledges a situation as something more than the sum of its parts. This gestalt understanding is interesting for exploring an intervention as a meeting place between the researcher's world and the practitioner's world. Another important reason for applying this method of analysis is that it is concerned with mapping the relation among various elements in a research situation. Situational Analysis has helped me to discover the importance of e-mails when sitting on the 'transparent roof' (Postholm & Moen, 2011, p. 399) analysing the research situation itself. That said, a further understanding of e-mails is as mediating artifacts that are necessary means for dialogue continuity.

Situational Analysis enables a researcher to construct maps that elucidate the key elements as discourses, structures and conditions of the possibilities available in a

research situation and to analyse the relation among them. By the term 'relation', I mean there is a clear linkage or an attachment that can be traced from the e-mails to the other elements.

The situational maps I have used have helped me comprehend the complexity of the intervention, and they were modified and revised several times during the research process. First, I identified the miscellaneous elements of the intervention. Then, I constructed a situational map, as shown in Figure 1, to relate the different discovered elements to each other, one at a time. As seen in Figure 1, the e-mails are related to most of the other elements. This made me ask how and when the e-mails relate to the other elements.

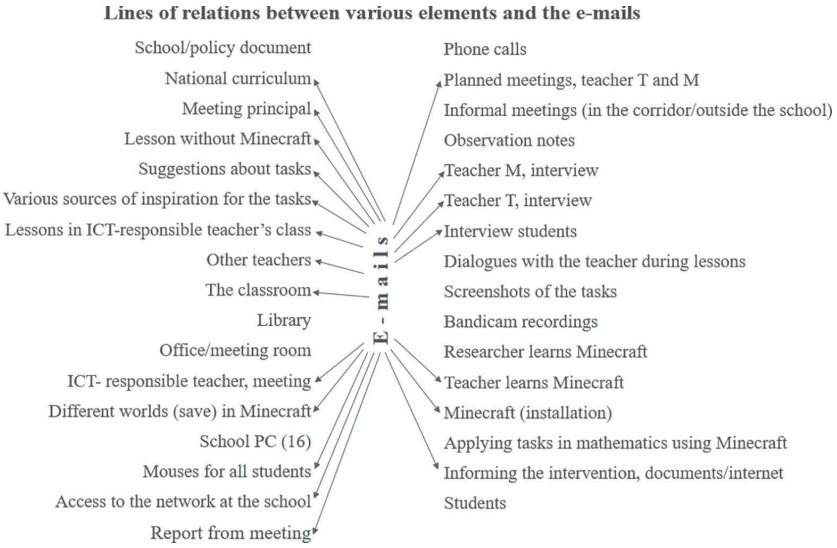

Figure 1: Elements of concern found in the intervention, with a special focus on the relationships between e-mails and the other elements.

Memos are a tool recommended in Situational Analysis, as well as in the Constant Comparative Method (Charmaz, 2014; Clarke, 2015; Strauss & Corbin, 1998), as they have been essential to maintaining my direction during the research process. From the beginning, I noted my thoughts and the ideas that emerged concerning what was needed for me to proceed. Later, I asked where the empirical data and experience led me (Charmaz, 2014, p. 162). Bearing these questions in mind, I examined the e-mails more closely.

Analysing the e-mails

The data consisted of the contents of 56 e-mails, which began before the intervention was planned, starting on 16 October 2013, until the end of the intervention on 13 June 2016. The use of e-mails was an important part of maintaining the dia-

logue in this intervention between the people involved. E-mails are a type of document, and there is evidence of their strengths and weaknesses (Yin, 2014, p. 106). E-mails contain the names of the people corresponding, which could threaten their anonymity if they are not stored correctly. They can also lead to bias in the study's findings if data collection is incomplete. All the people involved in the e-mail correspondence were anonymised, and data collection and storage adhered to the requirements for personal data (NESH, 2016). However, some ethical considerations may appear in the use of e-mails. As far as possible, I tried to present a complex picture of an initial collaboration, analysing the e-mail correspondence, which provided justice to the participants. Nevertheless, a holistic representation of participants' perspectives that includes other sources has been limited. Still, I am reasoning that the analysis does shed light on the setting connected to the participants' perspective and not my preferences as a researcher. Using a Change Laboratory approach positions me as a collaboration partner who is reflexively following whatever may appear or emerge during the intervention processes. If the opposite was the case, it would be difficult in a flexible manner to be supportive when needed (Aas, 2011, p. 281).

In this study, dialogue continuity was maintained in different arenas over a longer period. The dialogue included planned and unplanned spontaneous meetings, lessons, mobile phone calls and e-mails. However, with the e-mails, it was possible to locate various activities throughout the entire intervention. The e-mails show suggestions with details, and they provide clarifying information, as well as information about appointments. In short, the e-mails were a stable resource throughout the lifespan of the intervention, documenting different parts of the process. After a comprehensive review of the different elements of the intervention, it was clear that the e-mails played a central role (Clarke, 2015). The e-mails show a timeline of the different phases and activities that took place, and they reflect the different elements of the study.

After reviewing the e-mail correspondence, several themes emerged during the process of coding and categorising using the Constant Comparative Method (Strauss & Corbin, 1998). Moreover, three basic phases emerged. The first phase of the e-mail correspondence, from 16 October to 12 November 2013, consisted of my dialogue with the principal about the future collaboration. This phase focused on the principal's acceptance of the research topic and his permission to conduct the intervention at his school. The second phase, from 11 November 2014 to 24 September 2015, consisted of my e-mail correspondence with the first teacher about the possibilities and contradictions connected to the emerging collaboration. This phase was fundamental in laying the groundwork for the possible collaboration in the classroom. The third phase, from 2 October 2015 to 13 June 2016, consisted of e-mails about concrete planning and task suggestions, as well as all the practical solutions and pedagogical thinking that led to the accomplishment of the lessons as the intervention progressed. This phase was realised because of the first two phases I consider to constitute the initial collaboration in the intervention. The next section will present more details about the three phases.

Findings

The first phase, eight e-mails

This phase started with one meeting between my institution of higher education and a network of collaborating schools, where I presented some thoughts connected to the use of ICT in teaching. One principal was highly interested in a collaboration where teachers could expand their ICT practice. In an e-mail after our first meeting, I confirmed that the use of ICT to support learning processes is interesting and asked whether teachers have concrete needs or if they could send me any thoughts or ideas that I could include in an outline. The principal answered that the ICT-responsible teacher with whom he spoke agreed that this was a highly relevant theme. Further, he wrote:

> I will present your request during our meeting Monday morning. The first step in our school will be to make some teachers eager for this idea. I hope teachers will see the possibilities and not only the limitations. If someone has some suggestions, I will pass them on to you.

The principal signalled again his interest. However, as seen in a later e-mail, he also noted that lack of time was a concern:

> It has been such a hectic morning. One class was going to have this national test, and we had some technological problems. Therefore, I had no time to answer you earlier. I am at a hotel now. It is too bad that we do not have more time to talk, but I feel that we have enough time to make a plan about this project.

I asked him if he had talked with teachers about the ICT theme and learning processes. I wrote:

> Did you find time to talk about the possibilities connected to learning processes and ICT with your teachers? It can be ok to consider this theme. I will be away until Friday, so we can have a meeting on Friday or next week. Just choose what suits you best.

After the second meeting, he noted in an e-mail that to be able to 'sell' the possibilities when he was meeting with teachers, he needed me to provide an outline of what I had in mind. He also wrote, 'Teachers must feel that this type of collaboration would be beneficial to their busy workdays'. He suggested that we then could have a meeting where I described closely what I have in mind, so he could pass this on to the teachers and so 'we could hope that someone would join this collaboration'.

The second phase, 23 e-mails

The teacher (Mr Todd) who wished to collaborate with me stated in the beginning that he wanted to try something else in his mathematics lessons, and he chose Minecraft to be his new teaching practice. In my first e-mail to him in November 2014, after we had our first conversation about collaboration possibilities, I asked him when he had an opportunity to start. I wrote:

> The reason for my question is that I have the possibility to connect some of my working hours to our collaboration, and the use of ICT in education is of special interest to me,[3] particularly when it comes to mathematics education.

He wrote back that we could start right after Christmas, because 'it's too much right now'. We had our first meeting on 20 January 2015. The report from the meeting was e-mailed to the principal to keep him updated.

The ICT-responsible teacher[4] had no time to install Minecraft, and he was the only person who could do it. I told Mr Todd that I might have a solution and asked for a meeting among the three of us. Unfortunately, Mr Todd had to be elsewhere. Nevertheless, the ICT-responsible teacher accepted my suggestion that I could relieve him for some of his lessons so he could find time to install Minecraft, writing:

> Hi, I am sorry that I did not answer you earlier; the reason is that I had to do some rearranging. Counting up for installing Minecraft: 16×20 minutes = 320 minutes = 5 hours and 20 minutes. It could be suitable for me if you have the possibility to take lessons Thursday, week 15. Friday is also possible. If you want to come and say hello to the class before Easter, it can be done Thursday this week. Just send me the time that suits you!

Thus, to resolve the issue concerning the necessary installation of the game, I presented six lessons in the ICT teacher's class so he could complete the installation.

This second phase also deals with organising and conducting the introductory lesson. In the beginning, we planned to have this introductory lesson during week 17, but after some correspondence, Mr Todd wrote that 'it's very busy, but maybe week 22 is the most feasible?'

I provided Mr Todd with information about the possibilities connected to the national curriculum[5] and Minecraft. I also made suggestions concerning the tasks, and I suggested that Mr Todd, who had not tried Minecraft earlier, could work

3. I am a teacher educator in pedagogy with a special interest in the use of media/ICT in schools.
4. This is the same ICT-responsible teacher about whom the principal was talking earlier.
5. Directorate of Education (2015).

together with one student, meaning that he could be a student himself. Mr Todd wrote back:

> You have been working very well in planning what we can do in Minecraft. I am sorry that I have not been 'on' so much lately. The plan looks nice and we shall use the special multimedia room. Our time is from 08:00 to 10:00. I am looking forward to being a student! I understand that you have been in contact with the ICT-responsible teacher and received our password.

The same day, I wrote back the following:

> Yes, I have the password. If you don't wish to make changes to my suggestions, then we can just try the tasks as they are. I have completed all of them myself, and I think that most of the students will be quicker than I am. It will be exciting! It could be nice to have an evaluation after the lesson tomorrow or at least this week when it is fresh in mind. Can you make it?

The third phase, 25 e-mails

Minecraft had to be upgraded, and new worlds had to be installed. I asked in connection to this whether Mr Todd could look at two attached tasks. Mr Todd wrote, 'Very good tasks, I like them. We have to organise the classroom before Monday; can you come today at 14:30?'

In December 2015, Mr Marvin, who replaced Mr Todd, joined the intervention. Our first meeting was about what the class had done and how the intervention could proceed. Mr Marvin wrote that he was short of time: 'I am sorry about my late response, a lot is happening right now. We can have a meeting on Monday at 14:00'. After the meeting, Mr Marvin wrote that the students had started with fractions, but he did not have time to think about this yet. It sounded good if I (the researcher) could have suggestions. After receiving suggestions from me about fractions and the area for our first lesson together, Mr Marvin answered, 'Both suggestions to the tasks look reasonable. This week, we have been through fractions, both how to abbreviate and expand fractions, so it should not be any problem. They [students] are also familiar with the area now'.

The e-mail correspondence is frequent and reveals suggestions from me about the tasks, positive feedback from the teacher and further planning regarding meetings and interviews. When we were about to start planning our last session in May 2016,[6] I wrote:

6. This is the follow-up session in week 24, as mentioned earlier.

> It has been a while since we had Minecraft. Students had a break and that might be a good thing. Does it suit you to have a lesson during one of the following weeks: 22, 23 or their last week in school, week 24? What do you think is appropriate to do with the class now at the end of the school year? You know best what they need.

During this correspondence, I also expressed that I had to interview some students and Mr Marvin after the lesson. Mr Marvin wrote back:

> Yes, it was a good idea to wait, especially when the oldest students have exams and the priority to use the computers. In addition, the ICT-responsible teacher has been busy. We can schedule the lesson and the interviews in week 24. It suits us well to have something alternatively to do when the students have to return their books and are tidying their classroom.

In a later e-mail, I suggested tasks about volume, which we used in the last session.

Discussion

To investigate how the beginning of an intervention can create a meeting place between educational research and educational practice, I asked the following research question: *How does initial collaboration between a researcher and practitioners create a meeting place, and what implications can be drawn from this?*

After the process on the 'transparent roof' (Postholm & Moen, 2011) and after discovering that e-mails were discursively related (Virkkunen & Newnham, 2013, p. 113) to most of the other elements, I moved forward with the e-mail analysis. It must be remembered that while the e-mail correspondence was not the only form of communication, it structures the various actions that were taken in connection to the intervention. This is shown in the right column in Figure 2. Three phases containing these actions were identified, as shown to the left in Figure 2. In addition, the contradictions (Engeström & Sannino, 2011) that emerged are outlined in this phase. The first phase was about gaining admittance from the principal. Furthermore, in the first phase, the principal mentions several possible impacts, such as whether teachers will find such a collaboration beneficial, and this might have presented a dilemma. When I asked about teachers' needs, he wanted me to concretise what I had in mind, writing, 'We could hope that someone would join this collaboration'. This could be a beginning expression of helplessness, such as in double binds (Engeström & Sannino, 2011, p. 375). However, I will not draw a conclusion because the tone in the e-mail was rather encouraging. This situation was resolved with Mr Todd having a clear purpose for collaboration.

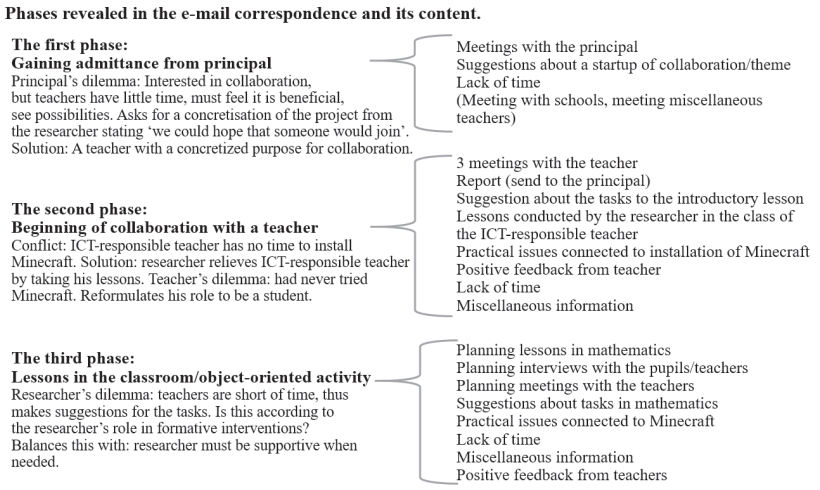

Figure 2: Unwrapped information about activities connected to the three respective phases revealed throughout the analysis of the e-mail correspondence.

The beginning of the collaboration with Mr Todd started in the second phase. A continuous dialogue is maintained using e-mail planning activities. One conflict started to emerge when the ICT-responsible teacher had no time to install Minecraft. As I see it, if the e-mail correspondence had stopped, particularly about this matter, further activity in the intervention would be difficult. To secure the installation of the game, we entered into a compromise where I offered to lead lessons in his class. Mr Todd also had one dilemma: he did not know how to use Minecraft, but he had no problem with reformulating his role in the introductory lesson and becoming a student.

In the third phase, I was obliged to design the tasks to facilitate the collaboration. The e-mails from the third phase show that both teachers had positive responses to the received tasks, but they also demonstrated that they did not make many suggestions themselves. Due to lack of time, it seems the teachers were expecting the researcher to make the suggestions.

These phases show that the researcher needs to provide various solutions that do not necessarily seem to be part of the researcher's role in formative Change Laboratory interventions (Engeström & Sannino, 2010; Virkkunen & Newnham, 2013). An explanation was that the researcher must be flexible and supportive when needed (Aas, 2011, p. 281). Looking at this from another angle, the teachers could have ended the collaboration if it did not add anything useful (Postholm, 2008). It was challenging to find time to collaborate; however, the collaboration had enough relevance and continued despite busy workdays. Thus, I think this collaboration was worth more than the sum of its costs, contributing to expanding the teachers' practice (Postholm, 2015, p. 48).

The implication is that the researcher has an explicit practical impact on the collaboration activity by moving across boundaries (Engeström & Sannino, 2010) and overcoming conflicts and dilemmas. In this way, the researcher moves into the practitioner's world, not only informing with academic knowledge, but also securing further teaching activities in mathematics using Minecraft. For the researcher, this kind of intervention is time-consuming from the beginning. That said, if the researcher did not make this a priority, this could have contributed to a separation of these two worlds (Biesta, 2007; Rønbeck & Germeten, 2014). Instead, from a gestalt viewpoint (Clarke, 2015), the researcher and the practitioner accomplished an object-oriented activity (Virkkunen & Newnham, 2013) by collaborating in using Minecraft as an educational tool in mathematics.

The e-mails show dialogue continuity, which was essential for the intervention to proceed and for the object-oriented activity to be achieved (Sannino et al., 2016) in the third phase. Dialogue can be understood as essential for creating and expanding, with further actions, a meeting place between the researcher and the practitioners. Conversely, withdrawing from or closing the dialogue would end the collaboration.

Concretising the expansive dialogue

Virkkunen and Newnham (2013) defined an intervention as a 'purposeful action by a human agent to support the redirection of ongoing change' (Virkkunen & Newnham, 2013, p. 3). In an attempt to concretise the experience with a continuous dialogue creating a meeting place where change could be realised, I developed a model, as depicted in Figure 3.

The spiral shown in Figure 3 refers to the dialogue, and some, but not all, of it is captured by the e-mail correspondence. Not all of the activities could be documented by e-mails, as Figure 1 shows. Nevertheless, e-mail correspondence is understood as the timeline, visualised as an arrow, which continues throughout the dialogue process as the intervention proceeds. The e-mails as mediating artifacts were used to facilitate a meeting place between the researcher's world and the practitioner's world, where dialogue was manifested. In Figure 3, the spiral gradually widens because the dialogue, as I see it, had to expand (Engeström, 2016, p. 9) and become spacious enough for any object-oriented activity to be realised (Engeström & Toiviainen, 2011). The model presented in Figure 3 is an abstraction that aims to grasp the essence of the study (Engeström, 2016, p. 42). It represents the continuation and expansion of a dialogue through a mediating artifact facilitating a meeting place that works towards realising an object-oriented activity, that is, from words to practical actions, as emphasised in a Change Laboratory (Sanninno, 2008, p. 237).

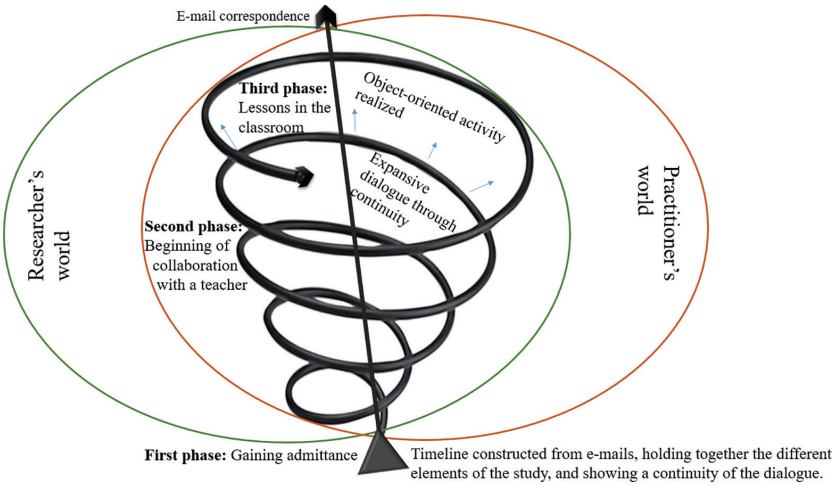

Figure 3: Model of expansive dialogue between the researcher's world and the practitioner's world.

Conclusion

This article points to the need for research that aims to clarify the importance of initial phases in a formative Change Laboratory intervention. Based on research from the field of education, I developed a model to demonstrate how to map the initial phases of a collaboration. Further empirical studies are needed to question and refine phases that may appear in transformative studies, especially with a focus on the initial phases and to what they may lead or not lead when it comes to the creation of a meeting place and an object-oriented activity. The limitation of these findings is that only the content from the e-mails is examined. Other sources of evidence would be helpful to strengthen the findings. Practical implications from this study may be that detected phases in other studies can be compared to or analysed with the help of the phases that emerged during this intervention.

Contradictions are interesting to explore when it comes to the initial phases, especially with a focus on how they appear and may be resolved, as they can have a crucial impact on how a formative Change Laboratory intervention is brought into being by a researcher and a practitioner.

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