Doctoral theses at NTNU, 2022:348

Teresa Beste

Strategic change towards cost-efficient public construction projects

Doctoral thesis

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of Philosophiae Doctor
Faculty of Engineering
Department of Civil and Environmental Engineering

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ISBN 978-82-326-5912-8 (printed ver.)
ISBN 978-82-326-5936-4 (electronic ver.)
ISSN 1503-8181 (printed ver.)
ISSN 2703-8084 (online ver.)

Doctoral theses at NTNU, 2022:348

Printed by NTNU Grafisk senter

I. Preface and acknowledgements

A life chapter of being a PhD-candidate comes to an end. Four years of my time, I am grateful for twice – once for having started it, but right now mostly for finally having finished it. This has definitely been the most difficult challenge I have ever engaged in.

For the last one and a half years, I have shared my time between leading a group of project controllers at Statsbygg, while trying to focus on academic writing. The Covid-19 pandemic also impacted the process of writing this thesis. Instead of splitting my time between the office in Oslo and NTNU in Trondheim, lockdown and restrictions confined me to home office, partly with my energetic boys around me. Of course, nobody expects that the process of writing your dissertation goes exactly according to plan. That the change of my original plan included compulsory home office, home schooling and home kindergarten of my three sons and several periods of quarantine, was far beyond my imagination before I started this journey.

There are many people without whom it would not have been possible to do this project. First of all, I would like to thank the Norwegian Research Council for partly financing this PhD within their public sector PhD-scheme as well as my employer, Statsbygg, for giving me the opportunity to be their first PhD-candidate within this scheme. Especially Morten Dybesland, Kari Kleppestø, Roar Fosse and Trine Eiken need to be named here for their support, as well as my colleagues in the project management office, for backing me up, encouraging me and showing interest in my work. The empirical material is mainly based on work in the strategic initiative “Cost down? Step up!”. I would like to thank Trygve Sagen and Jørgen Kjetil Knudsen for their collaboration in the initiative, as well as all those project managers and other project staff who participated in interviews and meetings.

I am very grateful for having been part of an active research environment during this time. The discussions with my fellow PhD-students, especially Ida, David, Atle and Anders, were extremely valuable. Olav Torp, Jan Alexander Langlo, Jardar Lohne, Ola Lædre and Nils Olsson gave me important feedback during the midterm-evaluation, seminars and courses. Nils deserves a special mention as he gave me the initial idea for the PhD-project, when I participated in his course “Practical project management” in 2016-2017. A big thanks also to the co-authors of my articles, Ole Jonny Klakegg and Jørgen Kjetil Knudsen.

Jørgen Kjetil Knudsen was also my co-supervisor during the first two years, and Agnar Johansen during the last year. However, the single most contribution was undoubtedly by my main supervisor Ole Jonny Klakegg. In German, the traditional denotation for the main supervisor of a PhD-student is *Doktorvater* (PhD-“father”). This is really true for Ole Jonny. Without his genuine interest in my work, his always positive attitude, motivation, expertise, and ideas, I might have given up halfway. His feedback was always immediate, encouraging, professional, to the point, constructive and challenging. Thank you so much for your inspiring collaboration and help!

Last but not least, I thank my family and friends for supporting me during this sometimes quite busy time – for being there for me, listening to my complaints and for accepting that I needed to focus on writing both evenings and weekends. A special thanks to my husband Ansgar for his support, bearing with me and my moods, and for taking over extra responsibilities at home during busy writing periods, as well as my three sons Leander, Jonathan and Valentin for their understanding and patience during this time.

II. Summary

The construction of public buildings, such as universities, museums, prisons or hospitals, creates value for society, but also comes at a cost. Limited public funds make it necessary to assure an optimal use of public resources. However, not all projects succeed with that, and complaints about a high cost level of public construction projects are numerous. Although academic research on construction project costs is abundant, the problem does not seem to have improved in practice.

This PhD-project has followed a two-year strategic initiative, which a public building commissioner pursued to increase the cost-efficiency of their construction projects. Cost-efficiency means achieving the desired result of a project with minimal resources invested into the project. In addition to investigate cost-efficiency on a project level, the PhD-project also looked at cost-efficiency at an organizational and a strategic level. The research purpose was to investigate how to achieve lasting change towards higher cost-efficiency in public construction projects. Three research questions have guided the research: (1) Which actions do public construction projects take to achieve higher cost-efficiency? (2) How can knowledge transfer between the projects on cost-efficiency actions be increased? (3) How can we achieve lasting change towards more cost-efficient construction projects?

The research has been conducted by a practitioner-researcher inside a public organization with an action research approach. Mainly qualitative methods have been used, augmented with quantitative data where necessary.

This paper-based thesis consists of an introduction and a compilation of academic papers. Five papers form the main body of this thesis, each covering a different aspect of the main topic of achieving strategic change towards increased cost-efficiency in public construction projects. The first three papers address systematic completion, standardization, and stakeholder involvement as examples of actions for increasing cost-efficiency. The fourth paper on microlearning addresses the necessity of knowledge transfer on cost-efficiency and the fifth paper presents a meta-perspective looking at how the results of the strategic initiative are implemented in the organization.

The research shows that many different actions for cost-efficiency are executed by the construction projects. Some of the actions, like standardization, are quantifiable and scalable. Especially actions in early project phases involving the user as an important stakeholder, result in a significantly positive effect on project costs. However, to profit from cost-efficiency not only at a single project level, but at a portfolio level, knowledge transfer on successful cost-efficiency actions between the project teams is necessary. Microlearning can be one of the tools to increase knowledge sharing. In addition, the results from the strategic initiative need to be implemented in the permanent organization to achieve lasting change. For the implementation, the Pentagon model with its five dimensions of structure, technologies, social relations and networks, interaction and culture can serve as a tool for the organization to increase organizational capabilities and performance on cost-efficiency. Creating cost-efficiency actions together with the construction project teams in meetings, was vital for involving the project teams in the change process.

The practical contribution of this research is inherent to its action research approach, as the starting point was a practical problem to be solved. Through the research, the organization has

gained important insight on how to increase cost-efficiency permanently on a portfolio level. This study answers the need for more practice-based research in project management by giving a rich empirical account of how change processes in organizations practically happen. Furthermore, the study extends the Pentagon model and applies it as a tool in a new field – the implementation of a strategic initiative in a project-based organization.

III. Abbreviations

ASCE	American Society of Civil Engineers
BIM	building information model(ling)
BVP	Best Value Procurement
cf.	*confer* = compare
DFØ	Direktorat for Forvaltning og Økonomistyring = The Norwegian Agency for Public and Financial Management
e.g.	*exempli gratia* = for example
et al.	*et alii* = and others
ibid.	*ibidem* = at the same place
i.e.	*id est* = that is
incl.	including
IPD	Integrated Project Delivery
KPI	key performance indicator
mgt.	management
NOK	Norwegian crowns
NTNU	Norwegian University of Science and Technology
OECD	Organization for Economic Co-operation and Development
org.	organizational
n/a	not applicable
p.	page
PBO	project-based organization
PhD	*philosophiae doctor*
PMBOK	Project Management Body of Knowledge ®
PMO	project management office
QA	quality assurance system of the Norwegian government
RQ	research question
SC	systematic completion
US	United States

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1	Systematic completion	**Effect of systematic completion on public construction projects**
	Beste, T. (2021). Effect of systematic completion on public construction projects, *Facilities*, Vol. 39, No. 3/4, pp. 156-171. https://doi.org/10.1108/F-11-2019-0127	
2	Standardization	**Standardization and industrialized construction of special purpose buildings**
	Beste, T.M., Klakegg, O.J. and Knudsen, J.K. (2019). Standardization and industrialized construction of special purpose buildings, Lill, I. and Witt, E. (Ed.) *10th Nordic Conference on Construction Economics and Organization (Emerald Reach Proceedings Series, Vol. 2*), Emerald Publishing Limited, Bingley, 25-31. https://doi.org/10.1108/S2516-285320190000002033	
3	Stakeholder influence	**Stakeholder influence on public construction project costs**
	Beste, T. and Klakegg, O.J. (202X) Stakeholder influence on public construction project costs. *Unpublished paper*	
4	Knowledge transfer	**Knowledge transfer in a project-based organization through microlearning on cost-efficiency**
	Beste, T. (2021). Knowledge transfer in a project-based organization through microlearning on cost-efficiency. *The Journal of Applied Behavioral Science*. https://doi.org/10.1177/00218863211033096	
5	Strategic change	**Strategic change towards cost-efficient public construction projects**
	Beste, T. and Klakegg, O.J. (2022). Strategic change towards cost-efficient public construction projects. *International Journal of Project Management*, Vol. 40, issue 4, May 2022, pp. 372-384 https://doi.org/10.1016/j.ijproman.2022.04.006	

1. Introduction

1.1. Background

Special purpose buildings, such as universities, museums, prisons, or hospitals fulfil important purposes in society, as they enable important societal functions. There is no doubt about the necessity of those buildings. However, building them comes at a cost – which is paid for with taxpayers' money. As the monetary resources of the public are limited, allocating budgets is always based on prioritizing between different public tasks. In the end, expensive construction projects can result in cuts in other public expenses e.g. in public healthcare or education. To secure an optimal use of public resources, public construction projects must be cost-efficient and assure not to spend more money as necessary to fulfil their purpose.

Cost-efficiency in construction project means weighing the result (output) of the project in relation to the resources (input) invested into the project (Zidane and Olsson, 2017). Cost performance has thus two facets: In early project phases, the aim is to create a project concept fulfilling the project objectives of the project with minimized financial input. This also includes finding the right cost estimate for the preferred concept. The other facet is avoiding cost increases in order to finish on or below the project's budget, once the concept is decided upon and the project's budget is set.

In Norway, Statsbygg is the Norwegian government's building commissioner, property manager and developer and advises the government in construction and property affairs (Statsbygg, 2022). In the role of the government's building commissioner, Statsbygg has experienced that project management of large and important projects was given to private companies, because the cost level of Statsbygg's projects was perceived as too high. In recent years, the demand from political players for both avoiding cost overruns and generally building public construction projects at lower cost has increased significantly. High media exposure of projects with cost escalations also contributes to the necessity to act. Just lately in spring 2022, negative media coverage culminated with reports on cost overruns in completed projects and exorbitant cost growth in ongoing projects. An example for that are the late completion and 1.3 billion NOK cost overruns (compared to the estimate at the decision to build), when enlarging the University of Life Sciences in Ås (Regjeringen, 2022). Recent developments, such as the Covid-pandemic, the war in Ukraine and a galloping increase of market prices contributes to increased project costs. The co-location project of the Norwegian University of Science and Technology was forced to pause in the planning phase in order to reduce estimated project costs by several billion NOK (Khrono, 2022). And the project for enlargement of the Museum of the Viking Age in Oslo red-flagged a cost growth of 1 billion NOK right before starting construction (Uniforum, 2022).

This is the practical rationale behind this research, pointing towards an urgency to act. Academically, construction projects costs and cost-efficiency are by no means a new topic. The costs of construction projects, also with focus on the public sector, have been studied by academics from all over the world for many decades already. Scope creeps, budget overspending and exploding project costs are well-known problems, also as an academic research topic.

The most known comprehensive study on cost overruns in construction projects might be Flyvbjerg et al.'s (2002) study on 258 transportation infrastructure projects. They found

underestimation of project costs in nine out of ten projects, and actual costs exceeding estimated costs by 28% on average. They assign cost overruns to strategic misrepresentation or an optimism bias rather than to errors. They also found, that cost underestimation has not decreased over time, and they thus conclude that there is a lack of learning from previous projects (Flyvbjerg et al., 2002). Love et al. (2019) found in their study of 85 transportation projects both cost underruns and overruns, with a mean project cost increase of 12.62% between the contracted value and the final account. There is no consensus if the size of the project determines the likelihood of cost increases (Love et al., 2019). In their literature study on construction projects overrun, Aljohani et al. (2017) have collected several studies from project all over the world presenting ranges of average overruns of between 16.5% and 175%, with overruns as a 'regular feature' specifically in public projects. As two of the main reasons for overruns, they name poor resources management, and a lack of effective communication between a project's internal and external stakeholders (ibid.).

Welde and Klakegg (2022) demonstrate in their study of 96 projects in Norway, that a project governance framework with stochastic cost estimation and external quality assurance contributes to reducing cost overruns on a national level. So a quality assurance system is one possibility to regulate project costs on a portfolio level. However, between the project level and the national level, there is the organizational level, focusing on how one organization works with avoiding cost overruns and reducing project costs in their portfolio. This specific aspect has not been explored by academic researchers to the same extent as the project and the national level.

For a project-based organization (PBO), who organizes its main activities in temporary organizations to perform project tasks (Lundin and Söderholm, 1995; Hobday, 2000), the transfer of successful practices between projects is vital for long-term success (Sydow et al., 2004). To achieve this, the organization needs to support knowledge transfer between the projects, as there is no automatic transfer of lessons learned between projects (Wiewiora et al., 2009). However, the strategic aspect of implementing change in a project portfolio – in this case related to cost reduction – lacks practice-based research. Clegg et al. (2018) e.g. ask for studies exploring the reality of strategic enactment through a project portfolio.

Another aspect not covered in current literature are studies on how organizations actively work together with the projects to optimize project costs to deliver on the project objectives. Existing literature often focuses on ex-post evaluations and lacks a practical view of what really happens in the projects.

So we know both from practice and research that public construction projects are expensive, and that cost escalation presents a well-known problem. It is a global phenomenon and learning from previous projects seems to be limited, as project cost performance has not improved over the last 70 years (Flyvbjerg et al., 2010). It is not enough to know about the problem – you must do something about it to achieve change.

When Statsbygg initiated a strategic initiative on the topic of cost reduction in construction projects in 2018 to meet the demand of higher cost-efficiency in their construction projects, it seemed to be the right point in time to conduct research in the initiative. At that point, I had been working at Statsbygg for five years as a project controller and had thus considerable insights into project costs and the dynamics leading to either good cost performance or cost overruns. My experience combined with an interest in a more analytical and academic way of

approaching the topic, made me the right person to engage in this endeavour. The problem was of practical nature, and thus action research was chosen as the most appropriate methodological approach. Action research allows to practically work with creating change and simultaneously generate academic knowledge on this process. This also fits well with by background as a practitioner-researcher.

The contribution of this research lies in giving a rich empirical account of how to work on increasing cost-efficiency in public construction projects. In addition to the project perspective, I focus on how the organization can use efforts in the single projects to achieve a strategic change towards higher cost-efficiency on a portfolio level. This answers the quest for more practice-based research to examine the translation of strategy in a project portfolio (Clegg et al., 2018). I will also establish a link to knowledge management and elaborate why this is an important factor in achieving a lasting change towards more cost-efficient public construction projects. Although this piece of research is from within one organization, I assume that also other building commissioners can benefit from the results and that other academics can build on this research.

1.2. Research purpose and research questions

Initially, the general objective of this PhD-project was to gain more knowledge about cost management and cost-efficiency in Statsbygg's public construction projects, including both the right front end cost estimation as well as good cost management during the project.

However, early during research, I noticed that many factors influencing cost-efficiency already had been investigated and documented in prior research initiatives in the organization. For some of the identified factors, the potential for cost reduction had been quantified, for others, the quantification proved to be more difficult. In addition to find out how to increase cost-efficiency in each project individually, a focus much more directed at the portfolio and organizational level emerged. The real problem to investigate turned out to be connected to the following questions: How can we assure knowledge exchange about cost-efficiency actions between different projects, trying to achieve cost-efficiency on a portfolio level? Furthermore, with the identification of factors and the knowledge transfer of isolated actions, an additional challenge occurred: How can we assure that the actions do not remain 'one-offs' in a particular project, but allow effective actions to be transferred to other projects? How can we achieve a lasting change on a strategic level towards a project environment appreciating cost-efficiency in the construction projects and always seeking to create the required value in the projects without spending more money than necessary?

These considerations led to the following redefinition of the research purpose:

> *to investigate how to achieve lasting change towards higher cost-efficiency in public construction projects.*

The research purpose is substantiated in the following three research questions, each constituting one specific research aspect covered in this thesis.

1. *Which actions do public construction projects take to achieve higher cost-efficiency?*
2. *How can knowledge transfer between the projects on cost-efficiency actions be increased?*
3. *How can we achieve lasting change towards more cost-efficient construction projects?*

With these research questions, I move the research from a pure cost perspective to also include an organizational knowledge perspective as well as a strategic aspect of how to include a higher focus on cost-efficiency permanently in the organization also after the end of the strategic initiative.

1.3. Scope and limitations

This thesis is a paper-based thesis. The introductory chapters (1-7) constitute an overview setting the scene, introducing and relating the topics in the papers, while the main results are presented and discussed in the papers.

The scope of this study is an investigation into possible project cost reductions, both in single projects and more permanently on a portfolio level. Mostly qualitative, but also quantitative data is used. The study is a document from inside a Norwegian building commissioner in the public sector and uses empirical data of one organization from the years 2018 - 2021. This limits the study's direct transferability to other building commissioners or its use in an international context. The scope is also somewhat limited to actions which the organization can implement internally. In addition, societal preconditions can influence project costs, which are outside the direct influence of the organization. These aspects are not covered in this study.

This thesis covers a strategic aspect, as the title states: 'strategic change'. I want to clarify, that this is not the aspect of strategic management of a portfolio, but how a strategic objective, in this case that of cost-efficiency, is implemented in a project-based organization and which role the construction projects play in this process.

The starting point of the research is a practical problem. While the closeness and direct applicability to the organization enhances the relevance for practitioners, it might delimit the theoretical contributions of this study. Methodological limitations are also addressed in chapter 3, especially the role of the practitioner-researcher (section 3.3), and the validity and reliability of this research (section 3.7).

Another limitation results from the both the topic, the design and the results of the study: Cost-efficiency actions in construction projects touch upon many different aspects across different disciplines. In my opinion, it is beneficial to tie together different theoretical and empirical aspects in a PhD-study, but the downside is, that each aspect cannot be investigated in such detail than it would have been possible in more specialized studies.

Practical limitations arising in this study are amongst others the long execution time of many of the sample projects, which makes it difficult to see an immediate effect of the initiated actions for cost-efficiency, as some projects forming part of the study are not completed until later. Measuring the effect of the actions on a portfolio level has proven to be challenging (see also section 7.2).

1.4. Structure of the thesis

In this paper-based thesis, the collection of academic papers forms the main body with the presentation of results. In the research process, the successive publication of papers allowed to make the results accessible for a larger audience continuously. The paper-based format also allows to present each of the different aspects of the research topic in an academically sound and thorough way.

The introductory text in chapters 1 to 8 serves as both an introduction to the papers, presents the central theme and shows the coherence of the results presented in the papers.

This thesis starts with introducing the research purpose and the research questions, as well as the scope and limitations of this dissertation in chapter 1. Chapter 2 outlines the empirical context for this research, with a presentation of the place of research and of the internal research initiative, which I followed as an internal action researcher. In chapter 3, the methodological approach for this research is summarized, both the overall approach as well as for the different papers. This includes a description of the action research approach, epistemological and ontological considerations, a discussion of my role as a researcher, information on how data was collected and analyzed, as well as considerations of validity and reliability. Following methodological considerations, I describe the theoretical background for this research with the three different perspectives of cost, knowledge, and strategy in chapter 4. The results are presented in a summarized version in chapter 5 by presenting the five papers forming part of this PhD-project, as well as in chapter 6 where I present additional results from the strategic initiative. In chapter 7, I combine the three different theoretical perspectives used to look at the issue of cost-efficiency in public construction projects: cost, knowledge and strategic perspective. Further, I discuss the research findings. This includes an overview of cost-efficiency actions identified in different phases of the construction projects. I also discuss how change can be implemented successfully in the organization. In the concluding chapter 8, I draw conclusions from the findings to answer the research questions presented initially in this thesis. I present both theoretical research contributions and the practical implications of this study. Recommendations for further research are outlined.

The full text of the five papers is provided in the appendix.

2. The place of research and the strategic initiative

In the following chapter, I will present the context for this PhD-project. To place this into context, I will first outline the background of cost performance of Norwegian public construction projects before I describe Statsbygg as the place of research and the strategic initiative within which I performed my research.

2.1. Cost performance of Norwegian public construction projects

In Norwegian public construction projects, cost issues similar to those in an international context can be observed. However, even if large Norwegian public construction projects show cost increases, there seem to be fewer examples for exorbitant cost overruns – meaning that based on cost data, there is relatively good cost control in Norwegian public construction projects (Berg et al., 2022). Mostly, large public investment projects have been completed within budget (Regjeringen, 2021). However, the cost level of those projects is high, and the average increase in project costs before the decision to build is over 40%, mainly due to costly changes in early project phases (ibid.).

The Menon-group (Ulstein et al., 2015) has analyzed cost increases in the early project phases of four large Norwegian public building projects and has identified the direct causes of changes in the gross area, the composition of different area types, the standard of the building, localization and real estate costs, as well as overhead or transaction costs. Factors explaining these causes are low estimates in the concept phase of the project, changes in the requirements and solutions desired by the client, and a lack of focus on keeping the cost on the level of earlier estimates (ibid.). Systemic, or root causes for cost increase are identified as project governance schemes, time used in the processes, and project organization including the incentive structure for main parties involved in the projects (ibid.). Torp et al. (2016) identified factors contributing to cost increases in the planning phase: scope and design change, project complexity, site and location constraints, as well as the need for special facilities. Klakegg et al. (2018) conducted six case studies on value creation in Norwegian public construction projects and concluded that project costs are largely determined in early project phases and that the owner's decisions have a high impact on project cost. In the next phase, the choice of a competent project team and the conceptual choice and project delivery model are most important, along with specific area requirements and the systems and material choices made by the design team and contractors (ibid.).

Bygg21, a Norwegian collaboration of the construction and property industry and public authorities, identify good collaboration with trust and openness between different actors, industrialization, resources with the right competency at the right time, and effective processes between the public and the industry as key success factors for cost-effective buildings (www.bygg21.no).

In Norway, large public investment projects are required to pass through a mandatory external quality assurance system, both after the concept phase and before the decision to build (see Figure 1).

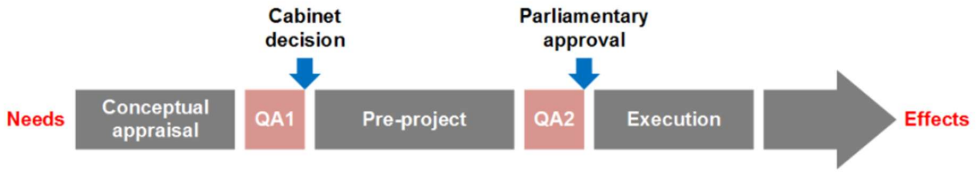

Figure 1 Quality assurance (QA) of Norwegian major public investments (Concept, 2022b)

Welde (2015) concludes that cost control of Norwegian public projects is good, as 80% of large building construction projects falling under the quality assurance scheme (excluding infrastructure projects) were completed within budget. As possible explanations for cost overruns in the remaining 20%, Welde (2015) identified the following factors: tactical underestimation and over-optimism at the front end of projects, changes in the project's scope or shortcomings in the tendering document, underestimation of risk, and weak project management by the project owner (ibid.). The national quality assurance system seems to have a positive effect on project cost performance.

One of the organizations executing public construction projects is the organization which is the entity studied in this PhD-project. In the following chapter, I will describe Statsbygg as the place of research.

2.2. The place of research

Statsbygg is the Norwegian government's building commissioner, property manager and developer. Statsbygg's role is to provide and maintain quality public facilities and workplaces for state agencies. Statsbygg also functions as an advisor for the government in construction and property affairs as well as during concept development and planning phases. In addition to managing public special purpose properties in Norway, Statsbygg takes care of Norwegian embassies and consulates worldwide.

As a government agency, Statsbygg is a public enterprise entirely owned and financed by the Norwegian state, under the regime of the Ministry of Local Government and Regional Development. Statsbygg's customers are ministries and public authorities.

Statsbygg's historical roots date back as long as to 1814. Today, there are over 2 300 public properties in the portfolio, ranging from small mountain cabins to the largest governmental buildings, museums, prisons and university buildings. Around 850 employees work for Statsbygg at five locations: the headquarters in Oslo, and in the regional offices in Porsgrunn, Bergen, Trondheim and Tromsø. At any point of time, Statsbygg manages over 100 construction projects of various size.

As a public enterprise, Statsbygg is financed by the annual government budget. The Parliament determines its annual budgets and can thus exert power over which projects Statsbygg executes. Statsbygg has income generated by rent paid by their public tenants, through advisory tasks for public customers and through selling public property. The costs include wages for their employees and other costs of operations, costs for administration, operations and maintenance of their properties as well as depreciation of their costs of financing construction projects. The surplus is used for three different purposes: one part is revenue for the state budget, one part is used for re-investment into public projects, and one part is placed into a financial fund.

Decisions on the two first-named elements are made by the Parliament, while Statsbygg manages the use of the financial fund.

Statsbygg manages both construction projects for buildings which they will operate themselves and projects, where the property is owned and operated by other public institutions. Types of projects include new buildings as well as refurbishment projects. All larger projects have to be approved by the government first. The Parliament has to authorize financing before construction starts.

The total annual investment costs of the last years, as well as the annual rent income is shown in Figure 2. During the last years, increased investment costs reflect an increasing project portfolio and more larger projects. However, there was a decrease from 2019 to 2020 and 2021, as there are many large projects in earlier project phases, where the annual spending is lower. At the beginning of the Covid-19 pandemic, there were also delays in some of the projects due to unavailability of workforce and material. In 2020, the annual investment cost in construction projects was 7.3 billion NOK (approximately 730 million EUR), while the annual rent income from the buildings in the portfolio was 5.2 billion NOK (approximately 520 million EUR). The following year, two of the largest projects were completed, resulting in a decrease in investment cost, but an increase in rent income. As several megaprojects are going to proceed with construction during the next few years, the investment volume per year is expected to increase.

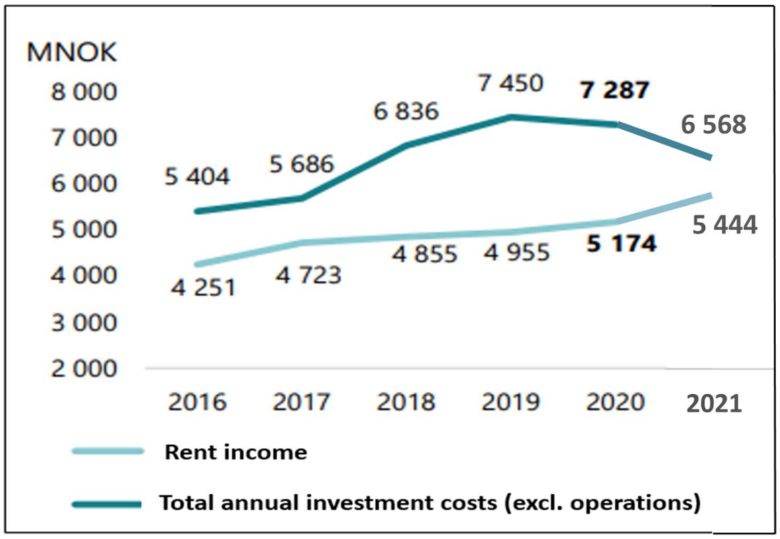

Figure 2 Statsbygg total annual investment level and rent income

There are four departments representing Statsbygg's core functions:

- Construction and project management
- Property development and management
- Operation and maintenance
- Advisory and pre-study department

In addition, these departments are supported by experts in the professional resource centre, who serve as quality control in their respective fields, as e.g. electric, or environmental engineers,

architects or juridical experts. Figure 3 shows an overview of Statsbygg's organization, including support functions like finance, IT, human resources, internal audit and communications.

The department of construction and project management is the building commissioner for the construction of public special purpose buildings in Norway. Building types include university buildings, prisons, museums, governmental buildings, courthouses and traffic control stations. The sub-departments are organized according to sectors (universities and university colleges, justice buildings, etc.). In addition, the largest projects (new building for life sciences, new government district, and NTNU campus co-location of campus) are sub-departments on their own. In the building commissioning department, there is also a project management office (PMO) with the sub-departments of project control, project support and health and safety.

The main information in this chapter is retrieved from Statsbygg's offical website (Statsbygg, 2022), with some additional points from internal documents.

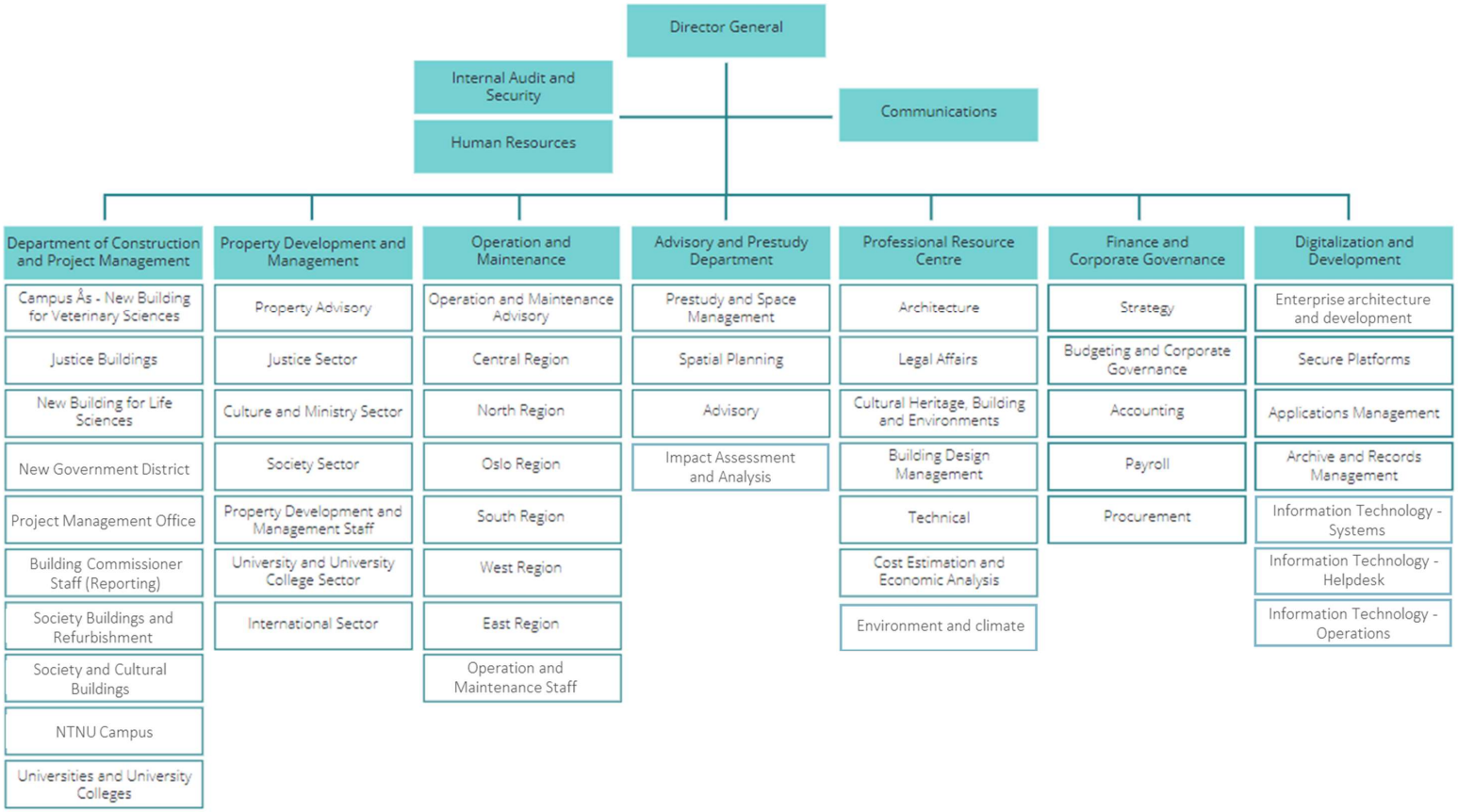

Figure 3 Statsbygg's organizational chart (Statsbygg, 2022)

2.3. The strategic initiative and the PhD-project

In 2018, an internal development project to reduce construction projects costs was established. This was necessary as Statsbygg's building commissioning activities are increasingly exposed to competition. The cost level (here illustrated by the development of m^2-price for new buildings in Figure 4; each m^2-price is in the respective year's price index, no price index adjustment has been made) was perceived as high by Statsbygg's customers, making potential customers consider to use private building commissioners or use alternative ways to conduct their construction projects.

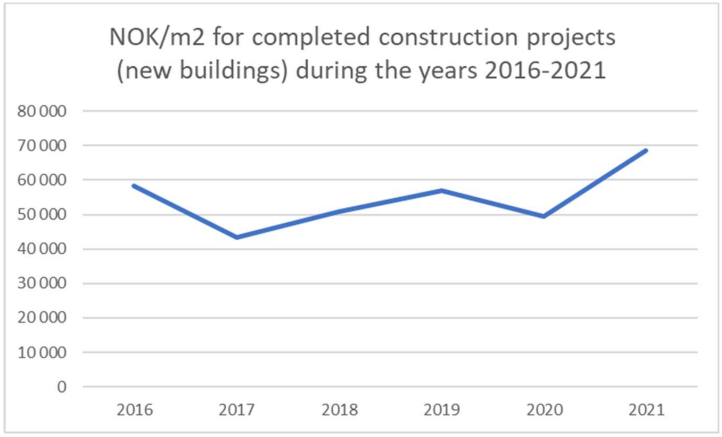

Figure 4 Development of m^2-price for Statsbygg's new buildings

The ownership for the initiative was placed in the strategy-subsection of the finance and corporate governance department. However, the objective was to achieve cost reduction in the organization's construction projects, which are mainly executed by resources from the department of construction and project management.

The core project team was composed of three people: an external project manager, one administrative resource/assistant project manager from the strategy department (part time) and myself.

An overview of the connections between the different entities and roles involved is shown in Figure 5. My role was both operational in the project team as well as academic with the PhD-project. Due to the small size of the core team, there were efforts in enlarging the team with an extra resource (part time) at several points of the project, but this was not possible on a permanent basis due to resource shortages in the operative part of the organization. In addition, the project reported to an internal project owner (head of the strategy sub-section) and a steering committee with members from top management. Other resources assisted the project on request, but in general, fewer people were engaged in working with the project as expected, as people were busy with working on construction projects (the operative tasks of the organization).

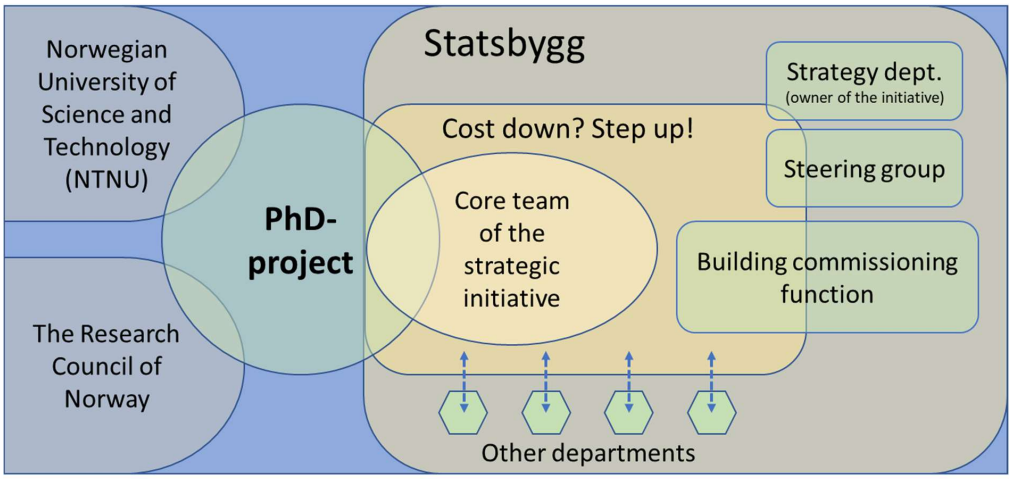

Figure 5 Statsbygg, the strategic initiative and the PhD-project

The strategic initiative was financed by Statsbygg's research and development budget and had a time frame of two and a half years, from January 2018 to June 2020. However, it took some time before activities started in summer 2018, thus the real duration was about 2 years. Although the project was formally finished in summer 2020, some implementation activities continued throughout the remainder of 2020.

The initiative was established to meet the challenge of a high cost level when planning and building special purpose buildings. To reflect that this was not only about cost reduction, but also about assuring not to reduce the value created through the construction projects, the initiative was given the name "Cost down? Step up!". It had the following main objectives:

- Contribute to the reduction of the total costs of Statsbygg's construction projects portfolio (tentative reduction of 20% until 2025 from a 2018-baseline).
- Contribute to make principles of cost-efficiency and learning of best practice an important part of Statsbygg's organizational culture, leading to faster implementation of successful cost-reducing measures.
- Contribute to innovation in the construction industry by engaging in new forms of collaboration with other players.

The preconditions for these objectives are that life cycle costs of the buildings should not increase as a result of reduced construction costs and that customers are equally satisfied (customer satisfaction index of >70).

From the start of the strategic intiative, I followed it with my PhD-project. The PhD-research was a collaboration between the three parties Statsbygg, the Norwegian University of Science and Technology (NTNU) and the Norwegian Research Council, within the Research Council's scheme for public sector PhD-candidates. The research was jointly financed by Statsbygg and the Norwegian Research Council. NTNU was responsible for assuring the professional and academic quality standard, and provided both supervisors and relevant educational courses.

In this chapter, I have elaborated on the cost performance of Norwegian public construction projects as a background for my research. I have introduced both the organization and the strategic initiative, which was my study object. The remaining part of the thesis concentrates on the PhD-project, but in chapter 6, I will explicitly report on important results from the strategic initiative.

In the following chapter, I will turn to the academic part of the study and introduce the methodological choices taken in the PhD-project.

3. Research approach and methods

In this chapter, I will outline the research approach and methods used in this PhD-study. Through the strategic initiative, which I described in the previous chapter, the setting of being an active researcher with practical tasks in the project I studied, was given. This precondition influenced the choice of research approach. Action research was chosen as the appropriate overall research approach. Action research as a research approach will be described before I outline the epistemological and ontological considerations guiding this research. Further, the implications of the researcher's role are discussed. In the following, the research methods as well as data collection and analysis for each paper are presented. The methodology chapter concludes with a reflection on the validity and reliability of the presented study.

3.1. Action research

A social science approach was used in this research, taking a practical problem as a starting point rather than a knowledge gap from literature. The overall methodological approach can be defined as a case study, focusing on the intensive research of one research object (Neuman, 2006) – in this case the department of construction and project management of a public sector organization. According to Yin (1981, p.98), a case study approach is appropriate when "*an empirical inquiry must examine a contemporary phenomenon in its real-life context*". In this case, it was not only desired to investigate the problem of a lack of cost-efficiency, but also to do something about it. Therefore, I considered an action research approach as appropriate for this project.

Action research is a "*type of applied research designed to find the most effective way to bring about a desired social change or to solve a practical problem, usually in collaboration with those being researched*" (SAGE, 2019a). This entails driving a parallel process of change in an organization while researching this process, with the aim "*of both changing the system and generating critical knowledge about it*" (Susman and Evered, 1978, p. 586). Rather than a specific method, action research is an approach of applied research linking theory and practice to generate a solution (Azhar et al., 2010) or, as Sexton and Lu (2009, p. 688) formulate it, a methodology for "*introducing change (or 'action'), and critically understanding that change to produce new knowledge ('research') within a social setting*". It encompasses many different ways of knowing (Reason, 2006). Lewin (1946) assigns the triple function of action, research and training to action research.

Checkland and Holwell (1998, p. 11) summarize the essence of action research: "*The concept emerged of a researcher immersing himself or herself in a human situation and following it along whatever path it takes as it unfolds through time. This means that the only certain object of research becomes the change process itself.*" Also Sexton and Lu (2009) stress the process-oriented nature of action research, focusing on change collaboration and developing both the 'know-that' and the 'know-how' in the current setting. Dick and Greenwood (2015, p. 195) underline the core aspect of "*constant confrontation of reflection and action, theory and method, theory and practice aimed at producing understanding and effective action*". A particularity of action research is the participative and democratic process, entailing research not *on*, but *with* the participants, empowering them to engage in inquiry and knowledge creation (ibid.; Reason, 2006). According to Robertson (2000), action research builds on the three underlying core principles of reciprocity (learning, sharing and development), reflexivity (self-awareness) and reflection (both on reality and in action).

There are different types of action research depending on the degree of involvement of the participants and the perspective of the researcher (SAGE, 2019a). The present research can be characterized as insider action research "*carried out by a researcher within their own organization or community*" (SAGE, 2019b), as I am undertaking research from within the organization. In this type of research, I am a full member of the organization both before research starts and after it finishes (Holian and Coghlan, 2012). There is also an element of participatory action research as it tries "*to transcend the boundaries between research and activism in order to produce knowledge and action that is directly useful to people, and to empower people through the process of constructing and using their own knowledge*." (SAGE, 2022).

Action research "*aims at both taking action and creating knowledge or theory about that action as [it] unfolds*", addressing the important issues together with those who experience them (Coghlan and Brannick, 2014, p. xiii). A three-step process characterizes action research: (1) assessing a situation in need of change, (2) initiating a transformation process, and (3) evaluating the outcome of the action (ibid.). Iterating this combination of action and reflection gives a process of informed trial and error using flexible processes to be responsive to the situation depending on an evaluation of the desired and achieved change as well as the implications on those involved (Dick and Greenwood, 2015). Susman and Evered (1978) give a more detailed picture of the action research cycle. They propose an iterative cycle with five steps (ibid.):

1. *Diagnosing:* Identifying the organization's primary problems in need for change and establishment of theoretical assumptions.
2. *Action planning:* Organizational actions are specified based on the theoretical assumptions.
3. *Action taking:* Planned actions are implemented in a collaborative process.
4. *Evaluating:* Reflection on and evaluation of the outcome/effect of the actions, and if success can be ascribed to the specified actions.
5. *Specifying learning:* Organizational learning happens based on both the successful and unsuccessful actions, plans are revised, and further actions are developed based on the learning outcome. Outcomes are shared in the organization and with the research community.

Martí (2016) advocates for an integration of an explicit element of measuring, when using quantitative methods and/or understanding when using qualitative methods. This form of assessment can be integrated in different stages of the action research cycle. As an example, quantitative measurements with the goal of monitoring changes and providing data for evaluation can be sequentially integrated between the stages of action taking and evaluating.

Reason and Torbert (2001, p. 7) define the following four dimensions of action research, which are not entirely congruent to the primary purpose of traditional academic research, which has the primary focus to "*contribute to an abstract 'body of knowledge*'". Action research focuses instead on:

- "*practical knowing embodied in the moment-to-moment action of each research[er]/ practitioner"* as the primary purpose of action research
- the participative nature of human knowing grounded both in human relations and the wider context of the world
- *"all knowing is based in the sensing, feeling, thinking, attending experiential presence of persons in their world"*

- *"all movements of the attention, all knowing, all acting, and all gathering of evidence is based on [...] fragments of normative theory of what act is timely now*". The respectively valid normative frame is dependent on the organizational setting in which research takes place.

The starting point for my research was to investigate opportunities for reducing costs in Statsbygg's construction projects. However, as soon as research had started, it showed that the real organizational need went beyond the identification of positive and negative cost-driversto also include the implementation of measures to improve the projects' cost performance and to evaluate their effect. Conducting the research as action research provided an organizational incentive to engage into research, as they will be able to see the effects of it more immediately than from traditional research approaches. This also legitimized my position as a researcher in the organization and made me a more integrated part of the workforce. Action research allowed for closeness of the practical work with the implementation and research on the process.

In order to conduct successful action research, certain prerequisites have to be in place. Henry (2000) summarizes the following primary requirements for successful action research:

- Creating a relationship based on trust between all parties.
- The researchers have fully accepted the organization's objectives and have negotiated the extent of involvement and the access to information.
- A research and innovation project is established in a shared process with an open-ended result.

As the attributes of action research are different from traditional research, it is relevant to look at the underlying research paradigm of action research and its implications for rigour, relevance and validity of the research process.

3.2. Epistemological and ontological considerations

The two traditional contrasting epistemologies are positivism, the natural science epistemology, and relativism, the modernist social scientists' epistemology (Bryman, 2016). However, they both fail to address the challenge of integrating research into everyday practice, making them not an appropriate backdrop for action research (Bryman, 2016; Reason and Torbert, 2001).

According to Reason and Torbert (2001, p. 2), a satisfactory epistemology for action research requires "*taking an action turn toward studying ourselves in action in relation to others. The action turn [...] places primacy on practical knowledge as the consummation of the research endeavor.*" This means focusing on achieving change as well as opening up the research to participation from anyone willing to integrate research and practice.

The alternative research paradigm of pragmatism fulfils the criterium of not only aiming at understanding processes and systems, but also trying to improve them. Thus, it can serve as a background for action research. Pragmatism builds on the notion of truth as useful belief and the assumption that understanding is only helpful when it contributes to improving the investigated system (Drevland, 2019), a notion which is highly relevant for action research. Based on the pragmatist paradigm, Van Aken (2004) has identified the need for practice-oriented, context-sensitive research within the field of management research, which at the same time holds a high academic quality standard. This description is similar to the characteristics of action research. Knowledge is developed and field-tested within the practice-context by finding and implementing solutions to particular problems (Tranfield et al., 2003; Van Aken, 2004).

In their four-fold categorization of methodological approaches, as illustrated in Figure 6, Anderson et al. (2001) classify applied social science according to its rigour and relevance: Quadrant 1 represents 'popularist science', which is of high practical relevance of the problem to be solved, but is conducted with low academic rigour and thus lacks reliance. 'Puerile science' in quadrant 3 is characterized by issues of both low practical relevance and low methodological rigour. Quadrant 4, 'pedantic science' represents research conducted with high academic rigour through its research design and methods, but delivering low on relevance as study questions are theory-based and fail to address real-life problems. Quadrant 2 stands for 'pragmatic science', fulfilling both the criteria for high practical relevance and high methodological rigour (ibid.). In plain words, pragmatic science means to approach a relevant problem in the right way. This makes it useful for both the academic audience and the community of practitioners (Tranfield et al., 2003).

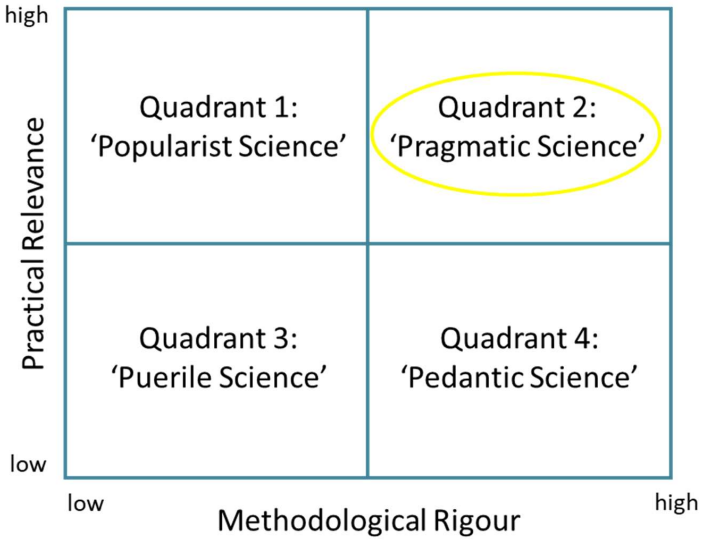

Figure 6 Rigour and relevance - A fourfold typology of research (Anderson et al., 2001, p. 394, adapted by the author)

Schuiling and Kiewiet (2016) propose four requirements to assure this balance of rigour and relevance: Action research has to (1) be joint inquiry in practice, (2) be driven by the client's problem (contrary to traditional research), (3) work with the combination of incompatible roles (practitioner and researcher), and (4) engage in reciprocal learning.

Action research based on the background of the research paradigm of pragmatism combining both rigour and relevance, generates the need to broaden our methodological view. By focusing on a pragmatic approach to methods and renouncing the desire for certainty and universalism, we accept the fact that reality can be messy, in which research is more a process than a product (Law, 2004). We have to deal with it by applying a diverse set of mixed methods with heterogeneity and variation, adapting methods to the research setting at hand (ibid.). This type of *situated inquiry* emphasizes, that each research is context-related and might not be directly replicable under other circumstances (ibid.).

Consequently, validity of action research has to be tackled otherwise than through the justification of precise statements of cause and effect (Somekh, 1995). Instead, "*the aim is always to make the best possible use of these tools* [i.e. research methods] *within the constraints*

of the workplace" (ibid., p. 341). Action research with high validity produces practical wisdom by using research methods for the exploration of multiple determinants of (inter)actions and deepening practitioners understanding of complex situations to make better-informed decisions (ibid.). As it is impossible to draw a clear line between research data and job data, interpretation of results in the light of prior knowledge can occur as a problem (ibid.).

Quality and validity of action research is connected to reflectiveness of the process (Reason, 2006). Action research is full of choices and its quality is dependent on awareness and transparency of choices at each stage of inquiry (ibid.). Consequently, validity can be judged by the reflection on social relevance, participation and practical outcome as dimensions of quality: "*validity as asking questions, stimulating dialogue, making us think about just what our research practices are grounded in, and thus what are the significant claims concerning quality we wish to make*." (ibid., p. 191). The validity of this particular research is evaluated in section 3.7.

3.3. The researcher's role

My background as a researcher was being a practitioner in the organization. Having been employed since 2013, five years before the start of the research project, as a project controller in the department of construction and project management, made me an insider. During the research project, I was theoretically released from all other tasks in the construction projects, but practically, I was still involved to some degree: Assisting with project controlling tasks if needed, mentoring junior colleagues, participating in internal meetings and executing administrative tasks. Towards the end of the research project, after data collection was completed, I also overtook leadership for the group of project controlling. This meant completing my PhD-project part time. The situation described above meant that I was very close to the organization, not losing my status of an employee and colleague during the PhD-project.

While being a PhD-candidate, I was actively working as a member of the project team for the internal strategic initiative 'Cost down? Step up!' (cf. chapter 2). The team consisted of three core members, one external project manager, one administrative resource/assistant project manager, and me. All project members except myself were dedicated part time (20-50%) to the project. My main tasks in the strategic initiative included working with the construction projects, conducting analysis, but also administrative tasks such as project meetings, preparation of reports and presentations for the steering committee, and participation in other meetings and seminars. Project work went parallel to PhD-coursework, training seminars and writing academic papers.

Being an insider when doing research comes with both benefits and constraints. In the following, I am going to reflect on my role as an internal practitioner-researcher and the resulting bias.

Between participation and reflection: Almklov (2008) states that most researchers experience an alternation between participatory and reflective moments in their fieldwork, using themselves as human tools, acquiring knowledge through participation. He advises researchers not to regard fieldwork as a pure phase of data collection. Having a clear research agenda can be a limitation for the researcher in many circumstances. Spontaneous participation, partly steered by coincidences, can be an effective method in itself, as long as you do it in a reflective way. Almklov (2008) argues further, that informants will not share all information with a passive observer, as they protect their own organization from the data collection attempts of an

'outsider'. On the other hand, an active researcher can become 'noise' in a dataset that would have been different without the researcher's participation (ibid.). This means that the researcher him- or herself is an active tool and has to reflect on the fact of becoming an integrative part of the data generated in the research project. When meeting the project teams, the researcher has chosen to take an active role to be flexible to react to the dynamics of the meeting (the meetings are described in detail in section 3.6.). I had the impression, that project managers discuss challenges more openly with me as a colleague than they would do with a researcher from outside the organization. In some cases, the project manager is eager to talk about initiatives in the project and the researcher can assume a more listening role, whereas in other instances, the researcher has to motivate the project manager to give an account of measures in the project. This is done by asking questions, telling examples from other projects and suggesting measures, which the project could implement to enhance cost-efficiency. Reflection takes place both during the meeting together with the project manager and after the meeting. Notes taken during the meeting facilitate reflection.

The insider's preunderstanding: "*The researchers are already immersed in the organization and have built up knowledge of the organization from being an actor in the processes being studied.*" (Coghlan, 2007, p. 336). Prior knowledge and insight in the more tacit organizational culture can facilitate the research as it allows the researcher to concentrate on the issues under research, without having to spend time on gathering background information and trying to understand processes within the organization. At the same time, this can be a disadvantage, as the researcher interprets the results in light of prior knowledge (Somekh, 1995) and might not see challenges within the organization as an outsider would do. As Coghlan (2007, p. 338) expresses it: "*Insider action researchers need to build on the closeness they have with the setting, while, at the same time create distance from it in order to see things critically and enable change to happen.*" The practitioner-researcher needs to be especially "*attentive, intelligent, reasonable and responsible in confronting the challenges of preunderstanding*." (Coghlan, 2007, p. 339). An advantage for the insider is easier access to and understanding of data than for an outsider (Arber, 2006). As I am an employee of the organization, I am assigned a clear insider role with a high level of preunderstanding. Inside knowledge provides good preconditions to see the contributions of the practitioners in the light of the constraints of the organizational structures. This assures good contact to the participants in the value meetings and good access to data. However, taking an outer perspective from time to time helps to avoid being restricted by one's own preunderstanding. In that way, the researcher remains open for new ideas, which can challenge acquired truths. To limit bias and ensure a high degree of reflection, research results were discussed with both colleagues ('non-researchers') and external researchers.

Role duality: Role duality in insider action research describes the fact that the organizational role of one employee is augmented with the role of a researcher (Coghlan and Brannick, 2014). The challenge is to tackle the "*role conflict in trying to sustain a full organizational membership role and the research perspective simultaneously*" (Coghlan, 2007, p. 339). This can also entail collecting naturally occurring data (Arber, 2006). Discussions with fellow researchers, who are not directly involved into the research project, can help to make one's role more transparent (ibid.). Credibility and reliability is achieved by clearly "*identifying the particular status position taken by the researcher, as this sheds light on what can and cannot be observed"*, being *"reflective about who offered the data and the context in which it was offered"* and provide *"a full account of theories that informed the research"* (Arber, 2006, p. 155). Role duality can be tackled by allocating time wisely between practical tasks and the process of reflection and writing-up, and to have discipline not to rush into practical tasks without assuring the right use of methods. A close connection to academia with peer researchers and supervisors

helps to keep up to date with academic research and to be challenged on the research strategy if personal bias tends to dominate (cf. Fraser, 1997). During the value meetings, project managers perceive the researcher more as a colleague (i.e. insider) than as a researcher. This helps to discuss issues in the project in an open manner, to go into details and to use an internal language and references to other projects.

Managing organizational politics: The researcher has to take into account organizational politics and dynamics in terms of choice of the topic and research approach, while at the same time assuring sound unbiased scientific research (Coghlan and Brannick, 2014). The fact that the practitioner-researcher is a permanent member of the organization and wants to stay in the organization after the completed research, possibly with the aim of a career advancement (Coghlan, 2007), should not lead to bias between organizational and research goals. In the present research project, top management has initiated and approved the research project. Even if this enhances the legitimacy of the research, it might also distort the results as sceptical participants might only participate in the value meetings to please management and are thus not contributing with their full knowledge and experience. An open and constructive atmosphere in the value meetings, giving full focus to the individual project, can counter this challenge.

Confidentiality and anonymity: Fraser (1997) problematizes the issue of confidentiality and anonymity. A strong connection between the respondents, their profiles and the collected data can make it difficult to guarantee anonymity and confidentiality, as even the use of pseudonyms might still enable others within the same organization to identify the respondent. Even if there is acceptance by the respondents, this might influence their answers in the research situation and make them more careful in their answers. As the present research includes researching facts and objective features of construction projects, this issue might not be equally problematic. Nevertheless, people might perceive a project's performance quite differently. In this case, people's personal opinions and statements suddenly become an important issue. A project with substantial cost overrun can still be a success project for the user of the building, and the project manager might feel that the project organization has done everything to make the project a success. Anonymization of people and individual construction projects as necessary is thus an important issue.

3.4. The interdisciplinary background

This PhD-project is characterized by a high degree of interdisciplinarity, which is considered an important asset for the research.

Public construction projects are complex, and when dealing with them, many academic disciplines or fields of studies are touched upon. The construction process itself is an engineering issue, often of a complex type as the buildings are large, of high quality, technically advanced, multifunctional and planned for long-term use. Architecture and design are of importance, especially in the planning and detail-engineering phase. Politics as well as public administration are an essential element when dealing with public construction projects: Projects are prioritized, weight up against each other in the decision process and money is allocated from the public budget to specific projects. There is also a business dimension, as projects are subject to business and management processes with all its facets of planning, leadership, decision making, finance, team work etc. The focus on project costs introduces the discipline of finance and economics. As the project includes the aspect of knowledge management and

organizational learning, this brings in the discipline of education. Also other sub-disciplines such as facility management, urban planning and sustainability are touched upon.[1]

The researcher also has an interdisciplinary background. My academic education is mostly from the management discipline: a Bachelor of Business Administration in international management with a focus on the Baltic Sea region and a Master of Science in sustainability and management, which was a collaboration between the department of management and the department of geography. Work experience includes accountancy, financial controlling and analytics in the private sector, and later project controlling for public construction projects. With this background, I started my PhD-project in the Faculty of engineering, Department of civil and environmental engineering at NTNU.

The interdisciplinarity of the research project is also reflected by the range of perspectives the papers cover and the journals, in which they are published: *Facilities* is a journal covering the topics of property management, the built environment and architecture. The *Journal of Applied Behavioral Science* publishes research on organizational change, organizational dynamics, academic-practitioner collaboration, and knowledge creation processes. The *International Journal of Project Management* is the leading journal in the field of project management and organization studies. The currently unpublished paper is planned to be submitted to the journal *Project Leadership and Society*, whose focus is on the interaction between projects and society in a broad sense. The included conference paper was presented at the *Nordic Conference on Construction Economics and Organization*. This shows a broad spectre of thematic orientation of the different journals.

3.5. Basic principles for research

Action research as the main research approach has been described in section 3.1. In addition, the research methods of engaged scholarship as well-as a co-creation approach were used as important principles in this research.

3.5.1. Engaged scholarship

In traditional research approaches, practitioners often fail to adopt findings of academic research if they don't believe that the findings are useful for solving practical problems, especially when research is conducted without involvement of the practitioners and not grounded in the practical reality (Van de Ven, 2007). To solve this theory-practice gap, Van de Ven (2007) proposes the concept of engaged scholarship as a deeper form of research assuring both rigour and relevance and thus classifying as pragmatic science (see Figure 6). Scholarship in this context means engaging in original research in a particular subject with the ability to step back from one's own investigation and look for connections between theory and practice as well as communicating the obtained knowledge effectively (Van de Ven, 2007).

"*Engaged scholarship is defined as a participative form of research for obtaining the different perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) in studying complex problems*." (Van de Ven, 2007, p. 9). Through the involvement, more

[1] The denotation of disciplines is based on https://en.wikipedia.org/wiki/Outline_of_academic_disciplines (accessed 11.03.2022).

penetrating and insightful knowledge can be produced than when researchers – or only practitioners – work on the problems on their own.

In this concept, the explicit epistemic scientific knowledge and the tacit practical knowledge complement each other, and the practical knowledge is not just considered a derivative of scientific knowledge, but a distinct mode of knowing in its own right (ibid.). While the academic perspective allows a bird's eye view of the organization and a high degree of reflexivity, the practitioner's perspective focuses on the reality and constraints of the organizational context. The organization represents an idea factory or a learning workplace, where researchers and practitioners engage in negotiation and collaboration (ibid.). The information emerging from this collaboration between scholars and practitioners can be converted "*into actions that address problems of what to do in a given professional domain*" (ibid., p.9). Furthermore, this helps to advance the scientific purpose of regarding "*specific situations as instances of a more general case that can be used to explain how what is done works or can be understood*" (ibid., p.4).

Engaged scholarship is an iterative model. The activities of problem formulation, problem solving, research design and theory building are highly interdependent (Van de Ven, 2007). A coherent pattern emerges only at completion of the research process (ibid.). Activities are evaluated according to their relevance (problem formulation), validity (theory), truth or plausibility (research design), impact (problem solving) and coherence of the whole process (ibid.).

Van de Ven (2007) describes four different forms of engaged scholarship, depending on their research purpose and perspective. In this classification as shown in Figure 7, action research (in quadrant 4) is defined as research with an internal perspective with the purpose to control a problem in the organization or design a solution to it. The research presented here can be placed into this quadrant, with my own employer as the customer.

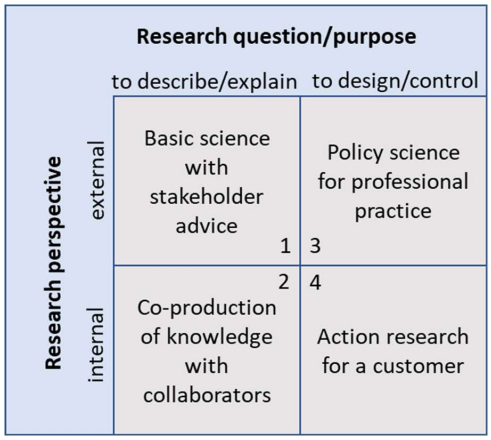

Figure 7 Alternative forms of engaged scholarship (Van de Ven, 2007, p.27, slightly adapted and reformatted by the author)

Van Marrewijk and Dessing (2019) present the issue of reciprocal relationship of academics and practitioners as central in engaged scholarship, amongst others to maintain equality and achieve a better exchange of data. They identified the three types of generalized, balanced and negative reciprocity and argue that the relationship is constantly negotiated and changes over time (ibid.). *Generalized reciprocity* is typically present in long-term commitments between a researcher and a researched organization, with low self-interest and a high social component, an undefined equivalency of returns and where a lack of return does not necessarily cause the

other part to stop giving (ibid.). In *balanced reciprocity*, there is a symmetrical and simultaneous exchange of approximately equivalent resources during a temporarily limited period in the researcher – researched relationship (ibid.). *Negative reciprocity* is characterized by an exchange of equivalent returns, but high self-interest where the parties try to maximize their own gain from the relationship (ibid.).

3.5.2. Co-creation and democratic dialogue

Action research implies a participatory turn in action research, integrating the research objects into research and emphasizing dialogue and democracy. This means acknowledging that "*people as subjects and participants of research have capacities also significant for research and knowledge generation*" (Lindhult, 2019), not only for organizational development processes. According to Reason and Torbert (2001, p.2), action research requires "*taking an action turn toward studying ourselves in action in relation to others. The action turn [...] places primacy on practical knowledge as the consummation of the research endeavor.*" This means opening up the research to participation from anyone willing to integrate research and practice. Being a colleague in the research process made it easier for me to see the project managers not as research objects, but as equal members in the research process. Thus, I was able to take full advantage of their specific expertise as practitioners.

In the value meetings with the construction project managers, democracy as an inherent element of action research supports the legitimacy of the process. There is a conversational element in the meetings. An initial discussion among the involved parties serves to mobilize knowledge, intelligence and generate agreement. The meetings were conducted to engage practitioners in the co-creation of cost-efficiency measures. "*Co-creation is the joint, collaborative, concurrent, peer-like process of producing new value, both materially and symbolically*" (Galvagno and Dalli, 2014, p. 644). Lindhult (2019) calls this kind of collaboration 'democratic dialogue', acknowledging that all research participants, both academics and practitioners, have significant capacity for knowledge generation.

3.6. Data collection and analysis

In this research project, different methods of data collection and analysis have been used. Table 1 provides an overview over the different methods for data collection and analysis in the five papers included in this thesis. The details of the approach are described in each paper. Looking at the totality of the research, both qualitative and quantitative approaches are used in the overall action research approach. Different methods for data collection and data analysis are used, both to fit the purpose of the investigated aspect and aiming for triangulation of methods and thus assuring to view the research problem from different angles.

Overview of data collection methods used in the research papers				
Paper no.	**Paper theme**	**Approach**	**Data collection**	**Data analysis**
1	Systematic completion	Qualitative single case study (with a minor quantitative element)	Semi-structured interviews Document study	Open coding to identify analytical categories + axial coding of interview transcripts Spreadsheet summary
2	Standardization	Qualitative	Group discussions, results collected through quest back forms	Compilation and comparison of quest back results
3	Stakeholder influence	Qualitative	Document study Literature review	Content analysis with manual scanning and list compilation
4	Microlearning	Mixed	Microlearning lessons incl. two integrated short questionnaires Development of and reflection on microlearning lessons	Basic statistical analysis Structured reflection on process
5	Strategic change	Qualitative	Meetings as intervention with value cards Document study	Content/Thematic analysis

Table 1 Overview of data collection methods used in the research papers

In the following, I will shortly present the most important methods for data collection and analysis in order of importance and extent they have been used in the research project.

The overall approach is an abductive one, taking the practical problem and thus the empirical evidence as a starting point for a claim that may be true, also on a more general or even theoretical level. A general assumption for the analysis of data is that the interpretation of the empirical data from the projects represents a probable conclusion in the context of this research, based on the information available.

3.6.1. The value meetings

A central method used in this PhD-project was a series of meetings with the construction project teams. Conforming to Feldman's notion of collaborative conversation and in line with Van de Ven's (2007) concept of engaged scholarship, the method of 'value meetings' was conceptualized in this PhD-project. The prerequisite for developing new methods in ongoing research is a clear idea of the ultimate goal of the research, both in terms of practical outcome (the desired change), and in terms of research outcome. The desired change in the organization is achieving higher cost-efficiency in the construction projects, and the academic objective is to analyze the process and dynamics of getting there.

The value meetings can be described as a form of field interview, which according to Newman (2006) consists of joint production by the researcher and the interviewee, involving mutual sharing of experience. The interview is an in-depth and unstructured conversation, focusing on the participants stories and examples, without pressing them into a standardized format (ibid.).

As the meetings were named 'value meetings' ('*gevinstmøter*' in Norwegian), a short explanation of the term 'value' is necessary. Drevland et al. (2018) have discussed the concept of value and the different facets of the term comprehensively, especially in relation to

construction projects. For the purpose of this research, a basic definition of value is sufficient: Value is "*a fair return or equivalent in goods, services, or money for something exchanged*" (Merriam-Webster, 2020). The perceived value is the result of an evaluative judgement and is context-specific, based on comparing two or more alternatives and its consequences on gained or lost experiences or money (Drevland et al., 2018). Construction projects have to fulfil defined needs and this fulfilment can be done in different ways with potentially different price tags. To summarize, 'value' in value meetings and value cards comprises all measures leading to a better ratio of benefits and costs, either maximizing benefits at a given cost level or minimizing the costs of the desired benefits – in this case mostly reducing costs of a project with the desired results. As the client often determines the desired benefits before the start of the construction project, the main goal with the value meetings is optimizing the scope and cost level of the project provided that the desired benefits of the construction projects are achieved.

The meetings with the project manager (and in some cases other key resources from the project team) have the aim to identify measures for cost-efficiency for the individual project. Beforehand, an initial orientation and analysis of cost drivers and success factors was performed to serve as the basis to get into dialogue with the projects. The purpose of the meetings is both to achieve understanding and reflection, an exchange of knowledge and initiating action (Feldman, 1999). Furthermore, the meetings can help to make tacit knowledge of competent practitioners explicit for others. The participants are familiar with the topic of cost-efficiency, but it has not been approached as a separate topic in a systematic way before.

In order to structure the meetings and to document the outcome, the tool of 'value cards' was developed and used during the meetings. At the beginning of the meeting, I presented the different topics to the project manager. They could then choose one or several topics for cost-efficiency, which are relevant in the particular project. Figure 8 shows an authentic example (translated from Norwegian to English) of how the card for the topic of analysis of needs/concept was used in a construction project of a university building. The generic inner circle shows the facts concerning the topic on hand, how success is measured, examples of actions which can be taken, and information about facilitation possibilities within the organization. The information in the inner circle is the same for each project. The outer circle is filled in by each project individually: The outcomes of the actions are noted for of the four aspects: the facts for this project, the actions taken, how actions have been implemented and how they have been measured. In a separate box, the chosen actions for the respective project are listed together with their intended effect. This part is also individual for each project.

ANALYSIS OF NEEDS / CONCEPT

Responsible for this topic: xxx

PROJECT INFORMATION	
PROJECT NUMBER	xxx
PROJECT NAME	University building
PROJECT MANAGER	xxx
PROJECT OWNER	xxx
PROJECT PHASE	Conceptual phase

ACTIONS	INTENDED EFFECT
1. Thourough analysis of needs, with e.g. in-depth interviews with the users, instead of drafting a concept directly.	The project solves the users' needs of functions, and does not necessarily fulfill their complete list of wishes.
2. Consider re-use of existing buildings on campus (which were not used efficiently before).	Considerable reduction of the need for new building. Optimalization of the use of existing area. Better environmental profile.
3. Co-use of existing area on campus (social areas, meeting rooms in the adjacent building).	Reduction of gross – net area factor in the new building.
4. Look at examples from comparable buildings to see how needs can be met.	Use of best practice in the project to meet (future) needs.
5. Education of specialists (internal + external architect) to work with early project phases.	Good work of the specialists in early project phases, transfer of experience to subsequent projects.

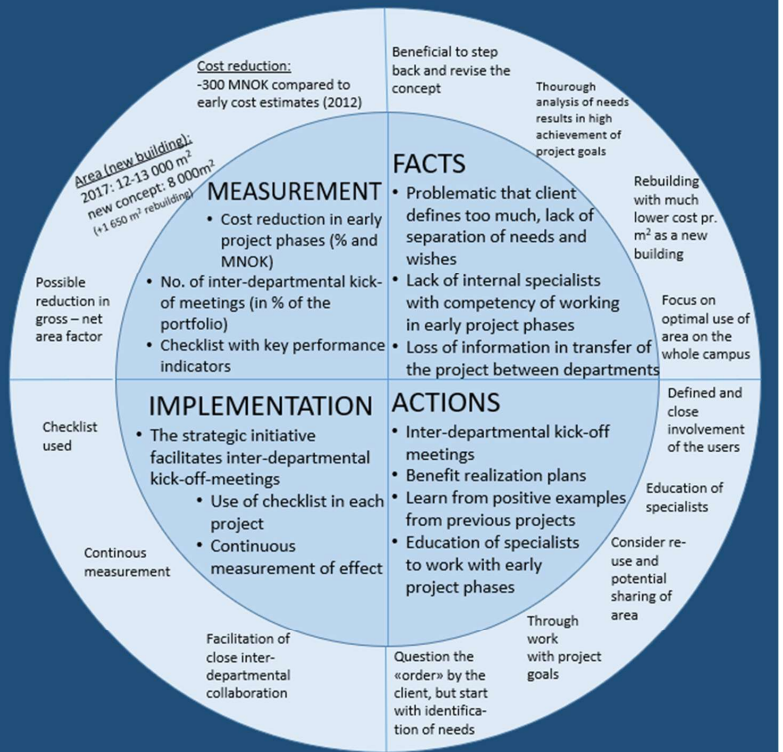

Figure 8 Example of a project value card on the topic of analysis of needs/concept

The cards serve to collect the measures for cost-efficiency during the meeting, but also to increase the commitment by the project manager, as a form of 'contract' or reminder after the meeting. On the practical level, the cards make it easier to share measures for cost-efficiency between projects.

The value meetings were not initially intended as a method when the research project started, but emerged in the early stages of the strategic initiative as a natural way to engage all project managers in the topic of cost-efficiency. The meetings constitute a general approach for all projects, which at the same time takes account of the individuality of each project. The method is adapted to the context of the research and is assumed being a suitable way of approaching the practical problem.

3.6.2. Systematic literature reviews

Systematic literature reviews were used in several instances during research, for an initial overview over the state of the art in the literature on construction project costs (parts of the results from this review are referred to in section 4.2), and as a method in paper 3 to systematically trawl the literature on stakeholders in public construction projects and how they influence project costs.

Conducting a systematic literature review allows getting an overview of the field of study and identifying key sources, topics, theories and concepts as well as the most important research methods and strategies employed for this topic (Bryman, 2016). It provides a way to look at the epistemological and ontological perspectives and shows how knowledge is typically organized and developed. It can help to identify research gaps, develop your own analytical framework and interpret your findings (ibid.).

A literature review with explicit search procedures is called a systematic review (ibid.). The reason for conducting a systematic review is to avoid bias of the researcher through explicit and transparent search criteria of which the author gives an account (ibid.). Grant and Booth (2009) provide an overview over different approaches of reviewing the literature in their article "*A typology of reviews*". State-of-the-art reviews were determined the appropriate type of review for this research, as the aim is to cover the current state of knowledge on the present topic, presenting it in a mainly narrative way with some tabular overviews (Grant and Booth, 2009). In addition, it helps to identify opportunities for contemporary research (ibid.). However, the timeliness of data is also its weakness as it can lead to the ignorance of earlier research (ibid.). Major electronic databases (Scopus, Oria, Web of Science, ASCE library, Science Direct) were used for research, leading to a result mainly covering literature from the last 20 years. According to Grant and Booth (2009), a state-of-the-art review does not comprehend a formal quality assessment of the included articles. The limitation of the literature review on peer-reviewed journal articles was judged as a sufficient general quality assessment for this purpose.

3.6.3. Document analysis

Bowen (2009, p.27) defines document analysis as "*a systematic procedure for reviewing or evaluating documents*". It is especially applicable to qualitative research and often combined with other research methods to achieve triangulation (ibid.). Document analysis is an efficient method to collect data. As a researcher in my own organization, I have easy access to relevant documents.

Document studies were used as a secondary data collection method throughout the PhD-project. The main purpose was mainly gathering facts about the projects and the relevant topics, rather than interpreting the documents to find meaning and read between the lines.

The studied documents were project documents, such as project management plans and the projects' organizational charts, as well as documents from the strategic initiative: the value cards, my notes from the value meetings, presentations for the strategic initiative's steering committee, the initiative's implementation strategy and the final report.

To analyze the documents, an iterative process combining content and thematic analysis was used. "*Content analysis is the process of organising information into categories related to the central questions of the research*" (Bowen, 2009, p.32) and is typically used for an initial document review. Documents can be studied further using thematic analysis to recognize patterns within the data in order to find emerging categories for analysis (Fereday and Muir-Cochrane, 2006).

3.6.4. Semi-structured interviews

Semi-structured interviews are a popular data collection method in qualitative research (Neuman, 2006). They are frequently used as the main method in research on construction project management. In this research, the method was used as a primary data collection method for paper 1 to collect empirical evidence from experts on how systematic completion is used in construction projects. I audiotaped and transcribed the interviews to sort the answers by topics in a spreadsheet. In this case, the interviews also contained a small quantitative element, where all interviewees were asked to rate at the end of the interviews, in how far they agree or disagree with a number of statements on systematic completion.

In semi-structured interviews, the researcher follows a predefined set of questions noted in an interview guide, in order to cover the same topics and aspects in each interview. However, the interviewer can adapt the order and the wording of the questions to the flow of the conversation and can add follow-up questions to the interview in reaction to utterances of the interviewee.

In the traditional view of qualitative research, the researcher is objective and neutral during the interview. Opposed to this, Holstein and Gubrium (1995, p.17) propose the vision of the active interview: "*The active interview eschews the image of the vessel* [of information] *waiting to be tapped in favor of the notion that the subject's interpretive capabilities must be activated, stimulated, and cultivated.*" Informants do not only talk about their own experiences, but also organize the meanings they convey, and they produce complex, shifting, subjectivities, which they form anew in each interview (ibid.). Consequently, the research interview becomes an interactive and structured process of information exchange and interpretation (Gudmundsdottir, 1996). Both the interviewer and the interviewee are part of the meaning making process during the interview, and new topics for further research can emerge in the interview process (Holstein and Gubrium, 1995; Rapley, 2004). This view fits well into the concept of insider action research. The active interviewer can never be fully neutral, even if they try to engage in a neutral conduct (Rapley, 2004). Interviewers take control of the situation, they provide the initial context to engage the informant into the interview topic, and they guide through the interview, choose the questions, react to the answers and decide which parts to use in their research (Holstein and Gubrium, 1995; Rapley 2004).

The expert interview has been suspected of inadequate methodological rigour, lacking standardization and quantification of data, and guiding the conversation too actively to allow for fully open narratives (Bogner and Menz, 2009). Turning this accusation into an advantage, the methodological hybrid of the expert interview fits well into the background of a pragmatic research methodology, opening up for a less strict approach than traditional methodology. In this approach, interaction effects between the interviewer and the informant in the interview are not distorting elements, but constitutive elements of data production (ibid.).

In the setting of the active interview, also the sampling strategy is more active than in traditional survey research settings: "*The idea is not so much to capture a representative segment of the population as it is to continuously solicit and analyze representative horizons of meaning*" (Holstein and Gubrium, 1995, p. 74). The idea for investigating the effect of systematic completion emerged in one particular project. This made it natural to start by interviewing the resources from the project, who approached me with the idea. The next projects and interviewees were chosen purposely since they use systematic completion in their project. Partly, snowball sampling was used, where interviewed resources suggested other potential interviewees (Saunders et al., 2009).

Interviews were recorded and transcripts were analyzed using a coding approach in two rounds: a first open coding round placed the data into preliminary analytical categories, which helped to identify any surprising aspects (Neuman, 2006) in addition to the codes determined by the research questions. In a second round of axial coding with focus on the coded themes, the codes were applied to all transcripts (Neuman, 2006). All coded aspects were summarized in a spreadsheet to get a complete picture.

3.6.5. Group discussions

To collect data for paper 2, group discussions were used. "*Group discussion is a means of collecting data in one go from several people (who usually share common experiences) and which concentrates on their shared meanings*" (Payne and Payne, 2004, p. 103), allowing ideas to develop through interaction among group members. Group discussions are an appropriate method to brainstorm and generate a high number of ideas simultaneously. Group discussions were used as data collection method for the standardization paper. There were approximately 120 group members, mainly project managers and other project staff. The group was split into 15 equally sized groups composed of members with different levels of experience. The group discussions were facilitated by colleagues from the same department and I as a researcher participated in one of the groups. The groups were asked to discuss the possibility to further standardize the construction projects of the organization. Data was collected through a quest back form, with 11 of 15 groups reporting back. The analyzation of data happened through compiling all data in a spreadsheet, sorting them and looking for similarities and frequent answers within the data.

3.7. Validity and reliability

I have shortly discussed the validity of the action research approach when accounting for the epistemological and ontological considerations for this research in section 3.2, and when reflecting on the researcher's role in section 3.3. The appended journal papers also contain reflections on validity and reliability of each part of the research. Thus, I will only present the essence in this section.

Action research assumes a messy reality in which research is more a process than a product (Law, 2004). It takes its power from a practical applied science approach, which clearly dominates methodological concerns on rigour. Theory is used to solve a practical problem. A diverse set of heterogenous mixed methods, which are suitable for the research setting in the organization must therefore be applied. As this type of situated inquiry is context related, the research result might not be replicable under other circumstances. The validity of action research therefore lies in making "*the best possible use of these tools* [i.e. research methods] *within the constraints of the workplace*" (Somekh, 1995, p. 341). The workplace is interested in getting solutions to a practical problem (the high construction project costs). Thus, using meetings as a well-established form of interaction during the workday as one research method was a viable option. In addition to the familiarity of the situation, the meetings had a combined practical and research function and were thus timesaving.

Action research of high validity produces practical wisdom that is relevant to the organization by using research methods that allow the exploration of multiple determinants of (inter)actions. This deepens practitioners' understanding of complex situations, allowing them to make better informed decisions. This intertwinement, however, makes it impossible to draw a clear line between research data (for my PhD-project) and work-related data (for the strategic initiative). The interpretation of results in the light of prior practical knowledge can therefore be problematic (Reason, 2006). To a certain degree, this was accepted in the research project, especially because of the upside of this fact – that I could profit from previous practical knowledge to engage into a better dialogue with the construction project teams. One measure to reduce the adverse effect was to engage in a reflective discussion on the data and their interpretation with practitioners on the one hand and other researchers on the other hand.

The value of action research is mainly defined through its practical relevance to the organization, i.e. the practical goal of solving the problem at hand. The goal of the strategic initiative is to increase cost-efficiency in construction projects, an aim motivated by the need to maximize benefits from construction projects while minimizing the cost to the taxpayer. In that respect, the research project displays high relevance and validity. Data emerges directly from the case-projects taking part in the strategic initiative and is therefore an authentic and reliable record. In addition, the data's reliability and credibility can be validated through the final cost accounts of the projects (upon project completion). A situated inquiry into the organizational context, however, lacks direct external validity and makes no direct claim of generalizability.

The ideal situation would be an action research project, which at the same time maximizes practical relevance and methodological rigour (cf. Figure 6). It fulfils the requirements of being a joint inquiry in practice, driven by a client's problem, combining the practitioner's and researcher's role, and by engaging in reciprocal learning (Schuiling and Kiewiet, 2016). A limitation in this PhD-project is, that there have been trade-offs between those two aspects, as the real context made it necessary to adapt methods or use new methods during the research project. In those cases, practical relevance and practicability was generally prioritized, while the negative impact on methodological rigour was attempted to be reduced, e.g. by a high degree of individual reflection and reflection with other researchers.

To summarize, the study's internal validity and credibility is high, in the way that the study gives a true account of the situation in the organization at the specific point of time with this

specific portfolio of projects. The study is replicable with its approach inside the organization. However, results concerning the actions in the projects might be different as each project is individual. As this is a study within one organization, external validity and replicability have not been checked. Although I presume replicability at least of the used methods and procedures, more studies in other organizations are needed to confirm this.

4. Theoretical background

After having described the methodological considerations, I will now present the theoretical background for this PhD-study. Due to the practical and interdisciplinary approach and based on the chosen epistemological background of pragmatism, there is not one *single* theory or concept which this PhD-study is grounded in, but several.

Research started with a distinct cost perspective background, based on the aim of an organizational strategic initiative to reduce construction project costs. However, it became clear during the strategic initiative that cost reduction cannot be tackled as an isolated issue, and that knowledge transfer and strategically implementing change play an important role in that process. In addition to the dynamics in the construction projects and looking at cost reduction both on the individual project and portfolio level, there is also a meta-perspective: The strategic initiative is also a project, though not a construction project. The resulting strategic perspective is discussed in detail in paper 5.

In the following, I will provide insights into the three different perspectives on cost-efficient construction public projects – cost, knowledge and strategy – used in this study. The intent with this chapter is not to give an in-depth overview of each perspective, but to introduce the three perspectives and show how they are applicable for this study. Concerning the papers, paper 1, 2 and 3 are written primarily from a cost perspective, paper 4 takes a knowledge perspective and paper 5 has its stance in the strategic perspective.

4.1. Basic terms

Before introducing the three perspectives, I start by defining some basic terms which are important in this thesis.

A **project-based organization** (PBO) has projects as the primary unit to perform core business tasks (Davies and Hobday, 2005). With respect to the nature of **projects**, a common definition is given by the Project Management Institute: "*A project is a temporary endeavour undertaken to create a unique product, service or result. […] The temporary nature of projects indicates that a project has a definite beginning and end […], but their deliverables may exist beyond the end of the project.*" (PMBOK, 2017, p.4)

The entity of projects in an organization is called a **project portfolio**. The Project Management Institute defines a project portfolio as "*A collection of projects […] that is grouped together to facilitate the effective management of that work to meet strategic business objectives*" (Ross and Shaltry, 2006). **Project portfolio management** is the ability and endeavour of an organization to align their portfolio strategically and holistically with the organizational strategy, and thus support the success of the organization (Clegg et al., 2018). This includes "*identifying, prioritizing, authorizing, managing and controlling projects, programs, and other related work, in order to achieve specific strategic business objectives*" (Ross and Shaltry, 2006).

In a **construction project**, the product is a constructed facility such as a building or infrastructure (Jha, 2011). Construction projects have a set of unique features (Jha, 2011): amongst others a degree of complexity due to its multidisciplinary nature. A construction project is often 'one of a kind' and thus, the client ordering the construction project lacks experience with similar projects. Construction projects are fixed to a certain location, they tend

to have high cost, long execution times and a high risk of failure. When construction projects are not built for the private sector, but for a public purpose, we speak of **public construction projects**. "*Public construction project means the process of designing, constructing, reconstructing, altering or renovating a public building or other structure.*" (Law Insider, 2022). Public construction projects are publicly funded, i.e. the taxpayers are ultimately paying the bill and projects compete with funds for other public tasks.

Statsbygg mainly builds so-called special-purpose buildings. A **special purpose building** is a "*type of property* [with] *a unique design or layout, […] or other features that limit the property's utility for purposes other than the one for which it was built.*" (US Legal, 2018). This also implies that the market to sell such a property is quite limited.

4.2. The cost perspective

Intensive academic research on project costs has been conducted for a long time, and this short theoretic overview cannot and does not attempt to cover the whole topic in depth. Rather, I will present basic aspects of construction project costs, which are relevant for the PhD-study. Those topics and their relation are illustrated in Figure 9. Further details can be found in the papers, especially papers 1, 2 and 3, in which the cost perspective is dominant.

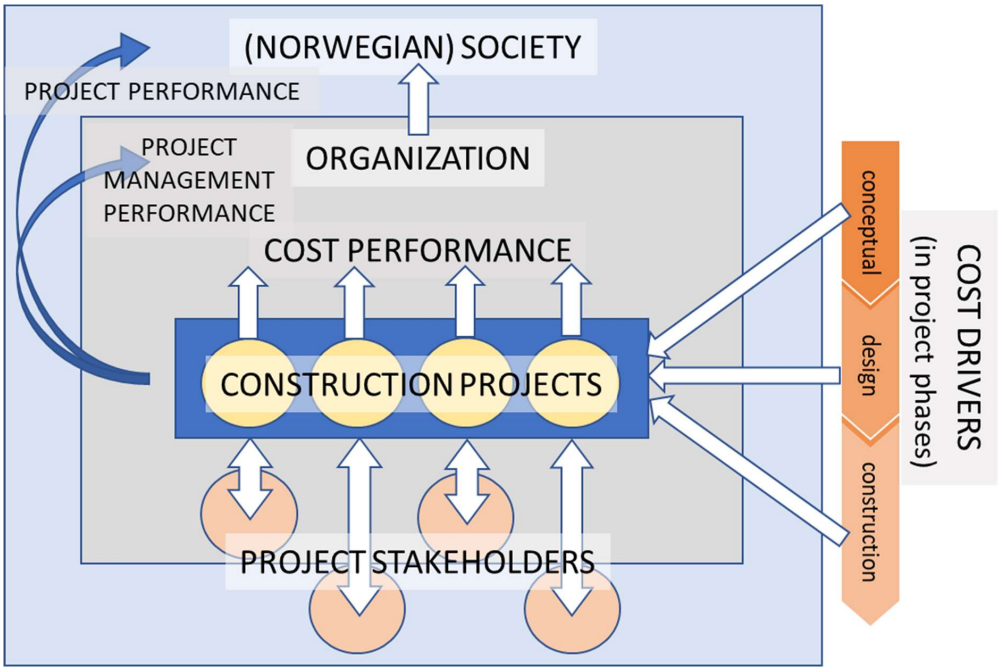

Figure 9 Important aspects of the cost perspective in PBOs

4.2.1. Project success and project failure

Pinto and Slevin (1988) propose a two-fold model of evaluating project success distinguishing between 'project success', providing the right project to the client, and 'project management success', meaning executing the project in the right way. Project management performance is compased of the components time, cost and quality. A project can be a success despite project

management failure due to high cost overruns (Welde and Klakegg, 2022). The indicators of project success or failure depend on the type of project, the project life cycle stage, and the fact how the organization measures a project's success (Pinto and Mantel, 1990). This model illustrates that "*project 'success' is something much more than simply meeting cost, schedule, and performance specifications*" (ibid., p. 68). In the project success perspective, the focus is turned away from cost reduction to the value created in and through the project (e.g. Jensen et al., 2013; Coenen et al., 2012; Martinsuo et al., 2019). The perceived value will differ among different stakeholders. True value creation means translating the users' and owners' objectives and needs into a functional building (Haddadi et al., 2016a). However, value also includes the financial and resource investments need to create those benefits – a topic which has not been focused on in project management literature (Martinsuo et al., 2019).

In project management research, the 'Iron Triangle' of cost, time and quality (Atkinson, 1999), i.e. project management success, has however remained in the focus of project management research. Traditionally, costs dominate the focus of project management, and it is an important component when evaluating the performance of public construction projects, especially directly after the project's completion. While looking at project success is extremely important, this thesis focuses on the cost aspect of project management success. In some projects, the budget can be so tight that it is not possible to complete the project with its agreed scope within the set budget (Barnes, 1988), in other cases cost escalation is due to unforeseen events or deficient project management.

In the following section, we will take a closer look at the definition and measurements of a project's cost performance.

4.2.2. Cost performance and cost overrun

Cost performance can be measured by two important components, either by cost growth from a baseline (estimate) to the final cost, or by looking at the cost per unit of work completed, usually measured by square meter (or by other units such as number of students, number of hospital beds) (Sullivan et al., 2017). There are different ways to determine a project's cost performance. As an example, a project's completion can be delayed and thus there is still uncertainty concerning the final cost for a long time. There is also the question how to handle scope changes when comparing the final cost with the estimated cost.

Researchers have different approaches to measure performance. There are also differences in terms of which estimate they use as a benchmark for comparison, either early estimates or the estimate at the decision to build. Invernizzi et al. (2018) provide a systematic approach to define cost overruns more accurately in terms of assessing the initial and the final cost. It is a common approach to compare the final costs with the estimate at the time of the decision to build (Invernizzi et al., 2018). This can be done in absolute or relative terms, where the latter allows for easier comparison among projects of different size (Flyvbjerg et al., 2018).

The following definition of cost overrun is used: "*Cost overrun is the amount by which actual cost exceeds estimated cost, with cost measured in the local currency, constant prices, and against a consistent baseline. Overrun is typically measured in percent of estimated cost, with a positive value indicating cost overrun and a negative value underrun.*" (Flyvbjerg et al., 2018, p. 175). Cost overruns refers to the final cost in comparison to the estimate at the decision to build, while cost growth refers to an increase in cost estimates before the decision to build.

4.2.3. Cost drivers of public construction project costs

A project's cost performance is the result of a number of different factors. Substantial research effort is put into identifying these factors in order to mitigate them in future projects. Terminology used to describe those factors is 'cost drivers' and 'project failure factors' (negative), 'factors affecting project cost' (neutral) and 'critical success factors' (positive).

In a literature review, Doloi (2013) categorized the influence on project cost into factors related to: project type and attributes, contract, project management team, quality, planning, market, and the relationship to the contractors. Cheng (2014) identified scope definition in the contract, cost control and contract disputes as the factors that have the greatest influence on cost. In contrast, Love et al. (2015) named changes in scope (or scope creeps), change orders, errors in contract documentation and rework as being central reasons for cost increases. Adam et al. (2017) investigated the factors causing cost overruns and time delays in large public construction projects by conducting a literature review including 40 articles. They grouped the factors they found into the following categories for easier comparison: Communication, Financial, Management, Material, Organizational, Project, Psychological and Weather (ibid., see
Table *2*).

Root cause	***Examples***
Communication	Lack of communication between contractors and customers
	Inefficient or late communication
Financial	Delayed payment to contractors/consultants
	Poor financial planning
	Price increases
Management	Poor site management
	Inadequate managerial skills
	Poor or slow decision making
	Customer initiated change orders
	Inadequate design specifications
	Rework
	Poor labour planning
Material	Shortage of equipment and material
	Poor material planning / logistics
Organizational	Unsuitable management structure
	Poor organizational structure
	Poor process procedures
Project attributes	Project complexity
	Project duration
	Project maturity
Psychological	Optimism bias
	Deception
Weather	Harsh weather conditions
	Unforeseen ground conditions

Table 2 *Categorization of cost drivers (based on Adam et al., 2017, p. 396)*

When looking at construction projects, the context in which they are executed is an important factor influencing project costs. Generally speaking, the context can be historical, cultural, social, national or geographical (Love and Ika, 2021). More specifically, a project always

operates in a hierarchy of multiple contexts. Project costs are affected by contexts such as typical contractor margins, procurement policies or governmental regulations (e.g. regarding safety, environmental and technical standards) (ibid.). Stakeholders can also be part of the context (see 4.2.5). Leviäkangas et al. (2016) refer to the stakeholder environment as the 'project ecosystem'. Another aspect influencing project costs is a project's complexity: The final cost of complex projects is supposedly both more difficult to estimate (Welde and Klakegg, 2022). Complex projects are more challenging to manage, making them more susceptible for cost overruns (Klakegg et al., 2016).

Another reason for cost overruns is of a different nature than other cost drivers: Project cost performance is always compared to an estimate of project cost. This cost estimate of the project must reflect the concrete project and must be realistic to attain. Bottom-up cost calculations of a project are prone to omit the uncertainty which lies in projects. This makes a completion of project within budget difficult. Stochastic estimation processes taking account of the uncertainty of input factors has the advantage of integrating contingencies into the cost estimate, and display the specific uncertainty factors, so that they can be mitigated with good project management (Welde and Klakegg, 2022).

Large sums are invested in the construction of public special purpose buildings such as schools and university buildings, museums, prisons, hospitals, government buildings or libraries. Cost overruns in those projects can therefore lead to high amounts of overspending of taxpayers' money. The challenge and extent of cost overruns in this kind of projects is well documented (Volden and Samset, 2017). Even if this problem is present in both the private and the public sector, public construction projects face additional challenges such as to act within a political environment with multiple stakeholders in society, multiple objectives, and difficulties in measuring success (ibid., Klakegg and Volden, 2016). Internal challenges specific to the public sector include a weakness in creating a strategic vision, as well as a lack of skilled resources or deficient coordination among different stakeholders internally in the project (OECD, 2015).

While e.g. Love et al. (2015) highlight project-internal and technical attributes to be the cause of cost increases, other scholars claim the human factor for being the root cause of cost overruns: Flyvbjerg (2005) argues that large cost overruns in public projects are due to a strategic underestimation of costs and an overestimation of benefits at the front-end of large public construction projects, in order to obtain approval for the decision to build. For him, the root cause for this underestimation is human bias:

> *"Your biggest risk is you, according to behavioral science. The root cause of cost overrun is human bias, psychological and political. Scope changes, complexity, geology, archaeology, bad weather, business cycles, etc. are causes, but not root causes. If you don't solve the problem of cost overrun at the root, you will not end overrun."*
> (Flyvbjerg et al., 2018, p. 183)

Although many studies have investigated the topic of cost drivers and cost overruns, only few studies have focused on how to improve cost performance (Welde and Klakegg, 2022). Welde and Klakegg (2022) demonstrate in their recent study of a sample of 96 projects, that the use of stochastic cost estimation within a framework of external quality assurance reduces cost overruns.

In addition to studies on cost drivers or cost estimation, there is literature focusing on specific approaches to reduce project costs. In this literature, the focus is often not directly or not entirely on project costs. Standardization or systematic completion are such topics. Standardization of a building means "*the extensive use of components, methods or processes with regularity, repetition and a successful history*" (Pasquire and Gibb, 2002, p.3). Standardization can contribute to improved performance, higher predictability, reduced costs, shorter lead times, less defects (ibid.) and increased learning for future projects (Berg, 2008). However, standardization can also lead to reduced flexibility, can endanger meeting the individual needs of the users (Craig et al., 2000) and compromise the individual architectonical expression, especially when building special purpose buildings.

Using a systematic completion approach can also be an important tool for quality assurance and cost-efficiency in construction projects (Mills, 2011b). Systematic completion (SC) is a managerially driven commissioning process integrating the completion aspect into all phases of the project, with the purpose to fulfil all functional requirements in terms of time, cost and quality (Johansen and Hoel, 2016). The aim is to assure operational readiness when the project is completed and handed over to facility management (ibid.). To achieve this, it is important to start the commissioning process early in the project and drive it continuously together with the user and representatives from facility management (Hopps and Babaian, 2014; Jensen, 2012). A test regime is used to eliminate errors as early as possible (Johansen and Hoel, 2016), as late changes and corrections are costly. Systematic completion can increase knowledge transfer from operations to future projects (Jensen et al., 2019).

4.2.4. Cost management in different project phases

As illustrated in Figure 10, the level of influence on construction costs decreases while the project proceeds. At the same time, the occurred costs increase (Nejat et al., 2010). Cost-efficiency actions in the conceptual phase will thus have more effect than actions in the construction phase of a project. At the same time, the cost of changes to the project increases as the project proceeds further.

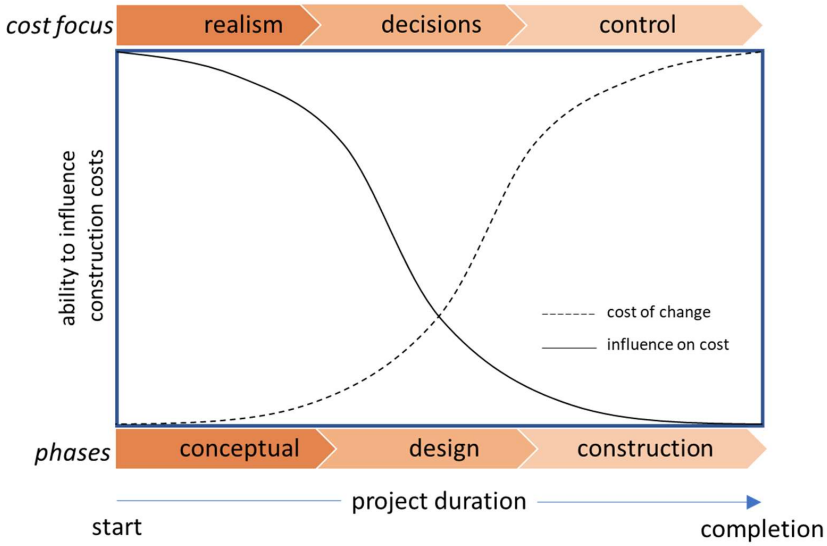

Figure 10 The cost-influence curve of a construction project (Nejat et al., 2010; Barnes, 1988)

In his overview of construction project management, Barnes (1988) refers to a shifting management focus during the different phases of a construction project. At the start of the project, it is important to account for a high degree of uncertainty and set realistic contingency allowances and control the use of those allowances tightly as the project proceeds. In the design phase, it is important to assure that the necessary decisions are made, and that the design process is properly controlled.

At the end of the design phase, most of the decisions affecting the cost of a project have been taken. Cost forecast and cost control during this phase has to assure that changes in instructions or unexpected events are included into the cost forecast for the final project. An appropriate design and the minimization of gaps in the design at tender stage led to less and less costly change orders at a later stage. In the construction phase of the project, the focus is on minimizing change orders, both through new instructions to the contractor, but also through unexpected events in the project. In case of change orders, project management has to assure that those are dealt with as soon as possible, that the project obtain value for money and that the client is involved into the process of prioritizing changes (Barnes, 1988).

4.2.5. Stakeholder influence on public construction project costs

Project stakeholders are "*those individuals and organizations who are actively involved in a project or whose interests can be affected as a result of project execution or completion*" (Li et al., 2013, 124, based on the definition by the Project Management Institute). A common distinction is between actors in the project (e.g. project management team, contractor) and external stakeholders (e.g. the media, public authorities). In public construction projects, there is an extensive and complex network of stakeholders, both public and private (Yuan et al., 2010). Stakeholders in the projects are the project owner, client/customer, user, financing authority/investor, contractors, suppliers and consultants, project management team, the public, neighbours, regulating authorities, non-governmental organizations, and the media. Many of

those stakeholders have an interest in the outcome of the construction projects and are affected by the value added in the project (Hanisch and Wald, 2011), but many of them also affect project costs directly or indirectly. Barnes (1988) postulated the importance to define the precise roles of participants and stakeholders at an early stage in the project. The project management team has to identify those stakeholders with high influence, that is both high interest and high power, on project decisions (Olander and Landin, 2005). Haddadi et al. (2016b) found that stakeholders' power can have both positive and negative effects on value creation in a construction project. Stakeholder expectations have to be weighed against the main objectives of the project and it is not likely that all their expectations can be fulfilled, as they often are in conflict with each other (Olander, 2007). Taking different stakeholder perspectives helps to identify their incentives in the project (Hanisch and Wald, 2011).

In a project, maximizing stakeholders' positive impact and minimizing their negative impact is the aim (e.g. Nguyen et al., 2009) and active stakeholder management has been found to have a direct and positive effect on a project's success (e.g. Saad et al., 2020). Stakeholders play a significant role in making a project successful (Mahmood et al., 2020) through optimizing it (Macias, 2017) as well as positively and negatively influencing the attainment of project goals (Bizon-Górecka and Górecki, 2017). Especially stakeholders' negative attitudes towards a project might obstruct its implementation, eventually leading to cost overruns (Olander and Landin, 2005, Bizon-Górecka and Górecki, 2017).

Four stakeholder influence strategies are identified by Vuorinen and Martinsuo (2019) to maximize positive impact through stakeholders and minimize their negative impact on project costs: 1) communication (e.g. stakeholders propose alternative designs via media), 2) complaints and disputes (e.g. between the contractor and the building commissioner about the payment responsibility for additional work), 3) decision-making authority (e.g. government postpones its funding), and 4) supervision (e.g. regulations that state when disruptive work can take place).

The stakeholder perspective is referred to in depth theoretically and empirically in paper 3. Additionally, paper 1 shows systematic completion as one possible way to use the competences of stakeholders to reduce project costs.

An awareness of cost drivers in construction projects and working towards cost-efficiency in each project is important. However, the positive effect can be increased enormously by transferring the knowledge and experience gathered in projects to future projects. In the following, I will therefore outline basic elements of the knowledge perspective.

4.3. The knowledge perspective

Paper 4 "Knowledge transfer in a project-based organization through microlearning on cost-efficiency" is written from a knowledge perspective and relevant theory is discussed in detail in that paper, with focus on microlearning. In this chapter, I will give a short overview of basic theoretical ideas on knowledge transfer in projects and PBOs. Figure 11 gives an overview of different aspects of the knowledge perspective, which are relevant in this study.

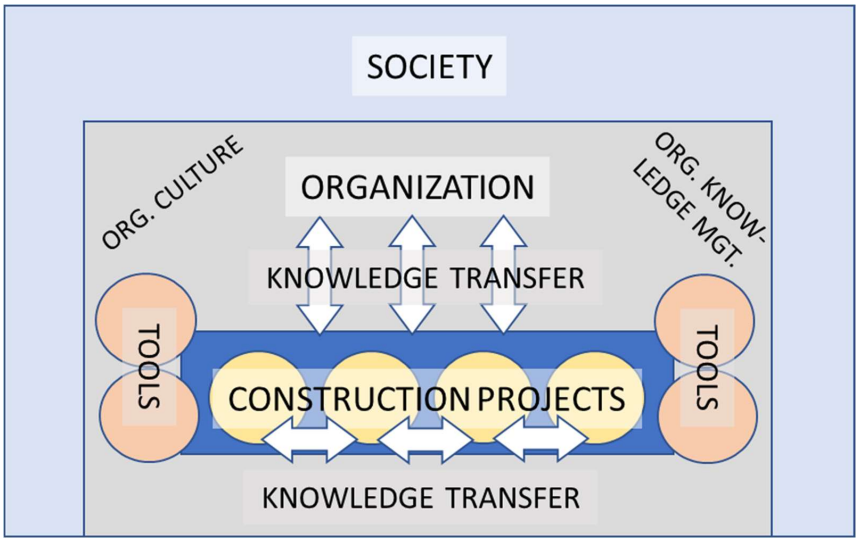

Figure 11 Important aspects of the knowledge perspective in PBOs

Today's society is complex and knowledge intensive, and we need to knowledge to manage public resources wisely. Also our common knowledge can be seen as an asset which belongs to the community, not only to ourselves. With an increasing adoption of technology and fast changes in society, also the need for managing knowledge efficiently increased. At the same time, information technology can facilitate knowledge management (Alavi and Leider, 2001).

Within an organization, the organizational culture - the shared values within an organization - serves as a moderator for knowledge transfer and has a significant influence on knowledge assets (Fernandes, 2018). Organizational knowledge management is the formal framework for knowledge sharing within an organization.

4.3.1. Organizational knowledge management

In contrast to information, which is facts or patterned data, knowledge is more as it also includes the capability to act and "*the set of facts and rules of thumb that experts have acquired over many years of experience*" (Liebowitz, 2001, p.1). Explicit knowledge is documented and formalized and thus made available for others, while tacit knowledge is closely linked to the individual possessing competence based on previous experience (Liebowitz, 2001). Especially tacit knowledge can be 'sticky', meaning that individuals keep knowledge to themselves and does not make it easily available for others to use for solving similar problems (von Hippel, 1994). Learning is the acquisition of knowledge or skills through study, experience, or being taught (www.dictionary.com, 2022).

Knowledge management means organizing an organization's collective wisdom, establishing ''*a practice that finds valuable information and transforms it into necessary knowledge critical to decision making and action*.'' (van Beveren, 2002). Knowledge management comprises all activities of knowledge-handling in an organization, meaning transfer of knowledge and thus creating added value from the organization's intangible assets (Liebowitz, 2001). Also Argote and Miron-Spektor (2011) argue for knowledge transfer being significantly beneficial for organizational performance, as it e.g. enhances problem-solving of the members of the organization. However, knowledge transfer does not occur automatically (ibid.;

Wiewiora et al., 2009; Ayas and Zeniuk, 2001). Ordanini et al. (2008, p. 18) suggest that projects can "*act as 'focusing devices' which balance the cognitive distance that is useful for exploration with the cognitive proximity useful for exploitation*", as it is easier to combine different functional knowledge when working project-based. Also Ayas and Zeniuk (2001) advocate for project-based learning, where communities of practice can share learning experiences in an environment of psychological safety in a systemic and collective reflection process.
Senge (1990) introduced the term of the 'learning organization', a place where a supportive learning environment enables the employees to create, acquire and transfer knowledge (Garvin et al., 2008). This is possible, because we are all learners, and we love to learn if we are in an environment which is supportive for learning (Senge, 1990). According to Senge (1990), five disciplines are needed to create a real learning organization:

1. *Systems thinking* as a conceptual framework to see patterns in previous experiences, helping us to see how to change them effectively.
2. *Personal mastery* and commitment to lifelong learning help us continuously realizing the results that matter to us. Individual learning is important, as the organization's capacity for learning is not greater than that of its members.
3. *Mental models* make us expose our own thinking and tacit assumptions and help us open up to the influence of others.
4. Building *shared vision* to make people excel not because they have to, but because they want to.
5. *Team learning,* when team members engage in dialogue and genuinely think together, is vital as teams, not individuals, are the fundamental learning unit in modern organizations. Team learning can lead to the collective intelligence exceeding the intelligence of the individuals in the team.

Knowledge management originally comes from the organization theory discipline, but it is now also an important perspective used in a project management context, as the projects both present good opportunities for learning, and because there is a high potential for future projects to benefit from previous projects.

4.3.2. Knowledge transfer in a project-based organization

In a project-based organization, the dynamics between the permanent organization and the temporary organization, i.e. the projects, has to be included into organizational knowledge management. Projects are independent organizations (to some degree) with their own culture, but they also have a sense of belonging to the permanent organization and its culture. This dichotomy makes it especially important in a project-based workplace to have an organizational culture conducive to learning (Ayas and Zeniuk, 2001). The separation of project teams, both physically and organizationally, results in the need for establishing arenas and common practices for knowledge transfer between projects (Ayas and Zeniuk, 2001; Garvin et al., 2008; Fitzgerald, 2003). There is no doubt that a lot of knowledge is created in and through projects. However, learning from projects is not naturally transferred to the organizational level (Ayas and Zeniuk, 2001). Wiewiora et al. (2009) also found a lack of communication of lessons learned directly between project teams in the same company.

With a constant change of project teams and their relationships, there is a higher risk of occurrence of fragmented and sticky knowledge (von Hippel, 1994). This limits the availability

to learn from experience of previous projects to future projects. Other constraints for organizational learning based on effective knowledge transfer between projects are the projects' temporality and exchange of key personnel (Jafari et al., 2011), and a lack of incentives for knowledge sharing and the absence of systems for knowledge sharing (Ajmal et al., 2010). However, when lessons learned are shared, "*projects may serve as practice fields for developing learning capabilities and cultivating effective habits of reflective practice that cross the boundaries of the specific project or project team*" (Ayas and Zeniuk, 2001, p. 61).

Knowledge transfer can happen directly between project teams. However, to assure systematic knowledge transfer, best practices have to be lifted from the project level to the organizational level, giving also incremental innovation in projects cumulative power from a portfolio perspective (Berggren, 2019). The permanent organization can act as a catalyst for knowledge transfer, e.g. by installing a project management office as a trustee for knowledge on project management in an organization (Kerzner, 2003). The PMO becomes a "*guardian of project management intellectual property*" by establishing systems for information collection and sharing, such as a performance failure information system identifying the causes of failure, a risk management information system, or a post mortem documentation of lessons learned (ibid.). Other activities of a PMO are the development of standards and templates, mentoring, benchmarking, or customized training (ibid.).

4.3.3. Mechanisms and tools for knowledge transfer

To facilitate knowledge transfer in the organization, multiple tools can be used. Normally, one tool will not be sufficient to allow efficient sharing of knowledge, but a combination is necessary. As mentioned before, it is important to make the organization a learning organization, which promotes and lives knowledge transfer actively (Senge, 1990; Garvin et al., 2008).

Frameworks can help to understand where and how knowledge transfer happens. According to a framework used by Argote and Ingram (2000), the three fundamental elements to consider for organizational knowledge transfer are members, tasks and tools as well as the networks formed between them. Members refer to the organizational social network, tasks refer to the routines within the organization and tools refer to which tools the organization uses for knowledge transfer. Multiple combinations of elements within these networks are possible. Examples for dynamics within those networks are personnel mobility from one unit to another for effective transfer of both explicit and tacit knowledge, or moving tasks and routines from one organizational unit to another to transfer their embedded knowledge (Argote and Fahrenkopf, 2016). Translated to the project-based organization, the same principle can be applied when considering the different projects as similar to organizational units. Establishing routines creates mechanisms for knowledge transfer and makes organizational knowledge persist also independently of individuals (ibid.). In a PBO, this means to include best practices from projects into the project management system to oblige all other projects to use and profit from the knowledge obtained in previous projects.

Tools for knowledge transfer can be either formal or informal. Formal tools include databases for information storage, training courses, seminars or reward systems and incentives for knowledge sharing (Asrar-ul-Haq and Anwar, 2016). Microlearning is an example for a formal tool for knowledge transfer. Microlearning is digital action-oriented learning of short duration on a specific topic with immediate relevance (Kapp and Defelice, 2018; Tipton, 2017).

Knowledge sharing can also happen in more informal ways: through spontaneous conversations between members across project teams or by building loose networks between project teams that allow other teams to repeat successful actions (Fitzgerald, 2003).

However, it is not enough to transfer knowledge between projects, but it also has to be applied in subsequent projects. Therefore, the steps in knowledge management do not only include creation, storage and distribution of knowledge, but also usage of knowledge (Jafari et al., 2011). Such a model also has to account for the difference between transferring explicit knowledge versus tacit knowledge. A knowledge management model displaying the different steps in knowledge transfer and accounting for the importance of applied knowledge is shown in paper 4 (cf. Figure 16 in section 5.4.4).

4.4. The strategic perspective

The strategic aspect of the PhD-project is covered in paper 5, "Strategic change towards cost-efficient public construction projects", which is written from a strategic perspective. In the following section, I will shortly introduce some basic aspects of the strategic perspective from the literature, as outlined in Figure 12.

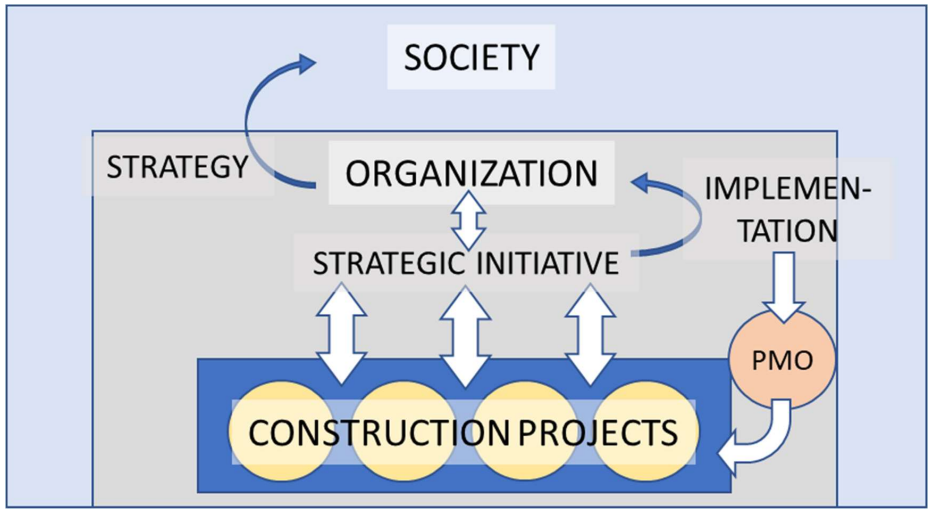

Figure 12 Important aspects of the strategic perspective in PBOs

Strategy has many connotations. For the purpose of this thesis, we use the definition of strategy as "*a plan of action designed to achieve a long-term or overall aim*" (Lexico, 2022). As such, it describes the discrepancy between where we are and where we want to be. In a business perspective, "*the essence of strategy is choosing to perform activities differently than competitors do.*" (Porter, 1996, p.44) Differentiation can ultimately be reduced to two aspects – either providing higher value to customers or providing comparable value at lower cost (Porter, 1996). Strategy is more than management tools, it is about the choice of activities and how they are performed (Porter, 1996). There is extensive research on business strategy and there are many aspects of strategy, but as the focus in this thesis is on how strategic change happens in a project-based organization, I will concentrate on this aspect.

4.4.1. Strategy and strategic initiatives

In project-based organizations, there are various strategic dimensions: Project management can be seen as a strategic asset, when corporate strategy is implemented through projects or programs (Hanisch and Wald, 2011). This entails that both strategy influences projects, "*but also that projects influence the success of strategy implementation*" (ibid., p.10). Strategic management of the project portfolio can also be achieved by aligning the project portfolio with the organizational strategic objectives (Paquin et al., 2016). However, Martinsuo and Geraldi (2020) found in their study on project portfolios, that project portfolios do not merely follow the strategy of the parent organization, but that they also anticipate the future by establishing their own strategies in their given context.

There are different ways to implement strategy: Organizational strategy can be implemented with a 'strategy-as-practice' approach, where the focus is on how strategy is enacted in everyday practices (Clegg et al., 2018). Another way for an organization to achieve necessary change is to perform a temporary strategic initiative. Those attempts can have many different names: strategic initiative, strategic project, transformation project, change project, innovation project, planned change etc. Those strategic projects represent agency for change, and can provide the necessary impetus to overcome established structures in the organization (Turner and Müller, 2003). A strategic initiative is an attempt to achieve organizational transformation and strategic goals (Ponomarenko et al., 2016), affecting the organizational long-term direction and scope of activities (Saunders et al., 2008). It serves as a means to turn the attention of the permanent organization towards a strategic aspect. To achieve this, the alignment of the objectives of the strategic initiative with the organization's strategy is important (Dietrich and Lehtonen, 2005).

4.4.2. Implementing change in organizations

A strategic initiative is a temporary action, but it has the aim to lead to permanent change. Implementation is necessary to make the actions work on a permanent basis, also after the end of the initiative.

For a successful implementation of change or innovation, a strategic initiative must achieve a balance between isolating itself from the permanent organization and being closely connected to it (Lehtonen and Martinsuo, 2009; Willems et al., 2020). Change activities must make sense to the projects who are supposed to adopt them (Stensaker et al., 2008). The innovations make sense if they either are perceived as effective, or if management commitment and good systems (databases, IT-artefacts) help to mediate change (Prado and Sapsed, 2016). However, the actions must ultimately be adopted by future projects. After the end of a strategic initiative, a project management office can be instrumental implementing strategic change throughout a portfolio of projects (Bredillet et al., 2018). Often, there is a risk of quick dissolvement of the strategic initiative, with members being assigned new tasks before the new knowledge is fully integrated in the parent organization (Stjerne and Svejenova, 2016; Swan et al., 2010; Sydow et al., 2004). In those cases, the PMO can take over the responsibility for change implementation. A PMO is also an important player in the transfer of lessons learned from previous to future projects, if it establishes structures to enable knowledge transfer (Sergeeva and Ali, 2020).

Research on how change is implemented in practice is still limited and more empirical research on those change processes is needed (van Marrewijk, 2018). Bresnen et al. (2005) have used a practice-based approach to understand how change is implemented in construction firms. They

found out that both existing management practices in the organization and the conditions in the different project organizations influence how change is perceived and implemented. Recent research emphasizes the need to involve the people who are affected by the change: Both Himme (2012) and van Marrewijk (2018) found evidence, that simultaneous bottom-up and top-down strategies help to implement change in the organization. Involvement of the employees adds value and helps to negotiate resistance, while top management commitment creates basic process outlines and has the authority to make decisions (Himme, 2012; van Marrewijk, 2018). Project employees can be change agents, while middle managers can act as resisters to change. However, when overcoming resistance, middle management can become the translators between the temporary initiative and the permanent organization (van Marrewijk, 2018). Resistance does not necessarily have to be negative but can be seen as a situational negotiation of meaning finally resulting in change (Thomas et al., 2011). Löwstedt et al. (2018) discovered in their study on strategy as-it-is-practiced in large construction PBOs, that also the projects are not only the implementation sites of organizational change, but that their actualities also shape strategy implementation. They found boundaries between project practice and situated strategy practice to be fluid, and thus, it is necessary to engage with both project managers and strategists to be able to deliver both strategies and projects successfully and on time.

After having introduced some aspects of relevant theory, I will present the five publications forming part of this thesis, in the following chapter.

5. Summary of the five papers

As this PhD-thesis is paper-based, the main results of the study are presented through five publications published during the project. The complete papers are provided in appendix. In the following chapters, I will give a short summary of each paper, focusing on a short abstract, the background of the paper including the research questions, data collection and analysis, the main results, and a short reflection on the contribution of each paper.

5.1. Paper 1: Effect of systematic completion on public construction projects

The paper "Effect of systematic completion on public construction projects" was submitted to the journal *Facilities* on 30th of November 2019, accepted on 22nd May 2020 and published as part of the special issue "Knowledge Management of the Interrelationships between Facilities Management and Building Projects" on 16th of February 2021. The complete reference for the paper is the following:

Beste, T. (2021). Effect of systematic completion on public construction projects, *Facilities*, 39 (3/4), 156-171. https://doi.org/10.1108/F-11-2019-0127

5.1.1. Abstract

The purpose of this paper is to analyze the effect of a systematic commissioning process on project management performance of construction projects, expressed as cost, time, quality and customer satisfaction. The building commissioner in focus uses the term systematic completion (SC), defining it as a structured process, throughout the whole project assuring the fulfilment of functional requirements in the building. A qualitative single case study was used to analyze the effect of a SC process by one Norwegian building commissioner in the public sector, exemplified with four projects. The analysis was conducted by studying project documents and conducting interviews.

Results from the study show that SC has a positive effect on the performance of a construction project, enabling completion on cost, schedule and with fewer defects at handover. Involving facility management assures mutual learning, trained operations personnel, and potentially lower costs of operations because of fewer corrections and optimized systems. Higher efforts and resource use in the early phases of the project and in testing are largely offset by the generated benefits.

This case study is limited to the building commissioner's perspective in four projects. The design team's, the contractor's and the client's perspectives are not represented in the study. Only one of the projects is completed, which limits the ability to draw quantitative conclusions.

Existing studies focus on the technical aspect of SC. The present study provides valuable insights into the effect of SC on project management performance, especially on its implications for the takeover of the building by operations.

5.1.2. Background of the paper

The initial idea for this paper emerged in a discussion with one of the construction projects. The project management team was interested in documenting the effect of the recently established routines of systematic completion (SC). Systematic completion is a managerially driven process

integrating the completion aspect into all phases of the project, with the purpose to fulfil all functional requirements in terms of time, cost and quality (Johansen and Hoel, 2016). The project management team suspected that SC had a positive effect on the project, but this had not been investigated. Systematic completion was introduced to counter the fact, that many construction projects are not ready for operations at the time of (expected) completion. The thorough commissioning process should assure operations readiness.

Academically, the aspect of systematic completion has not been well documented yet, although there is a connection to topic of commissioning, which is covered in literature. However, systematic completion has a more holistic approach, assuring full integration of the completion aspect in all phases of the project.

The paper covers the following research questions (RQ):

> *RQ1.* Which effect does systematic completion have on project management performance of public construction projects?
>
> *RQ2.* What are the prerequisites to make systematic completion work?
>
> *RQ3.* What are the learning effects from systematic completion?

The first ideas for the paper were developed as part of a study course on "Special topics in project management" at NTNU. The first draft of this article was submitted and accepted as the written assignment for the course.

As the single author of the paper, my role was the complete idea generation, data collection and analysis, summarizing existing theory, and writing the paper. Both during the idea generation stage and the writing process, Ola Lædre and Olav Torp (as lecturers for the study course) gave suggestions for improvement on the first draft of the article, and Ole Jonny Klakegg and Jørgen Kjetil Knudsen contributed with their constructive comments on later drafts of the article before submission to the journal.

5.1.3. Data collection and analysis

A qualitative case study approach was used to approach the topic. To increase the amount of data and the validity of the study, four projects were included. Data was collected from documents on systematic completion of the four construction projects and was consecutively analyzed. Document analysis was followed by a series of eight semi-structured interviews with nine participants in total. The documents were used to collect background information on systematic completion in the projects – both in general and how it was applied specifically in the respective project. All interviews were audiotaped and transcribed for analysis. A first open coding round helped to identify relevant topics (Neuman, 2006). In addition to the three topics of the research questions 'effect on project management performance', 'prerequisites', and 'learning', the additional codes 'attitude to and description of SC', 'test regime' and 'interface to operations' were identified. In a second round of axial coding (Neuman, 2006), the identified codes were applied to all transcripts and summarized in a spreadsheet to get a complete picture.

5.1.4. Results

The main result of this paper is that systematic completion is perceived as positive and beneficial for project management success. Systematic completion leads to fewer errors at takeover and fewer complaints at occupancy. The main reason is the continuous integration of

the completion aspect into the whole project, as shown in Figure 13. This is contrary to a traditional commissioning process, which focuses on completion at the end of the construction phase. A central aspect in systematic completion process is the involvement of facility management to increase value creation, ensure effective technical solutions and enable a smooth takeover of the building. A structured test regime with theoretic table tests, component, systems and integrated tests contributes to detecting deficiencies early in the process, making it less expensive to do changes.

There are direct costs associated with systematic completion, for the extra time it takes to plan and execute tests, as well as to involve facility management early in the project. However, the interviewees perceived that the investment into a systematic completion approach is surpassed by the savings through a timely completion with fewer errors, trained facility management, optimized technical systems and high customer satisfaction.

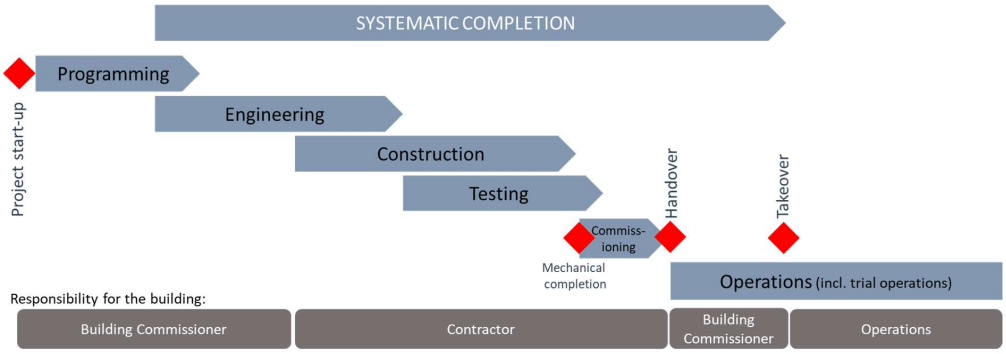

Figure 13 Processes, milestones and responsibilities in the completion process

The quantitative effect on project costs has been hard to determine at the time of study, especially as three of the four case projects had not been completed. In retrospective, two and a half years after conducting the study, we have now more information to evaluate the systematic completion process, as in total three of four projects have been completed.

Project 1, a university building, had already been completed at the time of the study. It can be considered Statsbygg's pilot project for systematic completion. The building was completed on time within the cost frame. Customer satisfaction is high due to a well-functioning building and competent facility management. In project 3, a university building, the use of systematic completion during the project contributed to completion on time and smooth handover, despite the Covid-19-pandemic. One of the main success factors in the project is the unique collaboration between project management, facility management, the user and the contractor – amongst others on the topic of systematic completion. The project costs are expected to be well below the cost frame of the project. Project 4, a museum, introduced systematic completion later than the other projects, which inhibited to take full advantage of the process. Defects in the building were discovered through integrated tests. However, in this project, the systematic completion process was started later than in the other case projects and has not been used in the same systematic way. Difficulties in the mechanical completion process (in combination with challenges due to the pandemic) led to a delay in completion. Project 4, a large university building, is still under construction, and it will take some more years until we can see the effect of the systematic completion process.

5.1.5. Contribution to practice and literature

Academic research on systematic completion is still limited. This research investigates SC as a concept extending a traditional commissioning approach. Empirical data from several projects using SC is a valuable contribution to both the practitioners' community and to the research community. This research provides a starting point for further work with establishing the theoretical approach to SC, substantiate its benefits and limitations, and provide practical advice to practitioners both on why and how to use systematic completion.

5.2. Paper 2: Standardization and industrialized construction of special purpose buildings

The paper "Standardization and industrialized construction of special purpose buildings" was submitted to the 10th Nordic Conference on Construction Economics and Organization on 28th of September 2018, accepted on 7th of December 2018 and published on 1st of May 2019. The complete reference for the paper is the following:

Beste, T.M., Klakegg, O.J. and Knudsen, J.K. (2019). Standardization and industrialized construction of special purpose buildings, Lill, I. and Witt, E. (Ed.) *10th Nordic Conference on Construction Economics and Organization (Emerald Reach Proceedings Series, Vol. 2*), Emerald Publishing Limited, Bingley, 25-31.
https://doi.org/10.1108/S2516-285320190000002033

5.2.1. Abstract

Research on standardization of special purpose buildings is limited. The article presents the results of a workshop with project managers, contributing to the topic based on their experience from the construction of special purpose buildings. The aim of the study is to look into the potential of standardization of special purpose buildings, with the example of the Norwegian Directorate of Public Construction and Property Management (Statsbygg). The study uses results from a group workshop on the topic of standardization, suggesting building types suitable for standardization or modular construction. In addition, data from Statsbygg's project database is used.

There is a broad spectre of special purpose buildings with potential for standardization, such as customs facilities, courthouses, university buildings and buildings with a high share of office functions. Even buildings with an individualized character, such as museums or government buildings, have a certain potential for standardization of functional or constructional elements. Modular construction can be used where and when appropriate.

Being on a brainstorming level and limited to Statsbygg, the study provides a starting point for further research looking at other building commissioners working with special purpose buildings or quantifying the potential for cost reduction. Based on the findings from this study, Statsbygg considers further standardization of their special purpose buildings, not only within building types but also across the portfolio or within a project, for example rooms or functional elements.

5.2.2. Background of the paper

In 2017, a colleague and I executed a small study, where we analyzed the how the standardization and modularized construction of prisons impacts risk and project cost. This study resulted in the conference paper "Standardization and modularization of prisons" (Økland et al., 2017), which was presented at ProjMAN – International Conference on Project Management in Barcelona in November 2017. In the case of prisons, the standardization concept has delivered on time, cost and quality compared to earlier prison projects. These results inspired to investigate if standardization and industrialized construction also can be used in other projects, in order to upscale the positive effect om project management goals.

A special purpose building is a "*type of property [with a] unique design or layout, […] or other features that limit the property's utility for purposes other than the one for which it was built.*" (US Legal, 2018). Standardization is using repetitive components, methods or processes, or elements with a successful history (Pasquire and Gibb, 2002). Industrialized building implies that parts of the building are produced in factories and assembled on site (Berg, 2005). In existing literature, standardization is perceived as incompatible with the unique character and purpose of special purpose buildings, where every construction project has to be approached in an individual way (Moum et al., 2016). However, this study wanted to make use of the favourable experience from previous standardized prison projects and investigate if this approach could be taken one step further.

In the paper, the following research questions are addressed:

> *RQ1.* Which types of special purpose buildings have a high potential for standardization?
>
> *RQ2.* How can also buildings with a highly individual character benefit from standardization?
>
> *RQ3.* What are the constraints when standardizing special purpose buildings?

As the first author, my role in this paper was the complete data collection and analysis, as well as the main responsibility for the theoretical background and for writing the discussion and conclusion. The co-authors Ole Jonny Klakegg and Jørgen Kjetil Knudsen contributed both in the idea generation process when elaborating the research questions and in the writing process of the paper.

5.2.3. Data collection and analysis

A qualitative case-study approach was taken (Neuman, 2006). As part of a seminar for the building commissioning department, the participants of the seminar engaged into a group work. In groups of 8 members, project managers and other project staff engaged into group discussions to develop ideas through interaction between the group members. "Group discussion is a means of collecting data in one go from several people (who usually share common experiences) and which concentrates on their shared meanings" (Payne and Payne, 2004, p. 103). 11 of 15 groups reported their results through a quest back form, constituting a response rate of 73%. The groups were asked to discuss the possibility of further standardization of special purpose buildings, based on a presentation on standardization of prisons, which they all had listened to previously.

Data was analyzed by inserting the results retrieved through the quest back into a spreadsheet to see emerging topics, as well as manually analyze similarities and differences in the answers.

5.2.4. Results

Engaging discussions in the groups produced both answers to the research questions and interesting side results.

The groups reported the following building types having a high standardization potential: educational buildings, office and administration buildings, court houses, traffic control and customs facilities, police stations, student accommodation and museums. The building types are listed in descending order (number of groups mentioning them), but the order does not necessarily only reflect the standardization potential, but also which buildings the participants mostly work with and have most experience with. It was also suggested to standardize building elements, such as facades, floors or doors, as well as room types. With this approach, even highly individualized buildings such as museums, could be standardized to a certain degree.

The discussion in the groups and the reported results show a positive attitude towards further standardization. The participants largely agree on a positive effect of standardization on project costs, and they are ready to transfer experiences from the standardizing prisons to other types of buildings.

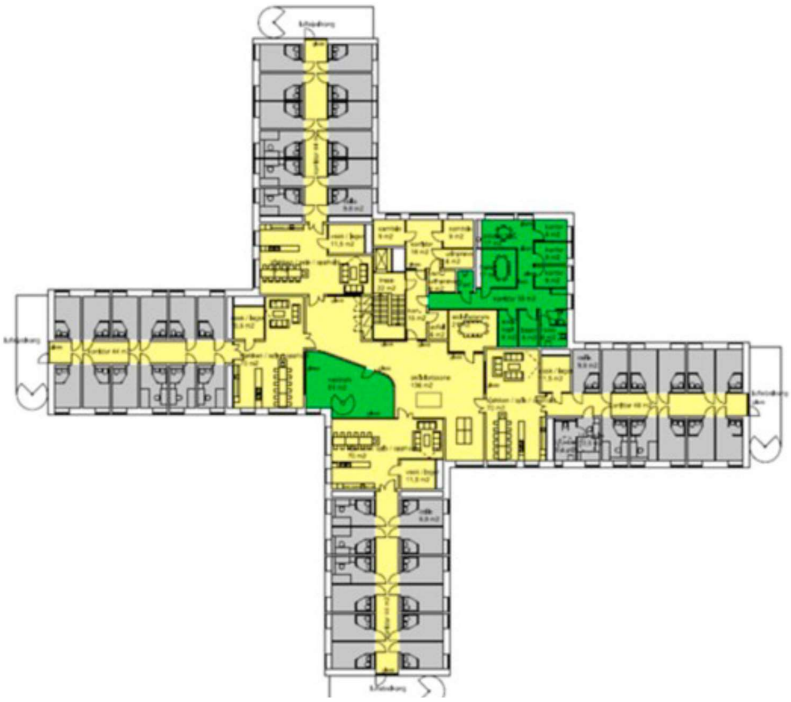

Figure 14 A standardized prison building (Statsbygg)

The participants also identified challenges: Standardization should not limit the possibility for unique architectural expression. Furthermore, standardization can lead to acceptance problems if it is not developed in collaboration with the client and the user of the building. And last, it is important to define the appropriate extent and level of detail of the standard.

Experience from standardized prison project (Figure 14) shows, that standardization contributes to cost-effective construction projects and faster project delivery. The savings achieved in the two completed standardized prison projects were around 20% compared to the last prison project completed before standardization. Taking advantage of this effect by extending standardization to the whole portfolio of projects, would lead to enormous cost savings for the organization who manages projects with an annual investment volume of around 7 billion NOK (in 2018).

5.2.5 Contribution to practice and literature

From a practitioner's perspective, the findings of the study provide a solid ground for further standardization of projects in the organization. The study expands existing research on standardization of special purpose buildings with insights from project practitioners that it is possible to standardize even elements of those buildings with a highly individualized character without compromising on the architectural expression. The presented research also confirms that standardization contributes to cost-effective construction projects.

5.3. Paper 3: Stakeholder influence on public construction project costs

Beste, T. and Klakegg, O.J. (202X). Stakeholder influence on public construction project costs. Unpublished paper.

The paper is currently prepared for submission to the journal *Project Leadership and Society*.

5.3.1. Abstract

The purpose of this paper is to help readers better understand stakeholders' influence on the costs associated with public construction projects. A two-fold systematic literature review and a case study investigating 21 projects undertaken in a public sector organization show a complex stakeholder structure. Stakeholders often have both positive and negative impacts on a project's overall costs, the most notable of which being the buildings' users. However, these users are not mentioned as being prominent stakeholders in the literature, while empirical evidence shows several instances where these same users have influenced project costs to a significant degree. The paper contributes to project management literature by presenting substantial empirical evidence that shows how stakeholders influence the cost of public construction projects. Practitioners and policymakers alike may include the insights from this study when adapting their project governance models to reflect a more conscious management style of stakeholder influence on project costs.

5.3.2. Background of the paper

The idea for this paper emerged in a brainstorming process on the empirical material from the value meetings with the projects. Stakeholder relations in the projects proved to be complex and many cost-efficiency actions are related to different stakeholders, who influence project costs either positively or negatively. Cooperation with stakeholders for cost reduction seemed a central aspect to achieve higher cost-efficiency in the projects.

The idea for this paper was developed together with the co-author Ole Jonny Klakegg. My role as first author was the collection and analysis of empirical material, conducting the systematic literature review as well as taking the lead in the analysis and writing process of the paper.

5.3.3. Data collection and analysis

A qualitative approach was used for this paper. Data was collected with two methods: a systematic literature review in two parts to cover the general aspect, and empirical data from 21 projects in the case study organization to cover the specific aspect.

A state-of-the-art literature review (Grand and Booth, 2009) served to assess the current state of knowledge on the topic and to use recent literature as the background to assess the examples from the case study. In two parts, information on the stakeholders in public projects (46 papers) and their influence on project costs (102 papers) was collected.

In the case study, empirical data was collected from 21 projects in different project phases with expected costs between EUR 5 and 700 million. The project management plans and completed phases of each project in the organization's database were searched for information about stakeholders' actual influence on project costs. The collected data was analyzed qualitatively using content analysis. I manually scanned the database's project management plans for any information on the projects' stakeholders and their level of influence. This information was compiled in a list format.

5.3.4. Results

Both the studies in the literature review and from the projects in the case study organization show a complex environment of numerous stakeholders of public construction projects. The stakeholders in the sample of projects are summarized in a structured way in Figure 15.

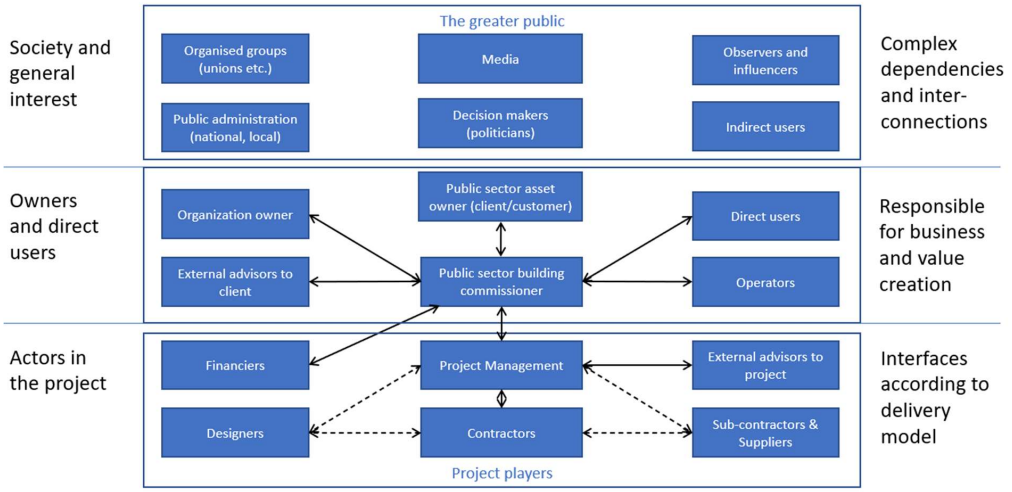

Figure 15 A structured view of stakeholders of construction projects in the case study organization

In contrast to the results from the literature review, the users of the buildings have a more prominent role in the case study projects. Contractors and suppliers are less in focus in the empirical examples than in the reviewed literature.

Stakeholders have a significant impact on project costs, both through direct costs (e.g. additional requirements by regulating authorities), indirect costs (e.g. the need for design changes due to the area's zoning plan) and costs related to project scope (e.g. the client's influence through the project mandate). Stakeholder influence in the construction projects is dynamic: Some stakeholders, like the client and the user, are more important during a project's

early phases when they can influence conceptual choices with significant impact on project costs. When those decisions are made, they become less influential, while stakeholders like contractors and suppliers become more powerful through market forces, collaboration and change orders. Based on the empirical results and literature reviews, the fundamental conclusion can be drawn that involving central stakeholders early and listening to their needs will make it easier to create a suitable and cost-efficient project.

The next step would be to further quantify the influence of stakeholders on project costs. From a practitioner's perspective, it will be beneficial to look at mechanisms on how stakeholder management can be integrated effectively into a project governance model and be used to optimize project cost.

5.3.5. Contribution to practice and literature

The presented study contributes with a demonstration of a clear interconnection between two important topics of project management: stakeholders and costs. One finding which has not found much attention in project management literature before, are the cost implications (both positive and negative) of collaboration with the users in public sector construction projects. This study delivers even some quantifiable examples of such collaboration.

For practitioners and policymakers, the study emphasizes the need of involving different stakeholders in a project's various phases – not only to minimize their negative impact, but to use their competences and knowledge to increase cost-efficiency in the project. For policymakers, this study provides good reasons for integrating the involvement of stakeholders into a project governance model in order to use the full potential of stakeholders contributing to cost-efficient projects.

5.4. Paper 4: Knowledge transfer in a project-based organization through microlearning on cost-efficiency

The paper "Knowledge transfer in a project-based organization through microlearning on cost-efficiency" was submitted to The Journal of Applied Behavioral Science on 28th of September 2020, accepted after revision on 28th of June 2021 and published online on 21st of July 2021.

Beste, T. (2021). Knowledge transfer in a project-based organization through microlearning on cost-efficiency. *The Journal of Applied Behavioral Science.*
https://doi.org/10.1177/00218863211033096

5.4.1. Abstract

This paper investigates the role of microlearning on cost-efficiency on knowledge transfer in a project-based organization. As part of an action research study in a Norwegian public sector organization working with construction projects, a microlearning series was initiated to increase knowledge transfer on cost-efficiency. Seven microlearning lessons were distributed to 334 employees, including short questionnaires after the first and last lesson. The study reflects on the design process of the lessons, on the participation rate, and on how it contributes to an increase of knowledge. Microlearning was perceived as relevant by the participants. It makes knowledge transfer less arbitrary by providing a common body of knowledge to all project teams. For the organizational practice, this implies that microlearning also has potential for knowledge sharing on other topics in the project-based organization. Updating the

microlearning series with further examples and new lessons is expected to contribute to continuous learning on cost-efficiency.

5.4.2. Background of the paper

During the internal research project, one goal besides the engagement into concrete cost-efficiency measures in the construction projects, was to increase knowledge transfer on cost-efficiency between the projects. Many successful actions for higher cost-efficiency in the projects had been detected. However, it is arbitrary, if and to whom those actions are communicated. This limits the learning effect for other projects. Therefore, one initiative was the design of a microlearning series on cost-efficient construction projects. The topics and content of the lessons was based on previous experience in the action research project. The topics were the following (see Table 3): Cost-efficiency – introduction, Cost-efficiency in early project phases, New contractual approaches, Standardization, Technology and digitalization, Cost estimation and cost control, and Knowledge transfer and learning. Each lesson was designed with a short explanation of the topic, followed by examples from the projects in the organization.

Lesson/topic	Started	% Completed
1. Cost-efficiency—introduction	75%—250 people	97%
2. Cost-efficiency in early project phases	68%—227 people	98%
3. New contractual approaches	66%—220 people	98%
4. Standardization	62%—205 people	100%
5. Technology and digitalization	57%—190 people	99%
6. Cost estimation and cost control	51%—171 people	95%
7. Knowledge transfer and learning	47%—157 people	98%

Table 3 Microlearning lesson topics and participation rates (as of 23.06.2020)

As the single author of the paper, it was my responsibility to generate ideas, collect and analyze data, summarizing existing theory, and writing the paper. In the design of the microlearning lessons, an employee from the internal training department assisted with reflections on the design of the lessons, focusing on the presentation of content and language. She also assisted in the data collection process considering participation rates as well as the results of the questionnaires included in the lessons. The content of the lessons was reflected on with colleagues with expert knowledge on the respective topic. Ole Jonny Klakegg and Jørgen Kjetil Knudsen contributed with their constructive feedback on several drafts of this article.

5.4.3. Data collection and analysis

In this study, a combination of qualitative and quantitative approach within the overall action research methodology was chosen.

In the qualitative part, a series of microlearning lessons on cost-effective construction projects was developed in a reflective process together with colleagues with expert knowledge on the respective topics. Both the topics, the content, the design of the lessons, was well as practical considerations were carefully considered. Seven consecutive lessons were sent out over a period of seven weeks to 334 employees.

Participation rates as well as short questionnaires included in the first and seventh lesson, were analyzed quantitatively. The questionnaires consisted of three questions with scores on a 1-5 Likert scale. In addition, one yes-or-no question on the relevance of the microlearning course was included after lesson 7. After ended microlearning, participation rates for each lesson were analyzed and the answers to the quest-back form questions were evaluated with basic statistical methods. The significance of the differences was tested with a paired samples t-test to test if the knowledge on cost-efficiency and on the perception of organizational tools and systems changed significantly. The test was performed on all complete datasets, that is, in those cases, where participants had answered both the questions after first and seventh lesson (n = 153).

5.4.4. Results

The microlearning lessons were designed as short informative lessons (3-5 minutes each) with specific and practical information to one aspect of cost-efficient construction projects in each lesson. The short execution time enabled to use other unproductive time spans, and the lessons were accessible both from PC and mobile devices. Participation was voluntary, but encouraged by the departmental managers. The desired effect was two-fold: direct transfer of knowledge from previous projects to ongoing projects, and to arise attention for cost-efficiency in construction projects. Participation rates were high, with 75% for the first lesson, and gradually descending to 47% for the last lesson. With 95-100%, the rate of completion by those who started the lessons was high. 91% of the learners evaluated the course as relevant for them. The learning effect was perceived highest by those who had low knowledge on cost-efficient construction projects before the course.

The microlearning course helps to provide a fundamental knowledge on the topic, also in those instances when direct transfer from project to project is not happening. Figure 16 shows how knowledge is transferred between projects. Microlearning can function as a vehicle for embedded knowledge which is shared, acquired and in the last step applied in other projects.

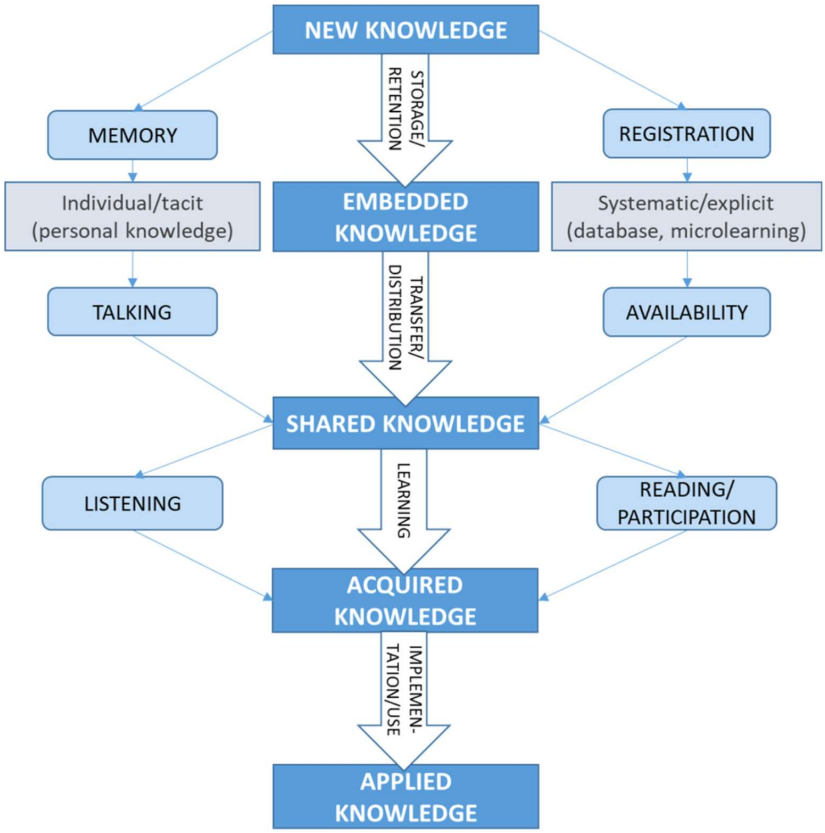

Figure 16 Adapted knowledge management model (based on Ordanini et al., 2008, and Jafari et al., 2011)

When continuously supplementing and updating the microlearning lessons, a feedback-loop can be created, where examples of cost-efficiency measures from projects can be picked up by other projects and thus become the new best practice.

5.4.5. Contribution to practice and literature

Microlearning is a learning tool which has been used in practice and has been written about from a business perspective, but which has not been in the focus of academic research before. Therefore, this study contributes to research on knowledge management in PBOs, that microlearning is a valuable tool for increasing knowledge sharing between projects. The study also links the use of microlearning to organizational culture.

For practitioners, the study provides empirical data on how microlearning can be used to convey important topics to a large group in the organization. Microlearning is an effective modern learning tool, for topics where the recipients have low previous knowledge. However, the study shows that further improvements include to improve participation rates, and to create a learning loop by updating the microlearning lessons continuously.

5.5. Paper 5: Strategic change towards cost-efficient public construction projects

The paper "Strategic change towards cost-efficient public construction projects" was submitted to the International Journal of Project Management on 31st of May 2021. Based on the feedback of two anonymous reviewers and two editors received on 28th of August 2021, a major revision of the paper was submitted on 26th of November 2021. Afterwards, two revisions with minor changes were submitted (revision 2 on 13th of February 2022 and revision 3 on 6th of April 2022). The third revision of the paper was accepted for publication by the International Journal of Project Management on 8th of April 2022.

Beste, T. and Klakegg, O.J. (2022). Strategic change towards cost-efficient public construction projects. *International Journal of Project Management, 40(4), 372-384* https://doi.org/10.1016/j.ijproman.2022.04.006

5.5.1. Abstract

The cost of public construction projects is a central topic in project management. However, studies have primarily focused on cost on a project level, not on cost management on portfolio level. In this paper, we take the perspective of a government agency, conducting a strategic initiative to increase cost-efficiency in their portfolio of construction projects. We use an action research approach to investigate the dynamics of the initiative and the implementation of resulting actions to achieve lasting change towards cost-efficiency. Accounting for the context of the organization and co-creating actions for cost-efficiency together with the project teams, was important for the success of the strategic initiative. For successful implementation, alignment of the objectives of the initiative with organizational strategy, and knowledge transfer between projects is central. This study expands the project management literature on strategic cost management of portfolios of construction projects and provides practical guidance for organizations.

5.5.2. Background of the paper

The PhD-project started with a cost focus, trying to collect and implement actions in the construction projects to achieve higher cost-efficiency. However, during the project, an important insight emerged: This research project is not mainly about cost reduction per se, but about how cost-efficiency can naturally be integrated in the construction projects. This meant shifting focus from a cost perspective to a strategic perspective. Therefore, this article focuses on an evaluation of in how far the strategic initiative could achieve this goal. It can be considered a meta-analysis of the strategic initiative and its different parts and can thus be considered as the conclusion of the PhD-study.

As the first author of this paper, I had the main responsibility for idea generation, as well as data collection and analysis. The co-author Ole Jonny Klakegg was involved in the writing process from the first idea generation to the revisions the paper. The article was written following a call for papers for the special issue "*Managing strategic projects and programs in and between organizations*" of the International Journal of Project Management. Based on a 1000-word proposal, we were invited to submit a draft of the paper for discussion in a paper development workshop together with the editors and fellow researchers. The engaged discussions in the workshop and the recommendations from other researchers led to substantial development of the paper before submission to the special issue.

5.5.3. Data collection and analysis

The methodological approach for this study is action research, which can be defined as a participative process with the participants, trying to solve a practical problem or achieve a system change while generating knowledge about the process (Susman and Evered, 1978; Reason, 2006; Dick and Greenwood, 2015). For this paper, we used meetings as a method to engage practitioners in the co-creation of cost-efficiency measures. 75 meetings were held with mainly project managers of the construction projects. During the meetings, so-called 'value cards' were established, listing cost-reducing actions categorized by the topics 'analysis of needs/concept', 'standardization', 'new contractual models', 'technology/digitalization', 'engineering costs', 'cost estimation and control' and 'project organization'. Notes were taken during the meetings and used for analysis. In addition to the meetings, the following documents were analyzed qualitatively with thematic analysis: the value cards, notes from the value meetings, the presentations to the steering committee of the strategic initiative, the initiative's implementation strategy and the final report of the strategic initiative.

5.5.4. Results

The paper presents how an organization tries to achieve lasting change through a strategic initiative. Challenges in this process were a lack of alignment of the objectives of the intitiative with organizational objectives, the resource-intensivity of the chosen approach, and a varying degree of acceptance of employing actions for cost-efficiency. The effect of the initiative does not show immediately due to long project duration and the need for a change of mindset by the project teams. Measuring cost reduction on the portfolio level in a good way also proved to be difficult.

It is important to both consider the organizational context and involve the project teams in initiating strategic change. The strategic initiative showed that explicitly addressing cost-efficiency with each project team individually brought many good cost reduction actions to the surface. As such, the intitiative has acted as a catalyst for cost-efficiency action in the construction projects. For a successful deployment of the results of the strategic initiative, an institutionalization of a checkpoint of cost-efficiency into the project governance model is suggested. A newly established project management office as well as good tools like a project database and microlearning to share best practice between projects shall help the projects direct the focus on cost-efficiency also after the initiative.

The Pentagon model (based on Rolstadås and Schiefloe, 2017, augmented by the authors with elements from Saunders et al., 2008), as shown in Figure 17, is suited to represent the implementation of the strategic cost initiative. The initiative was developed based on the organizational strategy to develop organizational capabilities to increase the organization's construction project cost performance at a portfolio level. Resulting from the strategic initiative, the future organizational strategy was changed to better accommodate a continuous focus on cost-efficiency. The 'hard' dimensions of the model, structure and technologies are tools to facilitate efficient cost reduction work in the projects, while the 'soft' dimensions of culture, interaction and social relations and networks are the enablers for change.

Figure 17 A framework for implementing a strategic initiative in a project-based organization

Concerning cost reduction, the organization has a long way to go to achieve the desired reduction on a portfolio level, even if successful actions to reduce costs have been taken in some projects. Especially in the organization's megaprojects, actions for cost reduction cannot offset cost increases due to other factors.

The strategic initiative was originally designed as a cost reduction attempt. However, to achieve such cost reduction on a portfolio level demanded more than just focusing on project costs. Rather, the initiative had to change its focus to transfer cost-efficiency an integrated element in the project governance model and make cost-efficiency a knee-jerk reaction for everyone in the project teams. The initiative has delivered an important contribution to this process, which has to be followed up after the end of the initiative. The Pentagon models helps to visualize the necessary elements to achieve a lasting change.

5.5.5. Contribution to practice and literature

The presented study provides guidance to practitioners on how organizations can cultivate a higher focus on cost-efficiency in their projects. Practitioners are invited to replicate the interactive approach working together with the construction projects in the strategic initiative.

The study contributes to project management literature by applying an organizational sociology perspective in a project management context. The study also answers the need for a more practice-based approach to project management research, by giving a rich empirical account of how strategic initiatives are implemented in project-based organizations.

6. The results of the strategic initiative

In chapter 5, I have summarized the results presented in the five papers of this paper-based thesis. In this chapter, I will give an overview of the results of the strategic initiative. Some of the aspects are addressed and highlighted in the papers, but for coherence and easier understanding, the activities and results of the strategic initiative are summarized below.

6.1. The value meetings and resulting actions for cost-efficiency

A central activity that emerged during the initiative was the direct involvement of the construction projects in the strategic initiative. The early plan to centrally develop a number of cost reduction measures which all projects have to implement, was changed in favour for a more individualized approach taking account of the individuality of each project. As an interactive method collecting and generating cost-efficiency action in projects, I held 75 so-called 'value meetings' with in total over 100 project managers and other construction project personnel. The sample of projects consisted of the whole population of construction projects over 10 million NOK in the organizations "active" portfolio, both in early project phases (conceptual, planning) and in construction phase. Only projects right before completion were excluded, as it was considered that the effect of additional measures for cost-efficiency would be too limited. The value meetings as a research method are described in detail in section 3.6.1, while the focus here will be on the practical aspects of the meetings.

I engaged in a dialogue with the project managers, focusing on the particularities of the project at hand. This was possible as the meetings were held with one project at a time. One to three people from the project team were present – the project manager and, in some cases, the assistant project manager or project controller. Most of the participants were eager to talk about their projects' cost issues and the cost-efficiency actions they had already implemented. The majority were also open to suggestions made by the researcher. However, lack of time was mentioned as an important constraint: "*We have enough tasks in the project as it is, can we please spend as little time as possible on this?*" Some participants were hesitant to mention cost issues that arose from organizational constraints, e.g. the unavailability of internal specialists to the project.

The meetings were characterized by active interaction with each project. Actions could be initiated, and information could be collected in real time. However, the meetings were a resource-intensive method, requiring me as the researcher to call, prepare and follow up the meetings. As the meetings concerned one project at a time, this meeting format did not allow direct contact between the construction projects to exchange their experiences from cost-efficiency measures. However, as more meetings were held, it was possible to draw parallels between the projects and connect those projects with similar planned actions for cost-efficiency.

To promote a structured discussion, I proposed the following topics at the beginning of each meeting: analysis of needs, standardization, new contractual approaches, technology/ digitalization, engineering cost, cost estimation and control and project organization. These topics had emerged from an initial analysis as being important. The project managers were allowed to focus on the topics that seemed relevant to the project at hand.

Cost reduction measures by the projects are the most direct and practical results of the initiative.

Examples include:

- Standardization of similar buildings.[2]
- Increase time and effort used for the technical specifications to avoid costly changes in the construction phase.
- Use a design-to-cost approach and maximize the value generated through the project within a given budget.
- Industrialized and modular building, use of prefabricated elements.
- Use of an open book approach with the contractor to adress changes and their consequences early and openly to avoid unnecessary high cost of change orders.

The actions that were developed during these meetings were documented on so-called 'value cards', which were used as a tool to visualize and summarize actions. The cards could be used as a reference point for projects to follow up actions and as an information source for other projects. All 75 value cards were made available to everybody and could be shared between project teams.

6.2. New contractual models

During the strategic initiative, introducing new contractual models has been an important aspect to consider when trying to achieve higher cost-efficiency. Statsbygg has traditionally mostly used design-bid-build approaches and turnkey contracts. As especially the design-bid-build approach proved to have disadvantages, hempering collaboration with the contractor and leading to cost overruns, top management desired to try new contractual model with early contractor involvement. Best Value Procurement (BVP) and Integrated Project Delivery (IPD) were chosen as two methods worth while exploring and testing in pilot projects. BVP is an approach focusing on the value created in the project. The contractor best suitable for solving the needs of the project is chosen, and executes the tasks in the project without detailed management by the client (DFØ, 2022). IPD is a project delivery approach integrating people, systems, structure and practices, using multiparty contracts. It is a collaborative approach to optimize the design and construction of complex construction projects.

Extensive work was done in the initiative to obtain information from other Norwegian commissioners on their experience with BVP-projects. Based on their positive feedback, the initiative arranged for education and certification of project managers and the selection of pilot projects for using BVP. After the end of the initiative, a first pilot project with BVP as the contractual approach was started. It is however too early to see the effect of the chosen approach.

IPD was also explored and considered for use in several projects. However, more information and education on the method seems to be necessary. No project has chosen IPD yet, and thus, no pilot project was initiated during the course of the initiative. It was decided to proceed with this contractual approach at a later point of time.

[2] The example of the effect of standardization of prisons in the organization is documented in a paper written prior to the PhD-project: Økland et al., 2018.

Working with new contractual approaches with the construction project teams showed that the project managers perceive this choice as taking a high risk, as they are unfamiliar with the new methods. The concrete work with the contractual approaches was not part of my focus in the PhD-project. More time and education is needed to promote and test new contractual models.

6.3. Cost-efficiency actions in early project phases

For projects in the conceptual phase, benefits realization plans were introduced. A benefits realization plan is an overview of expected and desired benefits from a project, with a plan of how the benefits can be achieved by the project. The plan is used to manage how the benefits should be implemented (DFØ, 2014). In the construction projects, it is important to align the objectives with the client's objectives, and involve the client in establishing the benefits realization plan. In a workshop, early indicators, as well as milestones and final benefits related to each goal are defined.

The benefits realization plan can contribute to higher cost-efficency, as they help the projects to keep on track regarding the intended effect that is desired through the construction project. If this is achieved, the invested money is spent wisely. At the end of the strategic initiative, experience with the benefits realization plans was highly positive and it was included into the project governance model as a mandatory activity in all projects.

There were also parallel activities for projects in the early project phases: A central point of contact for new projects was established in order to be able to direct the orders directly to the right place in the organization. Also quality control was improved for the deliveries in that phase, e.g. by establishing general check lists to be used by all projects. In addition, the customer dialoge in the early project phases was standardized and improved.

6.4. Evaluating the achievements of the strategic initiative

At the end of the strategic intitiative, the results for each of the objectives were evaluated. There was no significant change in customer satisfaction and there was no indication of increased life cycle costs in the completed projects. However, it is too early to conclude as a lot of the projects in the portfolio were not completed at the end of the strategic initiative.

Concerning the main objective to reduce total project costs by 20%, many positive actions for cost reduction have been both observed and initiated in the projects. Cost reduction can be achieved in early project stages and during the construction phase. Actions in early project phases have a high potential for cost savings and can include alternative concepts, area reductions and working with the project objectives. Even if an effect on project costs can be shown in single projects, the effect is still difficult to measure on a portfolio level. In projects in the construction phase, i.e. after the projects have been assigned a cost frame at the decision to build, measurement is easier: The final cost can be measured against the cost frame. There has been a positive development with expected cost below the cost frame in 'normal sized' projects, but this is not the case for the megaprojects in the portfolio. Thus, it is difficult to say if a 20% reduction until 2025 is achievable.

Concerning the objective to increase learning between projects and make principles of cost-efficiency an important part of the organizational culture, the strategic intitiative has continuously worked towards it. Existing structures, such as a project database to register experiences and best practice from the projects, seminars on knowledge transfer of specific

topics between projects and the inclusion of best practice in the internal courses in the organization, have been strenghtened. During the strategic initiative, we introduced two central tools for knowledge exchange: microlearning on cost-efficient construction projects and the value cards, which can be used to transfer good actions on cost-efficiency from project to project. Changing mindsets take time and continuous focus on knowledge sharing is needed, also after the end of the initiative. This is identified as a central task of the newly established PMO function in the organization.

Statsbygg's objective of contributing to innovation in the construction industry by engaging in new forms of collaboration is evaluated having the weakest performance of the objectives of the initiative. As mentioned before, the organization has just started new contractual approaches in single pilot projects. It will take time, until results and implications for the construction industry will mainfest. However, there are other attempts working towards this objective: Statsbygg has implemented systematic completion as one of the first actors in the construction industry in Norway, an approach also contributing positively to project performance.

Having presented the results of the study both through the papers in chapter 5 and a summary of the results from the strategic initiative, I will now turn to a discussion of the results.

7. Discussion

In the following, I will discuss the findings of this study on the background of the theoretical perspectives presented in chapter 4. The results of this PhD-study are mainly presented in the publications. However, I will in this chapter also emphasize some results, especially concerning the cost-efficiency actions from the value meetings, which are not mentioned in the papers.

The three research questions have three quite different focuses. In this discussion part, I will use results from the research study to exemplify how these three strands are tied together. The cost focus looks at the construction projects themselves and which actions for cost-efficiency are initiated. Further, the focus extends to an organizational perspective looking at how systematic knowledge exchange on cost-efficiency actions between the projects can be achieved. When turning to a strategic focus, the question to be answered is how change towards more cost-efficiency in both single projects and on a portfolio level can be implemented to make it last also beyond the strategic initiative.

Table 4 shows an overview of how the research questions, the theoretical perspectives, the empirical material used for each research question, and the papers are related to each other.

RQ no.	Research question topic	Theoretical perspective	Empirical material	Main focus of the papers
1	Project actions on higher cost-efficiency	Cost	Cost-efficiency actions (collected in value meetings) Interviews Group discussions Project data and documents	Paper 1: Standardization Paper 2: Systematic completion Paper 3: Stakeholder influence
2	Knowledge transfer on cost-efficiency actions between the projects	Knowledge	Cost-efficiency actions (collected in value meetings) Microlearning lessons Survey results (included in microlearning)	Paper 4: Microlearning
3	Implement higher cost-efficiency permanently	Strategic	Cost-efficiency actions (collected in value meetings) Strategic initiative documents Project data	Paper 5: Strategic change

Table 4 How the different perspectives are covered in the PhD-project

7.1. Combining cost, knowledge and strategic perspectives

Even though presented as three separate theoretical perspectives in chapter 4, all three perspectives, cost, knowledge and strategic, are relevant for this PhD-study. It is not new to integrate different perspectives in project management literature, but it is difficult to find explicit integration of the cost, knowledge, and strategic perspective. An example of integrating the strategic and the knowledge perspective in a project-context is presented by Thiry (2002), who names the importance of a learning loop in projects to make it possible to achieve strategic benefits on delivery of a project. As cost performance is essential for achieving strategic benefits, cost aspects will be a central topic to be integrated into a learning loop.

However, the integration of the three perspectives can be seen as 'project management research in a nutshell'. In their article on a project management research framework integrating multiple theoretical perspectives, Hanisch and Wald (2011) advocate the necessity to integrate research from different disciplines. They refer to different strands of PM research in the last 40 years: amongst others the project perspective focusing on the hard systems model, the organizational perspective focusing on the integration of the temporary projects and the permanent organization, the perspective focusing on the context in which projects are executed, and the perspective of projects contributing to value-creation in the company.

This corresponds well to the perspective levels in this study, as illustrated in Figure 18.

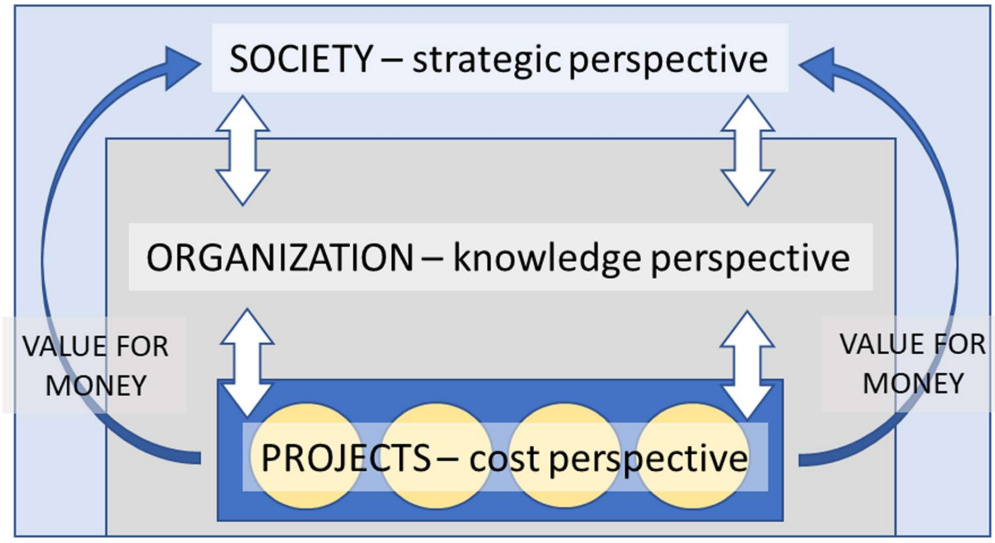

Figure 18 Integrating the three perspectives of cost, knowledge and strategy

The cost perspective can be classified as operational with the project as the unit of study. Using a bottom-up approach, we start with the cost perspective in the construction projects. We can say that this perspective is about the concrete 'what' to do to achieve more cost-efficient construction projects. When no knowledge exchange between the projects in the portfolio occurs, every project has to start again working with cost-efficiency actions. This is not efficient, especially for project-based organizations with projects as their main modus operandi, we can also interpret this process as an inter-organizational process, when regarding the projects as organizations in their own right. Knowledge transfer can happen both directly between

project organizations, or with the help of the permanent organization. This perspective is about the question 'how' the construction projects become more cost-efficient on a portfolio level.

In order to enable knowledge transfer of cost-efficiency actions in the projects, a strategic turn is necessary. The strategic perspective is situated at the interface of the organization and society and is related to the following questions: Which strategy can the organization choose to make or keep itself relevant for society? How can the organization live up to society's requirements and expectations of value for money? Through a strategic initiative, an organization can align the aim of the projects with the organizational objective of being more cost-efficient – which is the answer to the societal need for lower costs of public construction projects. The strategic perspective gives us the purpose of engaging into the quest for higher cost-efficiency, answering the question 'why' we are doing this.

I will illustrate the combination of the three perspectives with an example from the strategic initiative: In a university project (project 1 in Table 5), a thorough analysis of the users' needs in the conceptual phase could change the concept to a reduced area of the planned new building and a higher degree of re-use of the adjacent buildings on campus. From a cost perspective, this reduced the project's cost estimate by approximately 300 million NOK (a third of the original estimate). This is also an example of how active involvement of stakeholders, in this case the user, contributes to a positive development of project costs (e.g. Abolghasemi et al., 2018; Selin and El-Gohary, 2020; Rowlinson and Cheung, 2008). When stopping at this point, we would have achieved a cost reduction in this particular project, provided that the cost estimate does not change during later project phases.

However, looking at the same project from a knowledge perspective, we cannot assume that the positive experience from this project is automatically transferred to other projects (Ayas and Zeniuk, 2001; Wiewiora et al., 2009; Argote and Miron-Spektor, 2011). However, when the permanent organization makes the knowledge of the action available to other project teams, they can thereby increase the effect on project cost from the project level to the portfolio level. This was done in the strategic initiative by including this example into a microlearning lesson, which was distributed to project managers (and others) in the organization. Microlearning reaches more project managers than traditional classroom courses can. Every project manager had the chance to learn from the university project and apply a similar action to another project. This knowledge transfer could also have happened informally (and in a more arbitrary way), e.g. by two project managers chatting about their projects at the coffee machine.

Although knowledge transfer increases the possibility that several projects implement a successful action, it is by no means implicit that this happens. From a strategic perspective, the organization has to create processes and routines assuring that all projects implement best practice measures for cost-efficiency, which is one of the strategic objectives of the organization. In that way, they align the expectations of the projects in their portfolio to their strategic objective (Saunders et al, 2008). In the example from the university project, this was done by integrating the use of a mandatory checklist in the conceptual phase. The analysis of the needs of the user as well as an evaluation of possible area reduction is part of this list.

7.2. Cost-efficiency in different phases of the construction projects

An important insight from working on cost-efficiency actions with the construction projects is the fact that the nature of actions and their success is dependent on the phase of the project.

Projects in the conceptual phase are in need of other actions than projects in the design or construction phase. When structuring the actions more systematically, I have also observed that actions in earlier project phases generally have a more substantial effect on project costs. This observation is in line with prior research that the level of influence on project costs decreases when the project proceeds and that the effect of actions diminishes as a project continues into the construction phase and approaches completion (cf. Figure 10; Nejat et al., 2010). Early in the conceptual phase, there are numerous options of fulfilling the needs of the customer. As more decisions are made, the options diminish, and changes will in most projects have lower effect on project costs. Especially in the construction phase, the focus is more on avoiding cost increases than actual cost *reduction*.

Examples of actions for cost reduction in different project phases are shown in Figure 19. When possible, the effect of the action is quantified. However, this is not always possible, especially for projects which are not completed yet.

Figure 19 gives a short overview with examples on cost-efficiency actions in different project phases. Also in the papers forming the main body of this thesis, further examples are outlined: systematic completion in paper 1 and standardization in paper 2. In paper 3, the influence of stakeholders on project costs is presented. The last topic is different from the two other concrete actions in the way that several different actions for reducing costs are linked to the influence of or collaboration with stakeholders. Examples are mentioned in paper 3, such as area reductions and project optimalization through collaboration with the users, actively working with the client to establish a realistic list of possible reductions or achieving a cost-efficient and successful project by early contractor involvement.

Analysis of needs	**Courthouse** – ca. -30% reduction in project costs estimate because analysis of needs of the user led to area reduction (combined with a higher degree of quality differentiation)	**Public administration building** – analysis of needs for refurbishment in close co-operation with the user and the association for preservation of sites of historic interest led to optimalized measures of refurbishment	N/A
Standardization	**Children's homes** – a recently built children's home has been defined as a scalable best practice example to assure comparable standards and save time and costs in early project phases	**Prisons** – final cost -34% (ca. -550 MNOK) from estimate at decision to build through standardization (combined with favourable market conditions)	**Public housing in Longyearbyen (Svalbard)** – increased flexibility in the choice of contractor and shortened execution time through production of modules off-site (important due to long arctic winter)
New contractual approaches	**University buildings** – contractual strategy which is open for a combination of different contractual approaches to be able to adapt the strategy to current market conditions	**University building for energy supply** – the use of a BVP-approach is supposed to lead to higher project performance / achievement of project objectives; early involvement of contractors to play on the contractor's practical experience	N/A
Cost estimation and cost control	**Vocational college** – all changes to the original concept are logged and need to be approved, changes in scope are specified	**University building** – use of absolute cost limit in the tendering process, tender with options instead of list with possible cost cuts, this leads to cost focus both for the commissioner and the contractor	**Museum** – frequent cost estimation and uncertainty analyses in construction phase with focus on identifying opportunities / cost savings in separate workshops, and on early identification of remaining risks
Technology/ digitalization	**University building (extension)** – use of digital sensors to measure physical presence in order to be able to define the real needs for the extension of the building	**Public administration building** – the use of virtual reality in defining the design of the building led to a reduction in the need to travel and led to better communication with the user during design	**Traffic station** –use of digital models exclusively (computer stations at the site and on handhold devices; no printouts), led to less mistakes due to updated models/ information at any point of time

Figure 19 Exemplary actions for cost reduction in different project phases (project phases based on Concept, 2022b)

7.3. A detailed look at cost-efficiency actions in five projects

In the following, I will present five projects with their specific actions and (cost) consequences in more detail. The example projects have been chosen based on their application of different types of actions for cost-efficiency, which have a significant effect on project costs. An overview of the projects is provided in Table 5.

#	Project	Type of work	Phase	Approx. expected final cost (incl. value added tax)
1	**University building**	New building and refurbishment	Concept	514 million NOK
2	**Museum**	New building	Design	409 million NOK
3	**Public administration building**	Refurbishment	Design	140 million NOK
4	**Prisons**	New building	Construction	1 051 million NOK
5	**Courthouse**	New building	Concept	277 million NOK

Table 5 Overview of five case projects

7.3.1. Project 1: University building

The meeting with this project took place in the conceptual phase. The organization had originally received a project mandate from the client ordering a new building with 12 000 to 13 000 m^2. However, the organization decided to challenge this mandate and step back to evaluate if the demanded area would be optimal to fulfil the users' needs. When the project management team actively worked together with the users and identified their real needs and the prerequisites for the project, the planned square meters of new building area could be reduced by approximately a third. Instead, a light refurbishment of existing areas in other buildings was included into the project. To succeed with this, internal specialists for concept development were assigned the task. In in-depth interviews with the users, they identified the real constructional needs. The project team also looked at relevant best practice examples at other universities to see how the needs can be solved in an optimal way. An assessment of the current use of existing buildings led to the identification of unused space which could be used for parts of the identified needs. Other areas can be co-used with others, which in addition is also expected to lead a livelier campus in those areas. To conclude, the strong cooperation with the user has resulted in a reduction of new-built area to approximately 8 000 m^2 and a light refurbishment of an extra 1 650 m^2. In total, the actions led to a reduction of estimated project cost by over a third of the original estimate (equalling a reduction of approximately 300 million NOK).

7.3.2. Project 2: Museum

The meeting with this project took place in the design phase. The project was initially started ten years earlier and continued until the completed design phase, but due to lack of financing, construction was not started directly. When the project was re-activated, the project design from 2014 did not conform to 2020-standards. At the same time, there was a clear political expectation of keeping the original estimated cost (index-linked to 2020-prices), meaning that

a design-to-cost strategy has to be employed. To update the projects while minimizing extra design costs, finding the best solutions and minimizing interfaces in the project, a turnkey contract with early involvement of the contractor was chosen. The old design specifications are used as much as possible, but modern technologies (such as BIM) are used to adapt the project to today's requirements. In the tender, some work is going to be defined as options in the contract to be able to react to the cost development in the project.

The update to recent technological requirements also entails opportunities for the project: During the design phase, electrical heating was evaluated as the only possible heating technology. With today's technology, an expert involved into the project found a solution based on thermal energy, which is both more cost-efficient and environmentally friendly. This knowledge was not available during the earlier design phase of the project.

It is difficult to quantify the exact potential impact on project cost, but co-operation with different stakeholders, especially the contractor and technical experts, leads to increased (technological) value in the project, and reduces costs in the operation phase of the building due to updated technology solutions.

7.3.3. Project 3: Public administration building

The meeting with this project took place in the design phase. The project consists of an extensive refurbishment of several floors of a public administration building. Initially, the project encountered a problem related to stakeholders: The users were very sceptical towards the suggested activity-based workspaces. In workshops, the project team involved the users in designing their own solutions, which allowed them to participate actively in the change process and find solutions supporting their activities. Consultants with experience from similar issues, e.g. an architect who had experience from working together with users in designing activity-based workspaces, were involved into the process with the users. The users identified acoustics and the lighting concept as crucial technical aspects in the project, as well as the need for a combination of open work zones and silent work areas, and area enabling undisturbed digital communication. In the end, the user perceived the activity-based working spaces as a win-win situation. In addition, there was an active process of establishing a benefits realization plan together with the user in order to create a common ground for all participants how to achieve the objectives of the project.

Another important element in the project was the collaboration with the association for preservation of sites of historic interest, as the exterior of the building is protected. Close collaboration already early in the project led to the approval of important aspects in the refurbishment before initiating the tender with the contractor.

The project also tried to make use of virtual reality in order to visualize alternative concepts for the user and to be able to work digitally, minimizing the time and money spent on travelling for meeting the project team. This was especially beneficial due to the remote location of the building far North in the country.

The project wanted to achieve as much and thorough refurbishment as possible within the cost constraints, as well as optimized solutions for the users' activities. However, additional necessary refurbishment activities were identified in the design phase and included into the project. Those additional actions increased the potential value for the user but lead to increased cost estimates. To counter this, some parts of the project were defined as options in the tender

to enable more active cost controlling in the construction phase. The project is about to be completed in 2022, but unfortunately, it was not possible to stick to the original cost estimate nevertheless, and the current estimates of the final project costs are slightly above the estimates at the start of the construction phase. In the few months before completion, the project works actively with limiting the cost increase to an absolute minimum.

7.3.4. Project 4: Prisons

The meeting with this project took place in the construction phase. Due to favourable tenders, the expected final cost was at this point well below the original budget. In terms of stakeholder involvement, two aspects were decisive: In previous prison projects, a guide for standardization was developed, comprising a detailed analysis of needs and the resulting structural requirements in prison buildings, both in terms of architectural needs, rooms and security standards. This standard was developed by Statsbygg together with the client/user and tested in two previous projects (and slightly adapted with the experiences from those projects). The standard led to speedy and precise early project phases, both from the side of the building commissioner and from the user. The standard reduced the need for discussions substantially.

The other aspect was, that the project was fortunate with the market conditions, receiving favourable bids from contractors. This was partly achieved through a thorough assessment of market conditions before tendering and designing a flexible tender accounting for the marked situation. Nevertheless, after the low bids from the contractors, the project feared high extra costs in the construction phase, initiated by the contractors to increase their potentially low profit margin and compensate for the low bid. To proactively approach this issue, the project worked with active uncertainty management in an open way with the contractors, addressing potential extra costs immediately. The expected cost was estimated continuously and closely monitored during the construction phase, and change orders were categorized to be able to identify changes due to additional user demands which were not part of the original project, but constituted scope changes for which the user had to bear the extra cost. On completion, no large cost increases in the construction phase were incurred and the project was completed well below the original budget. Experiences from the project will be fed back into the standardization document for the benefit of consecutive prison projects. Due to the favourable tender situation and the active work with both standardization in the pre-project phase and active uncertainty and change order management in the construction phase, approximately 550 million NOK (34% of the estimate at the decision to build) could be saved.

7.3.5. Project 5: Courthouse

Two meetings took place with this project, a new courthouse building: one early in the concept phase and one at the end of that phase. At the time of the first meeting, there were two location alternatives for the building. When referring to costs here, I will focus on the alternative which was chosen later in the project.

This courthouse project is an example of cost reduction through a reduced area in the building as well as conscious decisions on the quality of materials used in the building. The project had already started a few years earlier, but had been stopped because of it was not prioritized, partly due to high expected costs. At this point, several changes were made in the new version of the project to reduce project costs by 30%.

Area reduction contributes the largest share of cost reduction. The area of the building was reduced by 31% compared to earlier estimates. The reduction was achieved by using an average $23m^2$ office space per person, constructing the building for the future needs assumed for 2030 instead of 2050 (but instead enable future enlargements), and by assuming a higher co-use of areas, e.g. courtrooms.

The other important element to achieve cost-efficiency is a more nuanced use of material qualities in the project. In the earlier version of the project, a high material quality standard was planned to be used in all parts of the building. In the current version, a high quality standard is only planned in the public areas, whereas a more sober quality level is used in office spaces. In addition, other cost drivers in the project were changed: the project changed the parking garage to an outdoor parking lot, reduced the ceiling height in the courtrooms, included fixtures, and reduced the high environmental ambitions in the project.

The new concept with higher cost-efficiency was also reflected in a change of priority of the project goals; from quality being the most important objective to cost being the prioritized objective before time and quality. In addition, the contractual strategy was changed from a design-bid-build contract to a turnkey contract with a design solution.

7.3.6. Practical cost-efficiency actions compared to existing literature

When comparing the actions detected and initiated in the strategic initiative to topics in existing research on project cost, a different focus can be observed. While literature focuses on cost drivers, which sometimes are out of the scope of influence for the project, the focus of the projects in the organization is on aspects which they are able to influence. In addition, examples from the literature are often more general than the examples from the case projects. Concerning cost-efficiency in the concept phase, literature describes the importance of executing the right project (e.g. Pinto and Slevin, 1988). Other literature focuses on general cost drivers, such as project attributes, contractor relations, the market (Doloi, 2013), scope definition (Cheng, 2014) and scope changes (Love et al., 2015), project-internal and technical attributes (Love et al., 2015) or a systematic underestimation of project costs (Flyvbjerg, 2005).

The empirical results in this study are more concrete and detailed than most of the literature on project costs. Some of the actions in the projects concretize aspects named in previous literature: One example is the issue of cost-savings through a reduced (more appropriate) quality level, which was both mentioned as an action in some projects, as well as a topic in literature (Doloi, 2013). In some instances, the investigated reality of the construction projects seems to be more complex than referred to in previous literature, as several examples from the projects are related to a mixture of the cost drivers from literature: The project managers focus on providing optimal tender specifications in order to both clearly define the scope and avoid scope changes (Cheng, 2014; Love et al., 2015) and establish a good relation with the contractor (Doloi, 2013). Other topics which received quite some focus by the construction projects in the sample, are not focused on in the literature on project cost. These topics are amongst others the concrete approaches of systematic completion and standardization, as well as the more general topic of stakeholder collaboration as a means to achieve cost-efficiency. Some literature on those aspects is found, but not specifically related to project cost.

The fact that there is a discrepancy between the literature on project cost and the empirical results found in this study, is an important finding. It entails that previous literature might not

have captured all elements of the reality of construction project cost factors and ways to achieve cost-efficiency. Thus, practitioners cannot draw full advantage of the literature, as it does not fully represent their reality. My research contributes to enlarging this picture by depicting a specific part of the reality of construction projects, and how they try to work practically with cost-efficiency.

7.4. Central cost-efficiency topics in this research

Systematic completion, standardization and the collaboration with stakeholders have been named before as important aspects of increasing cost-efficiency in the construction projects. Those topics are discussed in detail in papers 1, 2 and 3. In this section, I will summarize the discussion of essential aspects from the papers forming the main part of this thesis focusing directly on cost-efficiency actions in the projects.

7.4.1. Systematic completion

Systematic completion as an action for cost-efficiency has not been a subject discussed extensively in academic literature. However, the approach builds on a commissioning process and thus relates to it to some degree. Compared to the literature on commissioning, systematic completion adds a managerial aspect to the more technical commissioning approach. When looking at the cost aspect, the focus of systematic completion is not so much about reducing investment costs, but rather about avoiding extra costs for equipment failures or change orders, as well as reducing operations and maintenance costs (Mills, 2011a; Mills, 2011b). This is also an aspect emphasized by the interviewees in the presented research and can be quantified at least in the one completed case project, as there was only a comparably small amount allocated to the correction of future technical errors. However, it is too soon to see from the empirical data if operations and maintenance costs were reduced in those projects using a systematic completion approach.

There is a fundamental difference between a traditional commissioning approach and the empirical material collected from a systematic completion approach: Commissioning has a focus on a third-party control at the end of the project in commissioning (Ellis, 2015; Hopps and Babaian, 2014), while systematic completion is described as integrated and holistic process both by the (more practical) literature on the topic and by the interviewees. Consequently, systematic completion has to be considered throughout the project and not only at the end of the construction phase. Furthermore, it requires the involvement of several internal actors, such as the user, facility management and the contractor. Both starting early with the completion process and involving the right players has clearly emerged as a success factor from the empirical study.

Although the collected data shows that the effect of systematic completion is generally evaluated as positive, there are differences between the projects concerning the extent of the positive effect. In the interviews, those project resources evaluating the positive impact of systematic completion highest worked with projects which have implemented the process already at an early stage of the project. This is in line with previous literature pointing out that "*[s]tarting commissioning tasks late in the design or during construction limits your ability to make needed changes easily and cost-efficiently*" (Hopps and Babaian, 2014, p.2). This also includes the involvement of facility management in the project in order to assure robust systems and eliminate errors early – an aspect which is emphasized both in literature (Johansen and

Hoel, 2016; Jensen et al., 2019; Jensen et al., 2013) and confirmed by the empirical results from my study. The interviewees confirm Rasmussen and Due's (2019) view that a systematic approach to completion reduces a bad legacy from the project to operations and at the same time fosters mutual learning at the interface of project management and facility management (Jensen et al., 2019).

Although the financial benefit on project costs is hard to quantify, there is a general agreement both based on literature and on the empirical results that systematic completion has a positive effect on cost-efficiency in construction projects.

7.4.2. Standardization

Standardization was one of the topics which Statsbygg had worked with already before the start of the strategic initiative. The most significant example for standardized buildings in the organization are prisons, where standardization had a significant impact on reducing project costs. The benefits of standardization and modularized construction of prison buildings by the organization have been documented by Økland et al. (2018). These results confirm findings from previous studies, that standardization has a positive effect on project performance, quality, and profitability in terms of costs, time and quality (e.g. Pasquire and Gibb, 2002). An interesting aspect in the example of prisons is the learning effect, which is also referred to by Berg (2008): The positive effect on project costs increased in subsequent prison projects using a standard developed in previous projects.

Standardization is often used together with modularized construction. Modularized construction was chosen as a cost-efficiency action by a housing project the organization. The gains in the project were mainly linked to flexibility of the choice of contractor, less exposure to weather conditions, mass-production and thus lower cost, a shortened construction period and reduced uncertainty.

In literature, one downside of standardization is the danger of a lack of architectural expression or even dullness (Pasquire and Gibb, 2002), failure to meet individual needs of the users and a lack of flexibility (Craig et al., 2000). These aspects are also mentioned in group discussions on standardization performed as a part of this PhD-study. The participants see a high standardization potential of different types of special purpose buildings, interestingly not only for those buildings with a high degree of repetitive elements (such as prisons), but also to some extent for buildings with a high individual character such as museums. They also name challenges: standardization should not compromise the architectural expression of each building, and acceptance problems with the users can emerge. However, participants think that the acceptance challenge can be countered by developing the standard in collaboration with the customer and the users of the buildings. This has happened in case of the standardized prison concept, a fact that has contributed to high customer satisfaction.

To summarize, standardization is an action with a clear and quantifiable positive effect on cost-efficiency, both in literature and as a result of my study. This is especially true in those cases, where the organization builds many similar buildings.

7.4.3. Stakeholder involvement

In many of the construction projects in this research, cost-efficiency actions involved other actors or stakeholders in the project. Stakeholder involvement cannot be categorized as one

kind of cost-efficiency action, but can comprise many different actions, as stakeholders are a relevant influence factor in many of the actions. The empirical results largely confirm previous research: public construction projects have an extensive and complex network of stakeholders (Yuan et al., 2010), and many of those stakeholders are affected by and affect the project (Hanisch and Wald, 2011). Working together with stakeholders can be considered a tool to achieve a good process for standardization of a building, which the user is involved into and approves of. Also in the systematic completion process, stakeholder involvement is essential for success, especially the involvement of both the users and facility management.

Previous literature focuses much on how stakeholders' negative attitudes towards a project can lead to problems and cost overruns (Olander and Landin, 2005, Bizon-Górecka and Górecki, 2017). There are also examples for this in the presented study, e.g. when neighbours had to be compensated for inconveniences during the construction phase, or where requirements from authorities resulted in extra costs. Contrary to the focus in literature, there were also a lot of examples, where stakeholders improved the project and thus actively contributed to higher cost-efficiency. In addition to the case in standardization and systematic completion mentioned earlier, this showed to be especially important in the early project phases. As Macias (2017) emphasizes, stakeholders play a significant role in optimizing the project, which could be confirmed by the results of this study: Collaboration closely with the users contributed in several projects to optimization and downscaling of the area need, and thus led to reduced project costs. In a way, this even exceeds the four stakeholder influence strategies of communication, complaints, decision-making authority and supervision proposed by Vuorinen and Martinsuo (2019): the empirical results show collaboration which is much more than mere communication. Early in the project, the users are a central stakeholder in the project. This confirms that involving stakeholders with high influence (Olander and Landin, 2005) early in the project and taking stakeholders' perspectives (Hanisch and Wald, 2011) contributes to project success and which, based on the empirical findings, can result in lower project costs.

Concerning stakeholder influence on project costs, the empirical results confirm the complex stakeholder environment of public construction projects, but show a clearer positive focus on how stakeholders actually contribute to reducing costs, than it is presented in previous literature.

7.5. Knowledge transfer on cost-efficiency

Already early in the strategic initiative it became obvious during the value meetings, that many successful actions for cost-efficiency happen in the construction projects. However, if the actions are not transferred from a project level to the project portfolio, they do not enable the organization to take full advantage on an organizational level. Sticky knowledge, as referred to by von Hippel (1994) has also been observed in the value meetings. The meetings brought many different actions for cost-efficiency to the surface. Most of them were obvious for the project manager, but not necessarily known to many others in the organization. This also confirms that knowledge transfer between the projects, or between a project and the permanent organization, does not necessarily happen automatically (Argote and Miron-Spektor, 2011; Wiewiora et al., 2009; Ayas and Zeniuk, 2001).

In the presented research, important elements of the learning organization (Senge, 1990) can be observed: Personal mastery happens on an individual level in the projects, when individuals create and execute actions for cost-efficiency. Within the projects, team learning happens, when actions are the product of the collective intelligence of the project team. The shared vision of

cost-efficiency, which the organization wants to convey through the strategic initiative, is supposed to create a genuine interest in the topic by each project team. Mental models help both the individuals and the team to share their own successful actions and open up to learn from actions in other projects. Lastly, systems thinking helps the organization to see structures, patterns and relationships in the cost-efficiency actions, and translate the actions into structural changes and new processes.

The aspect of systems thinking is especially important as it assures the organizational institutionalization of cost-efficiency measures. As described in the literature (Kerzner, 2003), an organization's project management office can act as the guardian of the intellectual property of the projects. Also in this study, the PMO in the organization is an important catalyst for the administration and knowledge transfer on cost-efficiency actions. After the end of the initiative, the role of the PMO was strengthened, and the responsibility for future activities of knowledge sharing was placed in the PMO.

Argote and Fahrenkopf (2016) argue that networks within the organization as well as routines and structures help to make organizational knowledge persist independently of individuals. This transfer from the personal to the organizational level also happened in the presented PhD-study: During the value meetings, the participants shared their cost-efficiency actions. Successful actions were then gathered and turned into structures and routines for all projects to use.

The microlearning series developed in this study is one example of how information technology can facilitate knowledge management (Alavi and Leider, 2001) and how knowledge can be shared in PBOs. To share some basic information about possibilities for cost-efficiency, a microlearning series was designed and distributed. It served to transform individual knowledge from the projects into organizational learning, despite the temporality of projects (Ayas and Zeniuk, 2001). This new way of teaching and learning made it possible to share knowledge with a high number of people simultaneously while respecting their busy schedules. The immediate relevance of the topics in the lessons (Tipton, 2017) is confirmed empirically by acceptable participation rates and the result that 90% of the participants consider the microlearning course as relevant. This was achieved by providing many examples from the projects of the organization. The empirical results also confirmed, that microlearning is best apt for a condensed view of the topics (Kapp and Defelice, 2018). This is especially beneficial for participants with low prior knowledge of the topic. The microlearning might be expanded by other methods allowing deeper learning of relevant topics. This can be informal methods, such as conversations between project teams, or more formal methods, such as seminars or training courses.

To summarize, there are a lot of parallels between literature on the knowledge perspective in PBOs and the empirical observations in the PhD-project. However, the real benefit of knowledge management lies in the *usage* of acquired knowledge (Jafari et al., 2011). It is still be seen in how far the shared knowledge on cost-efficiency also will be applied broadly by the construction projects in the portfolio in the future.

7.6. Implementing lasting change

Having discussed the cost and knowledge perspective respectively, I will now turn to elaborate how this change was implemented in the organization. An important aspect to discuss is the role for the construction projects in this process. Furthermore, I will use an organizational model

with a holistic system perspective, the Pentagon model (Rolstadås and Schiefloe, 2017; Saunders et al., 2008), to show how five dimensions necessary for the adaptation of change in an organization are used in the presented case.

7.6.1. The role of the construction projects

In a project-based organization, the core business of the organization is executed in temporary organizations – the projects. This is also true for Statsbygg's building commissioning department. When trying to achieve change, there is the theoretical dichotomy of 1) using a strategic initiative as a means to implement change (e.g. Saunders et al., 2008; Ponomarenko et al., 2016) and of 2) implementing change through strategy-as-practice (Clegg et al., 2018; Löwstedt et al., 2018). However, in this PhD-project, I have observed that there is no clear dichotomy of those two approaches. This might be due to the unique set-up of a PBO, where change ultimately has to be put into practice by the projects, as they constitute the core business of the organization. Even if a formal strategic initiative was conducted, involving the construction projects into the creation of change, was marked by elements of a strategy-as-it-is-practiced approach:

The central role of the projects as important participants in creating change confirms previous research by e.g. Turner and Müller (2003), Lehtonen and Martinsuo (2009), Himme (2012), Löwstedt et al. (2018) and van Marrewijk (2018). Involving the construction projects also helped to avoid isolation of the strategic initiative from the permanent organization (Lehtonen and Martinsuo, 2009). However, in this initiative, the role of the projects was two-fold: In addition to being actors of change, they are also the entities having to implement with the changes resulting from the strategic initiative. In general, I have observed a positive attitude by the project managers related to this change. While previous literature reports resistance to change (van Marrewijk, 2018; Thomas et al., 2011), my empirical results do not show evidence for strong resistance. As long as the changes were more incremental than radical, there was a acceptance and a genuine interest by the project managers to contribute to the reduction of costs. One reason for high acceptance might be, that the projects themselves have been contributors in the process of creating the cost-efficiency actions. This increased the actions' practicability for the projects and resulted in the fact, that the project managers could make sense of the change and thus felt increased ownership (Stensaker et al., 2008). However, more 'radical' changes, such as the introduction of new contractual models, met more resistance due to high risk awareness of the project managers. However, as the organization has a large portfolio, also incremental changes towards cost-efficiency in each project will have cumulative power, provided that best practices are transferred from project level to the organizational level (Berggren, 2019) to be used by subsequent projects.

All the mentioned aspects are important to consider when an organization implements change. However, a structured approach to implementation is beneficial for the organization to achieve alignment of the project portfolio in the change towards higher cost-efficiency. In the following section, I will show how a Pentagon model with five dimensions can be a tool to embrace all the necessary elements for implementation.

7.6.2. The Pentagon model – five dimensions to make change last

As presented in paper 5, the augmented Pentagon model (Rolstadås and Schiefloe, 2017; Saunders et al., 2008) helps to structure and visualize the different elements necessary to

consider when implementing the results of this strategic initiative for change towards more cost-efficient construction projects. While the cost perspective relates to the object of change to be implemented (the 'what?'), the model includes elements of the knowledge (the 'how?') and strategic perspective (the 'why?').

The model has been used before to model project complexity (Rolstadås and Schiefloe, 2017), to analyze megaprojects and to assess the performance of a PBO during project delivery (Rolstadås et al, 2014). The original Pentagon model had the main core of 'Organizational capabilities and performance'. Based on the empirical results and inspired by Saunders et al. (2008), the Pentagon model was augmented with additional elements: 'Organizational strategy' and 'Learning and knowledge transfer'. The augmented model is shown in Figure 20.

The additional elements reflect that the strategic initiative was not only about creating organizational capability and improving cost-efficiency performance. To achieve this, the strategic objective of the initiative had to be aligned with the strategy of the permanent organization (Dietrich and Lehtonen, 2005). This is the case in the presented initiative: cost-efficiency is also one of the organization's objectives. Learning and knowledge transfer through creating arenas and structures for knowledge exchange, are central for transferring cost-efficiency actions to the portfolio level (see section 7.5). For the third central aspect, increasing organizational capabilities and performance, the establishment of a PMO is important. The empirical experience is similar to previous research in so far as the PMO is instrumental to leading strategic change throughout the project portfolio (Bredillet et al., 2018) after the end of the strategic initiative, and as the PMO supports collaboration across projects, e.g. by managing lessons learned in order to improve project performance on a portfolio level (Sergeeva and Ali, 2020).

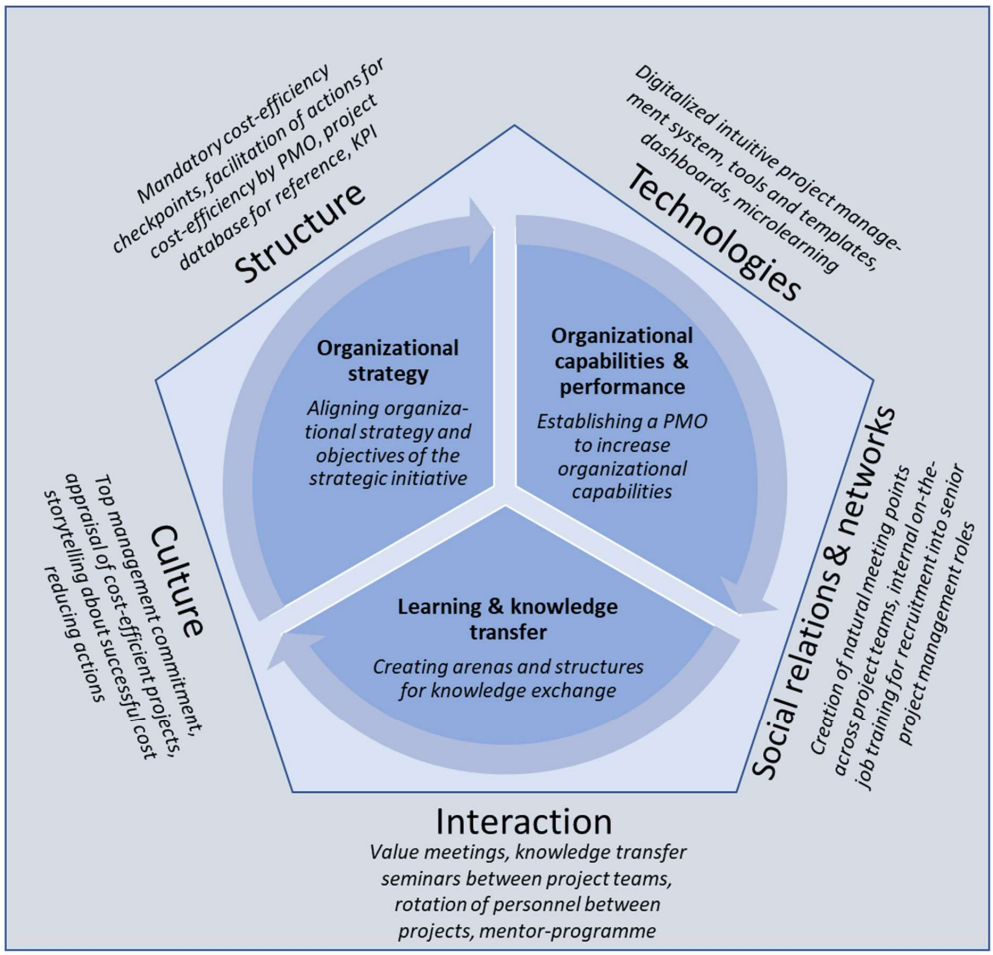

Figure 20 Using the Pentagon model for a structured implementation of change towards cost-efficiency

In the Pentagon model, the two upper dimensions are the 'hard' dimensions: *structure* and *technologies*.

Establishing permanent *structures* based on the results of the strategic initiative is an important task when implementing changes. Adapting existing structures or establishing new ones changing the way of working shows management commitment to the changes (Prado and Sapsed, 2016; Himme, 2012; van Marrewijk, 2018). Primarily, it makes it easier for projects to implement new ways of working. In this initiative, newly established structures were mandatory checkpoints for cost-efficiency, the facilitation of actions for cost-efficiency by the PMO, and a new KPI keeping track of the cost level of the project portfolio. Furthermore, an existing project database received new attention as one possibility for projects to document and share knowledge.

The second hard dimension is *technologies*. Here, the focus is on using technology to support cost-efficiency on a portfolio level, with all projects profiting from it. Following the strategic initiative, a more intuitive digitalized project management system is under development, and more tools and templates including instructions are provided for all projects. Dashboards help

to visualize e.g. early warning signs for projects showing a trend to overspend. Microlearning is one of the technological learning tools developed as part of the strategic initiative and this research (see paper 4). It is an example for making use of technological possibilities and has shown to be an effective learning tool, especially for a topic where the knowledge level is comparably low. The advantages of microlearning have been described in the (business) literature, but not as an element of a strategic initiative.

In the lower part of the model, we find the three 'soft' dimensions of culture, *social relations and networks*, and *interaction*.

At the end of the strategic initiative, the dimension of *social relations and networks* was still not fully developed. There are already established forms of networks in the organization, such as departmental seminars where projects share their knowledge, also on how they work with cost-efficiency. The idea was to increase natural meetings points across project teams, and to provide internal on-the-job training for recruitment of internal resources into senior project management roles. This is a dimension which has to be further developed. A start into further networking was made with initiating meetings with two project teams from projects with similar complexity, one completed project and one project before the construction phase. The aim of these meetings is to increase knowledge transfer from the completed project to the next project, to enable the next project team to repeat successful actions and avoid errors leading to extra costs.

This leads to the next dimension, the one of *interaction*. The value meetings are an example of interaction between the strategic initiative and the construction project teams, making them participants in the process (Turner and Müller, 2003; Lehtonen and Martinsuo, 2009; Himme, 2012; Löwstedt et al., 2018; van Marrewijk, 2018). More permanent ways of interaction after the end of the initiative include the above-mentioned seminars, as well as rotation of personnel between projects. Also a mentor-programme has been discussed, where senior project managers mentor junior project managers to achieve more knowledge sharing through this interaction.

As a last element, there is the dimension of (organizational) *culture*. A cultural change can be the result of working with the other dimensions. Doing well on the other four dimensions will increase a culture where cost-efficiency is appreciated and perceived as 'normal'. An important aspect is (top) management commitment to underline the importance of the topic. The strategic initiative has also used storytelling and appraisal of projects for their successful cost-efficiency actions. This is e.g. done as part of the microlearning, which includes examples from projects in the organization.

7.6.3. The Pentagon model – future development

The process of implementing all the elements in the organization is still ongoing after the strategic initiative was completed. New aspects emerge and practices evolve over time. Strategy implementation continues as strategy-as-practice after the end of the initiative.

However, even if the model itself is quite straightforward, there are organizational constraints to fast implementation of results from the strategic initiative, e.g. a lack of time and a lack of resources, as operational tasks in the construction projects are often prioritized over strategic tasks. This is an aspect which has to be overcome by allocating resources to the implementation of the different elements.

The initiative also unsheathed that it is more difficult to engage into specific actions for cost-efficiency in megaprojects, as they have a high degree of complexity. There are often complex structures and interrelations in those projects, so that single actions might not result in the desired effect. As a result of the strategic initiative, a follow-up initiative directed at megaprojects was started. Instead of on single actions for cost-efficiency, the follow-up focuses on strengthening project governance to assure conscious and pro-active cost-efficient choices early in and throughout the project. It would be interesting to observe the follow-up initiative with another research project and connect the results to the presented study.

8. Conclusions and contributions

In this PhD-project, I have set out to investigate how lasting change towards higher cost-efficiency in public construction projects can be achieved. More specifically, three research questions have been in focus, covering three different perspectives. From a cost perspective, I have asked which actions public construction projects take to achieve higher cost-efficiency. Taking a knowledge management perspective, I have investigated how knowledge transfer on cost-efficiency actions between the projects can be increased. Finally, I have addressed from a strategic perspective, how we can make the change towards more cost-efficient construction projects last.

More precisely, these research questions have guided me in the research process:

1. *Which actions do public construction projects take to achieve higher cost-efficiency?*
2. *How can knowledge transfer between the projects on cost-efficiency actions be increased?*
3. *How can we achieve lasting change towards more cost-efficient construction projects?*

8.1. Answering the research questions

The PhD-project confirmed that public construction projects actively work with cost-efficiency and that many actions are initiated to reduce project costs. Different actions are applicable in the different project phases, and the effect on project costs varies. However, even in an organization specialized on public construction projects, there is no automatic transfer of successful cost-efficiency actions from one project to another, or to the portfolio of projects. Therefore, the permanent organization has to work strategically to increase knowledge transfer between the projects and establish procedures and tools to make projects learn from each other and thus maximize the positive effect on project costs.

Thus, the conclusions from this study, based on the research questions, are three-fold:

(1) In the organization, various actions to increase cost-efficiency are initiated in the construction projects. Systematic completion (paper 1), standardization (paper 2) and collaboration with stakeholders (paper 3) are examples for such actions. Standardization and industrialized construction contribute to faster delivery and more cost-effective construction projects. Systematic completion increases cost-efficiency through an integrated completion process leading to buildings with fewer errors, which are ready for operations at completion. Stakeholders are important influencers of project costs. Involving relevant stakeholders early in the project and gathering information on their needs will make it easier to conduct a cost-efficient project. Especially involving the users and managing their expectations early in the project has shown a good effect to reduce project costs. In the various phases of a project, different actions have shown to be relevant. Some actions, e.g. area reductions early in a project, have a higher effect on project costs. However, the effect of cost-efficiency measures is difficult to measure on a portfolio level.

(2) Knowledge transfer on cost-efficiency actions from one project to another does not happen automatically. To make successful cost-efficiency actions accessible on the portfolio level, the permanent organization must institutionalize the facilitation of knowledge exchange between projects. Microlearning (paper 4), which covers different

aspects of cost-efficiency and informs on successful actions in the projects is one tool to facilitate such knowledge transfer. Microlearning with high practical relevance combined with project databases, formal trainings, and seminars, as well as the creation of informal arenas for knowledge exchange between the projects helps project teams to implement successful cost-efficiency from previous projects in their own projects.

(3) When conducting a strategic initiative on cost-efficiency, the permanent organization has to assure that successful measures are implemented permanently after the end of the initiative. Working both bottom up by involving the construction projects into developing cost-efficiency measures as well as top down by aligning the objectives of the strategic initiative with the organizational strategic goals assures high acceptance of the change towards higher cost-efficiency. The Pentagon model (Rolstadås and Schiefloe, 2017) can serve as a tool for coordinating the implementation of results from the strategic initiative.

These answers to the research questions provide a starting point for outlining the practical implications of this study, as well as the contributions to project management literature.

8.2. Practical implications and contributions to literature

The action research nature of this PhD-project implies that the impetus for research lies in a practical problem and that the relevance is defined by the usefulness of the research results to the organization. Statsbygg has learned about the power of enabling the construction projects to participate in developing cost-efficiency actions. Many positive actions for reducing projects costs have been detected and initiated. Involving the right stakeholders in the right way in different phases can have positive impacts on project costs. Apart from actions in single projects, the strategic initiative and the accompanying PhD-project have made Statsbygg aware of the need for a comprehensive approach to tackle project costs on a portfolio level. On a practical level, this resulted in giving the newly established PMO the mandate to pursue cost-efficiency further and to implement successful actions for cost-efficiency in the project management system of the organization.

This study shows that there is a substantial difference between the important topics in theoretical research and in practice in this field. Literature on project costs focuses on investigating cost drivers in public construction projects, mostly through questionnaires and project data, often in hindsight after project completion. Little focus is on research by involving the projects in what can be done to counter cost drivers. This study also contributes a descriptive account of the stakeholders' influence on project cost, as one aspect of the investigation into the totality of benefits and costs of involving stakeholders (McGahan, 2021). Especially the collaboration with the users may have both positive and negative impacts on project costs, an aspect which has not been much focused on in literature. This piece of research approaches the topic from a practical perspective, with me as a practitioner-researcher as the link between theory and practice. This is especially true for the aspect of systematic completion and microlearning, two aspects where academic research is still rare. Also the strategic aspect still lacks practical exploration, with this study answering to the need for more studies exploring the reality of strategic enactment through a project portfolio (Clegg et al., 2018). Through the action research approach, the study even tries to turn research from pure observation to applied theory, creating practical relevance and change.

This study also contributes to project management research by applying an organizational sociology perspective to a project-based organization, focusing on the portfolio instead of just single projects. The study extends the Pentagon model (Rolstadås and Schiefloe, 2017; Saunders et al., 2008) and applies it as a tool in a new field – i.e. when implementing a strategic initiative in a project-based organization. The rich empirical account from an insider's perspective answers the need for more practice-based research in project management (Oddane, 2015), especially the need for investigation of how change processes in organization practically happen (Söderlund, 2010).

8.3. Recommendations for further research

Suggestions for further research on the different aspects of this study are given in each paper. Here, I will focus on recommendations for further research connected to the superordinate study. Several interesting topics for further research evolve from this PhD-study.

A longitudinal study in the organization over a time frame of five to ten years would be beneficial to see the effects on the final project costs of the ongoing projects. This would enable the analysis of more quantitative data to identify the financial impact of cost reducing actions, further quantification of the effect on a portfolio level and make it possible to measure customer satisfaction. This would also make it possible to enlarge the understanding of cost-efficiency to comprise a life cycle perspective including both investment and operations costs.

Furthermore, I recommend conducting similar studies in other organizations and companies, both public and private, in Norway and internationally, so see if the results are generalizable. Favourably, a mix of different research methods should be applied. In this context, it would also be interesting to investigate if the Pentagon model also can be applied in other organizations, when implementing results from change processes. This could also comprise other topics than cost-efficiency, e.g. a change process with focus on environmental friendliness.

Also a similar study from a value perspective, looking at the value generated in the construction projects compared to the project costs, would be an interesting research topic to pursue.

Further studies on the possibility of establishing and combining further arenas for knowledge exchange (besides microlearning) between the projects would be worth while exploring.

Another aspect would be to further explore the role of the PMO, and the fact if the nature of the project portfolio (type, size, length etc.) impacts the management of strategic initiatives on cost-efficiency. Especially a focus on cost-efficiency in megaprojects would be beneficial to investigate, as the approach used in this study does not seem to be sufficient for megaprojects.

VIII. References

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IX. Appendix

Publication 1: Effect of systematic completion on public construction projects

Publication 2: Standardization and industrialized construction of special purpose buildings

Publication 3: Stakeholder influence on public construction project costs

Publication 4: Knowledge transfer in a project-based organization through microlearning on cost-efficiency

Publication 5: Strategic change towards cost-efficient public construction projects

PUBLICATION 1

Journal "Facilities", special issue "Knowledge Management of the Interrelationships between Facilities Management and Building Projects. doi: 10.1108/F-11-2019-0127

AUTHOR ACCEPTED MANUSCRIPT

Effect of systematic completion on public construction projects

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Abstract:

Purpose:
The purpose of this article is to analyze the effect of a systematic commissioning process on project management performance of construction projects, expressed as cost, time, quality and customer satisfaction. The building commissioner in focus uses the term systematic completion, defining it as a structured process throughout the whole project assuring the fulfillment of functional requirements in the building.

Methodology:
A qualitative single case study was used to analyze the effect of a systematic completion process by one Norwegian building commissioner in the public sector, exemplified with four projects. The analysis was conducted by studying project documents and conducting interviews.

Findings:
Systematic completion has a positive effect on the performance of a construction project, enabling completion on cost, schedule and with fewer defects at handover. Involving facility management assures mutual learning, trained operations personnel, and potentially lower costs of operations due to fewer corrections and optimized systems. Higher efforts and resource use in the early phases of the project and in testing are largely offset by the generated benefits.

Limitations:
The case study is limited to the building commissioner's perspective in four projects. The design team's, the contractor's and the client's perspective is not represented in the study. Only one of the projects is completed, which limits the ability to draw quantitative conclusions.

Originality/value:
Existing studies focus on the technical aspect of systematic completion. The present study provides valuable insights into the effect of systematic completion on project management performance, especially on its implications for the takeover of the building by operations.

Acknowledgements:

The present case study is part of a public sector ph.d.-project, which is jointly financed by Statsbygg, the Norwegian Directorate of Public Construction and Property Management, and the Norwegian Research Council.

The author would like to thank Ole Jonny Klakegg, Jørgen Kjetil Knudsen, Ola Lædre and Olav Torp for their valuable comments on drafts of this article. Furthermore, the author is grateful to the interviewees for their contributions and the two anonymous reviewers for their constructive comments and suggestions.

1. Introduction

The completion of a building with all its complex technical functions is the final milestone of the construction phase of a project. But why are so many projects not ready for operations at completion, even though this is agreed upon in the beginning of the construction phase? In many projects, it takes a long time before the owner finally agrees to take over the building from the contractor. In some cases, like the Berlin-Brandenburg airport, substantial construction flaws and technical difficulties led to a repeated postponement of the opening. However, there are also large projects completed on time, within budget and with the desired quality, such as the 14 billion NOK enlargement of Oslo airport completed in 2017. A systematic approach to completion is named as a success factor, focusing on operational readiness throughout the whole project, and working with continuous training of the operations staff (Langlo et al., 2018). Also other large public buildings in Norway, such as the new Munch museum and several school buildings recently finished or under construction use a similar approach to completion.

To assure operational readiness, a thorough commissioning process has been used in the shipbuilding and oil and gas industry for a long time. It was adapted to the Norwegian construction industry under the term "systematic completion". Systematic completion is a managerially driven process integrating the completion aspect into all phases of the project, with the purpose to fulfil all functional requirements in terms of time, cost and quality (Johansen and Hoel, 2016).

From 2018 on, Statsbygg, the Norwegian government's key advisor in construction and property affairs, requires all construction projects to use their procedure for systematic completion. The procedure provides a detailed list of actions with designated responsibility for all phases of the project, including testing. Two design instruction documents complement the procedure: one on systematic completion (Statsbygg, 2018) and one on the systematic collection of documentation for operations (Statsbygg, 2019). The building commissioner's documents build on the Norwegian Standard "Commissioning and testing of technical building installations" (Standard Norge, 2016). The standard outlines the processes for successful commissioning and trial operations of technical building installations, independent of the contract form. The core drivers for this process are to achieve operational readiness at completion, and well-functioning integrated complex technical systems in large projects, where technical installations take a larger share of the total delivery than before.

The effect of systematic completion on construction projects is not well documented yet. This case study looks on its effect on project management performance of public construction projects from a building commissioner's point of view. Project management performance means completing a project within schedule and budget and with the required quality (Cooke-Davies, 2002). Project success, the achievement of the project's business objectives (Pinto and Mantel, 1990) is touched upon in terms of customer satisfaction.

To concretize the research topic, this paper addresses the following research questions (RQ):

RQ1. Which effect does systematic completion have on project management performance of public construction projects?

RQ2. What are the prerequisites to make systematic completion work?

RQ3. What are the learning effects from systematic completion?

The article starts with presenting the theoretical background and the methodology. Findings from the case study are presented and discussed. To conclude, the research questions are answered based on the findings.

2. Analytical framework

2.1.Commissioning

Commissioning originally started in the shipbuilding industry to ensure that ships are ready for service (Mills, 2011a). It was later transferred to buildings to assure that today's buildings with complicated technical systems work properly (ibid.). Mills (2011a) gives the following definition of commissioning:

> *"[B]uilding commissioning brings a holistic perspective to design, construction, and operation that integrates and enhances traditionally separate functions. It does so through a meticulous 'forensic' review of a building's disposition to identify suboptimal situations or malfunctions and the associated opportunities for energy savings." (p.149)*

Commissioning especially takes into account the integrated nature of building systems (Khalilieh, 2014), "preventing system interface complications" (Schneider et al. 2016, p.313). This makes it an important tool for quality assurance and for cost-effectiveness in construction projects (Mills, 2011b). International standards, like the ISO 9000-standards for quality management can also serve as the basis for commissioning interpreted as a project-specific quality verification throughout the whole project (Wayne and Wade, 2002).

Commissioning has both costs and benefits: "Benefits can include energy savings, reductions in other utilities, and lower operations and maintenance costs. Costs include the identification and resolution of deficiencies [...], along with documentation [and] training" (Mills, 2011a, p.152). It can also "avert premature equipment failures", "mitigate indoor air quality problems, increase the competence of in-house staff, and reduce change orders" (Mills, 2011b, p.88). A thorough commissioning process with functional testing of technical systems can avoid leaving the correction of technical defects until operations (Shirkavand et al., 2016), which has been the case because clients tend to wait until operations to point out defects, or because contractors deliberately wait with the correction of remaining errors (Lohne et al., 2019). Kalilieh (2014) adds enhanced security, quicker occupancy with fewer complaints from occupants and lower overall project cost as benefits. Although commissioning is often seen as a confirmation of successful integration of installations (Ellis, 2015), using it as a continuous process with customer and user participation through all project phases, is considered to give the highest benefit (Dvir, 2005, Hopps and Babaian, 2014). "Starting commissioning tasks late in the design or during construction limits your ability to make needed changes easily and cost-effectively." (ibid., p.2). Other prerequisites for successful commissioning are third party control, alignment with the owner's requirements (Hopps and Babaian, 2014) and learning from previous projects (Ágústsson and Jensen, 2012).

2.2.The interface between construction projects and facility management

In the commissioning process, the interface between construction projects and facility management (FM) can pose a challenge. Scarponcini (1996) argues for an integrated approach to FM with a holistic view of life-cycle management. A higher investment in the design and construction phase is needed in order to optimize the costs of operations. "With 85% of the cost of a facility after it is built, it was believed that the additional cost of capturing information needed for maintenance and operation, during the design and construction phases, would be significantly offset by the resulting lower cost of maintaining the facility." (ibid. p.3). A Danish questionnaire survey reveals difficulties in operation due to the legacy from the projects, especially problems with documentation and indoor climate (Rasmussen and Due, 2019). Jensen (2012) found a limited degree of knowledge transfer from operation of existing buildings to new buildings. The involvement of FM both in the early design process and throughout the commissioning process is one mechanism to counter this problem (ibid.; Bjørberg et al., 2017). Also Boge et al. (2018) conclude that including FM already early in the project improves a building's lifetime value creation and results in a high perception of a building's usability by the user. In addition, FM should be part of the quality assurance to follow up that early specifications are met throughout the project (Bjørberg et al., 2017). The transfer of the building to operations benefits from detailed

specifications, clear agreements about quality, third party inspection and not accepting late design changes (Schneider et al., 2016). Also Jensen et al. (2019) discard the idea of considering a new building as a 'wrapped gift' to operations, encouraging instead interactive collaboration throughout the whole project to enable reciprocal knowledge transfer. From a value management perspective, there is great potential in changing the view from FM as a controlling instance reducing cost, which is often neglected in course of the construction process, to FM as an active stakeholder contributing to increased value creation in the whole life cycle of the building (Jensen et al., 2013).

2.3.Systematic completion (SC)

To answer the need for a holistic commissioning process of technologically advanced buildings, assuring a smooth transfer of the building to operations, the concept of SC has emerged in Norway in recent years.

"Systematic completion is an assurance that the project fulfils all functional requirements within the set time-, cost- and quality requirements, planned and verified by a structured process which is managerially driven from design and planning to handover." (Johansen and Hoel, 2016, p.9; translation by the author)

Planning should support both the functional requirements and the building's geometry, and work in the project should be done right the first time to achieve a well-functioning final product (ibid., p.9). Various rounds of testing, an interdisciplinary approach, as well as involvement and training of operations personnel assures robust systems and elimination of errors as early as possible (ibid., p.4/14). The resulting V-model is based on a Systems Engineering approach, where the left side represents the creation of systems requirements and the right side the integration of parts and verification against the requirements (Department of Defense, 2001). The V-model has also been adapted in the ISO 15288 standard for systems engineering (ISO, 2015) and is elementary for SC in the represented form.

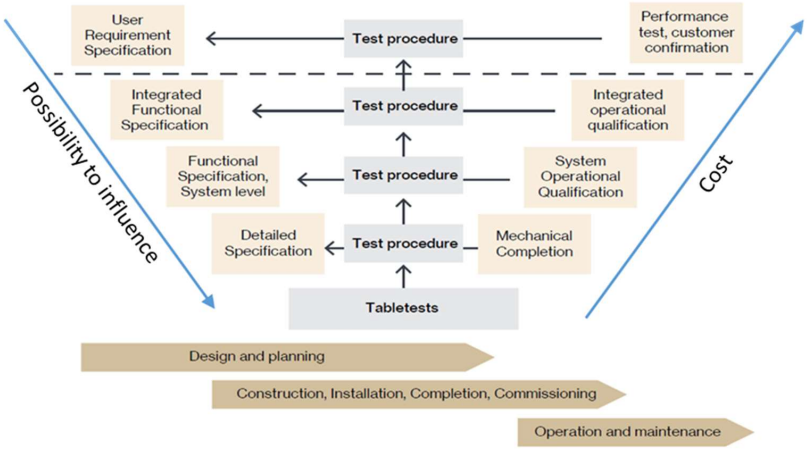

Figure 1 The V-model: Connection between engineering and testing (Holm et al. 2018, p.83; slightly adapted by the author)

The V-model as displayed in Figure 1 shows that the possibility to influence decreases gradually in the project. After construction has started, changes entail gradually increasing costs. Different levels of tests in the model assure early detection of deficiencies and optimization of systems as soon as possible in the process. Table tests after the completion of engineering constitute a theoretical review and verification of each technical system. Next, the installation of separate systems is verified, followed by testing of integrated functions and final testing of the complete system. In all tests, actions (results,

errors, rectifications) are transparently documented. Agreement of test acceptance criteria beforehand avoids conflicts in the project and gives higher predictability of the final commission.

To summarize, SC is the full integration of the completion aspect into all phases of the projects – and this distinguishes it from a traditional approach of a more arbitrary 'unsystematic completion' of construction projects. Early functional specifications serve as the basis, activities in the project are planned with completion and operations in mind, and deficiencies are eliminated as early as possible. The process is incorporated formally into the system and thus less dependent on individuals. Sequential testing, including theoretical table tests, and the involvement of personnel from operations, leads to a systematic commissioning process, which goes beyond a "functional testing of the different parts and systems before handover" (Shirkavand et al., 2016, p.5) by an external service provider.

3. Methodology

3.1. Research approach and methodology

A qualitative case study approach with triangulation of document analysis and interviews was used (Neuman, 2006). According to Yin (1981), a case study is a useful tool of empirical inquiry of "a contemporary phenomenon in its real-life context" (p.98). A single-case design is used, studying four projects handled by the same building commissioner, which allows for controlling one variable within the same context (Yin, 1981). A document study of four construction projects was followed by a series of semi-structured interviews (Neuman, 2006) with participants from the project management teams of those projects.

The author of this article is employed by the building commissioner and has access to project documents and interviewees, but has not been directly involved into the projects and has taken a researcher's role in this analysis in order to avoid bias.

3.2. Data collection and data analysis

In a first step, the building commissioner's general documents concerning SC were reviewed. Afterwards, project documents for systematic completion for four construction projects (cf. Table 1) were studied. For project 1 (Faculty of Fine Art, Music and Design of the University of Bergen), the only completed project at the time of the study, also meeting minutes and project finances were part of the analysis. The document study gave an overview of the formal implementation of SC in the projects. To get an insight into how the project organization perceive the impact of the implementation of SC in their projects, eight semi-structured interviews with nine people were conducted after the document study. Through purposeful selection, the author identified several of the interviewees herself based on professional knowledge of the projects. The first interviewees suggested the remaining interviewees. All had practical experience with SC on the commissioner's side within their respective management / technical coordinator roles. Seven interviews were face to face with one person, and one interview was conducted with two people jointly via skype. Most of the interview questions were case-specific, while in a few questions, interviewees could refer to their experience from other projects. As a small quantitative element, all interviewees were asked to rate statements on the effect of SC. All interviews were audiotaped and transcribed for analysis.

Interviews were analyzed in two rounds: A first open coding round placed the data into preliminary analytical categories, which helped to identify any surprising aspects (Neuman, 2006). In addition to three codes explicitly covering the research questions ("effect on project management performance", "prerequisites" and "learning"), the codes "attitude to and description of SC", "test regime", and "interface to operations" were added. In a second round of axial coding with focus on the coded themes, the codes were applied to all transcripts (Neuman, 2006). All coded aspects were summarized in a spreadsheet to get a complete picture.

3.3.The projects

The case study comprises four construction projects conducted by Statsbygg, the Norwegian Directorate of Public Construction and Property Management. Table 1 gives an overview over the projects:

	Project 1	**Project 2**	**Project 3**	**Project 4**
Name	*Faculty of Fine Art, Music and Design of the University of Bergen*	*New Building for Life Sciences of the University of Oslo*	*Western Norway University of Applied Sciences in Bergen*	*New National Museum in Oslo*
Type of building	University building	University building (incl. laboratories)	University building (incl. administration)	Museum
Gross area	14 800 m^2	66 700 m^2	14 300 m^2	54 600 m^2
(Expected) completion	April 2017	2024	April 2020	2020
Cost frame / expected cost	1.114 bill. NOK (price date July 2017)	6.8 bill. NOK (incl. user equipment)	0.5 bill. NOK (price date Dec. 2016)	6 bill. NOK (price date Sept. 2018)
Contract form	Contract management approach (11 contractors and design team)	Partnering approach with consecutive turnkey contracts	Turnkey contract	Architecture competition and contract management (27 contractors and design team)
Approach to SC	Building commissioner initiated SC from engineering phase on, in parallel with developing the Norwegian standard/ guide-book on SC	Building commissioner introduced SC in engineering phase, project team overlap with project 1, collaboration on SC with design team and contractors	SC led by the contractor and embraced by the project organization (from detail engineering)	Building commissioner initiated SC as a new process during construction phase

Table 1 Overview of the case study projects

4. Findings and analysis

4.1.Analysis of project documents

In project 1, SC was used in combination with a LEAN approach. In the engineering phase, SC requirements were included in the call for tender. A list over the technical infrastructure and all systems, as well as a test plan (theoretical table tests – area and system function tests – integrated tests – full-scale and user tests), test procedures and detailed functional specifications complete the foundation for SC. A training plan for FM was established.

Key figures from an internal project database for project 1 show completion of the project on time at a final cost of 99% of the internal cost frame. The absence of a specific cost item on SC makes it difficult to estimate any extra cost, but no change orders directly related to SC were issued. The minutes of the meetings between the project and FM show few guarantee issues after completion. Trial operations started as planned and FM overtook the building much earlier than similar projects. Operations perceived the standard of the technical documentation as higher than in other projects. After the trial period, the building commissioner overtook most of the technical systems from the contractors. Shortly afterwards, operations overtook responsibility of the building, with only two minor issues still handled by the project organization. Operations received 150 000 NOK to cover potential future issues – a low amount compared to other projects of similar size. The project was ahead of possible problems through continuous testing and early involvement of the operations team, resulting in a very low number of flaws in the final product. Transparency and good communication throughout the whole construction and trial operations period also contributed to a smooth transfer to operations.

The project published several brochures with an evaluation and their learning effects from SC. The project team especially stresses the importance of preventive planning with focus on completion already

in the engineering phase, involvement of the user and FM, and table tests as a final step of system engineering to reveal unsettled issues with technical systems.

In project 2, the building commissioner, the design team and the contractor collaborate on SC. A claim by the engineering team for 2 000 extra working hours due to SC gives an indication of extra costs in the early phases. For the contractors, SC should not lead to unexpected extra costs, as it is integrated into the contracts. At the time of the study, project 2 is in the detail-engineering phase. Several of the project team members have previously worked with project 1. SC has been one of the main processes of the project already from early stages on, reflected by a SC strategy and a dedicated project manager for SC. The strategy covers the interface between technical systems and the geometry of the building, as well as the different stages of tests. The test regime is the same as for project 1, with the addition of stability- and performance tests as a supplement between full-scale test and user tests. The strategy for SC lists documents to be established in the course of the detail-engineering phase, such as an action plan for SC, a list of all systems and a plan and procedures for testing.

Project 3 has not established any project-specific documents for SC, but uses general documents and instructions issued by the building commissioner. The turnkey contractor has established own documents for SC.

In project 4, a procedure for SC was established early in the construction phase. Later, plans for takeover and handover as well as for training of facility management was specified, and the building commissioner's general plan for transfer of the building to operations was adapted to the project. Even if a procedure and plan for testing was written, those plans proved to be insufficient. In summary, there was a good formal structure for SC in the project, but it was difficult to follow in practice, partly because important structures and documents were established too late to be included into the contracts with the contractors.

4.2.Interview findings

Knowledge on and description of systematic completion

All interviewees know the concept of SC, the guidebook and the Norwegian standard for SC (Standard Norge, 2016). Four interviewees have experience from one project with SC, three have participated in two projects with SC and one has worked with completion of construction projects in a systematic way since 2004, although he did not call it SC previously. One person has long experience from commissioning in the oil and gas industry. All but two interviewees also have experience from projects without SC. They agree on SC being "not entirely new and revolutionary", "no rocket science" or "hocus-pocus". One interviewee expresses it like this: "For many years, I have wished to work in this way in order to complete buildings on time, but we lacked the tools for it and the acceptance in the market."

The following statements illustrate the interviewees' attitude interviewees towards SC:

> *"My slogan for systematic completion is to start with thinking about the end."*
>
> *"The systematic reasoning behind the principles is to put in effort early to profit from it at a later stage in the project."*
>
> *"Systematic completion is about more than working systematically. It is about the integration of all and everything and about a broad interdisciplinary understanding of all functions."*

In project 1 (Faculty of Fine Art, Music and Design of the University of Bergen), a pilot for SC, the acceptance was high, apart from initial scepticism of some contractors. In project 2 (Life Sciences, University of Oslo), SC has been an integral part of the project from the early phases on, and discussions have changed from getting acceptance for SC to optimizing solutions. In project 3 (Western Norway University of Applied Sciences), SC was implemented early and is described as well working with the

turnkey contractor as one of the main drivers. For project 4 (The New National Museum), SC was introduced at a later stage and the interviewees had to "lobby" for SC among the engineering consultants and the contractors.

Test regime

All projects have a sequential test regime in place, perceived as beneficial by the interviewees. However, no table tests were performed in project 4, as SC started later in the project. Interviewees ascribe the highest saving potential to table tests, although some contractors were dissatisfied with the time-consuming exercise. Also component and system tests have revealed deficiencies, e.g. concerning the ventilation system in project 1. In project 4, more defects were discovered in integrated tests. Interviewees express the importance of integrating testing in schedules and allowing enough time for preparation to ensure readiness for testing.

The interface to operations

All interviewees stress the importance of a continuous involvement of facility management in the process of SC. They estimate that positive effects offset the associated costs:

- Resources from operations contribute to the project with their experience to optimize solutions from a facility management perspective, which also has an educating side effect on the engineers.
- Training of facility managers is integrated in the project, leading to a competent facility manager feeling ownership of the building.
- The takeover of the building by operations goes smoothly, because there are fewer defects and FM is familiar with the systems.

The effect of SC on cost, time, quality and customer satisfaction

"There is a lot of money to save if we can avoid sitting with a completed building with many deficiencies for three years without being able to transfer the responsibility of the building to operations". This reflects one interviewee's experience from a previous project where 7.5 million NOK were used for correction of flaws after completion. Two other interviewees recall instances where they have been engaged at the final stage of a project to "tidy up", a time- and cost-extensive process. Interviewees express the effect of SC on project costs as follows: "The whole process with systematic completion has [...] reduced unnecessary costs in a very simple and continuous way." and: "You avoid using money, which you originally have not planned to spend, but which you normally end up using nevertheless." Several interviewees expect a positive effect on operations cost due to fewer defects, trained facility management and optimized systems with complete documentation; potentially also through lower energy consumption. All interviewees agree that SC is important for reducing uncertainty concerning the final product, as the process assures a building where systems function well from day one. A statement from project 1 illustrates this: "I think that we would not have been able to complete the building within cost, time and quality without these processes." Interviewees also name a positive effect on customer satisfaction in project 1: A well-functioning building and competent facility management contribute to high customer satisfaction.

Prerequisites to succeed with systematic completion

One of the prerequisites to make SC work is to integrate it fully as a management task into the project. General documents by the building commissioner, including design instruction documents, are mentioned as a key to success. Enthusiasts and a good project culture across organizational boundaries contribute to the successful implementation of SC. One of the interviewees stresses the importance of team members with previous experience of SC. "You need to have been part of the process once to see the point of it. It is not enough just do read theory and documents."

SC requires more coordination and planning in the earlier phases of the project. All interviewees advocate starting early, with good functional descriptions, corresponding test procedures and system lists. This enables designing the building for completion, setting up the time plan accordingly, and including requirements for SC in contractual agreements.

There is ambiguity towards the importance of a tool for completion. It is perceived as beneficial, that the building commissioner has a tool for SC under development, but interviewees are sceptical towards testing a tool under development in a large project like project 4. Some of the interviewees mean that full understanding of the SC process is necessary before introducing a tool.

Learning effect

The interviewees agree on a high degree of continuous learning, especially in their first project with SC. This is especially encouraged by many competent people in the project organization and by a low level of conflict, providing an arena for dialogue and collaboration.

Learning for future projects includes:

- Start the SC process early in order to integrate it into design and the project schedule.
- Establishing thorough test procedures based on good functional descriptions, as well as (standardized) system lists early in the project, combined with interdisciplinary tagging of components.
- Optimization of tests and resource utilization for preparation of test procedures, limiting length of and participation in tests.
- The importance of functions and interdisciplinary collaboration.

These lessons have been partly integrated into the building commissioner's general procedures on SC.

Testing statements on SC

At the end of the interview, interviewees were asked to which extent they agree with eight statements on the anticipation of positive effects through SC compared with traditional projects without SC. The statements are taken from the guidebook on SC (Johansen and Hoel, 2016).

Claims: **Through systematic completion, projects can achieve the following:**	**No. of answers for each score**					**Average score**
	1	**2**	**3**	**4**	**5**	
	Highly negative effect	Negative effect	No effect/ neutral	Positive effect	Highly positive effect	
Early detection of errors avoiding costly rectifications.					8	**5**
Better involvement and training of operations personnel.				1	7	**4.875**
Good final documentation.				1	7	**4.875**
Better quality of building and installations.				2	6	**4.75**
More accurate lifecycle costs during operations.				4	4	**4.5**
Satisfied users of the building.			2	2	4	**4.25**
Buildings with better indoor climate.			1	6	1	**4**
Less stress and lower level of conflict.			3	2	3	**4**

Table 2 Interviewees' scores of the effect of systematic completion
(statements based on Johansen and Hoel, 2016; ranged according to descending average score)

Table 2 shows a unanimously positive picture with all answers in the range between three (neutral) and five (highly positive). Everybody agreed that SC in their project had a highly positive effect on the early detection of errors, avoiding costly rectifications at a later stage. The factors "better indoor climate" and "less stress" score lowest with a still high average of four, but the spread of the answers is different, as there is more agreement on a positive effect on indoor climate, while there was more ambiguity among the interviewees on the effect on the level of conflict in the project.

4.3.Discussion

SC is perceived as very positive by all interviewees. Negative issues are limited to acceptance problems and lack of full implementation. Nevertheless, there are nuances, as interviewees with a project management background perceive SC as a stronger cultural change than technical resources do. This indicates that SC augments a technical focus on completion with managerial focus. In this context, one might ask why SC has not been used before, if it so positive for a project. The findings give some indications: Because of split responsibilities in a traditional project execution, focus is on the project instead of the whole life cycle and especially the operation phase of the building. Narrow contractual obligations have been prioritized over a focus on functions and completion. This also entails a consequence for the professions involved in the project: Technical sub-contractors are involved earlier (during testing), and interdisciplinary technical coordinators are of higher importance than before. Also other stakeholders as the final users and especially resources from FM contribute with their competences and ideas into the project. A challenge might be that this requires additional effort, in terms of both time and cost. Additionally, SC requires a higher effort and more discipline in the early project phases. The results from the study challenge existing literature by promoting completion as an integrated process instead of a delimited commissioning process at the end of the project. The focus in the comprehensive process of SC is much broader than the narrow focus of commissioning often reported in existing literature, e.g. on indoor climate, energy efficiency or third party verification. The results also highlight the intertwining of project and FM, arguing for mutual benefits.

The findings from project documents and the interviews demonstrate the participants' clear perception of the positive effect of SC on project management performance: It assures successful commissioning of a building (c.f. Mills, 2011a, 2011b; Kalilieh, 2014; Schneider et al., 2016). Both commissioning and SC change the focus from building structures to technical systems (Forcada et al., 2013, Shirkavand et al., 2016). However, this can be perceived as problematic from a value management point of view, since focusing on technical conditions in the planning and construction process potentially can downplay the focus on the actual user value (cf. Bjørberg et al., 2017). Future SC literature would benefit from considering a value management approach. In line with Mills (2011a and 2011b), the present study indicates that the perceived benefits from SC outweigh its costs. According to the interviewees, the involvement of FM early in the project is a prerequisite for successful SC, as it increases value creation, ensures effective technical solutions and enables a smooth takeover of the building by operations. This is in line with the studies by Bjørberg et al. (2017) and Boge et al. (2018). It gives a holistic view of a building's life cycle beyond the construction project (Scarponcini, 1996) and reduces the problem of a bad legacy from the project to operations (Rasmussen and Due, 2019). Apart from the potentially subjectively positive impressions from the interviews, project data from the completed project 1 is a more objective indicator for a positive impact of SC: errors are successively eliminated (Atkinson, 2002), leading to fewer errors at takeover and fewer complaints at occupancy (Kalilieh, 2014). As perceived by the interviewees, SC fosters mutual learning and knowledge transfer when operations is involved (Jensen et al., 2019). The study also revealed the need for SC as an integrated and accepted process in order to give the full benefits. In contrast to the literatures' emphasis of a third party confirmation approach (Ellis, 2015, Hopps and Babaian, 2014), the building commissioner, the design team and the contractors apply completion as a management task throughout the whole project. This understanding is a result from the present study and illustrated in Figure 2. In contrast to SC, the traditional commissioning process is understood as the phase from mechanical completion of the building until handover, when the building commissioner accepts the contractor's work. In a project

with successful SC and no major deficiencies at completion, takeover by operations can almost coincide with handover.

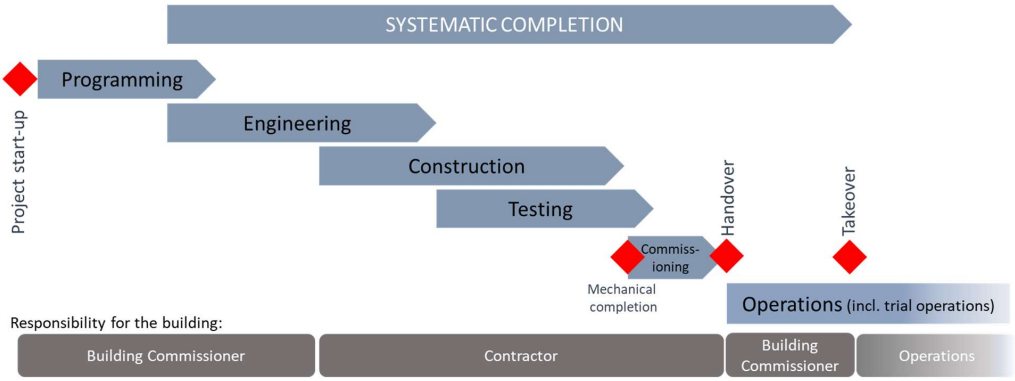

Figure 2 Processes, milestones and responsibilities in the completion process

The case study results indicate that a systematic approach to completion with clear strategies, requirements, test procedures and documentation as well as the inclusion of facility management personnel in the process has led to a less arbitrary completion process. Its integration results in buildings with fewer errors, which are operationally ready at completion.

4.4.Limitations, generalization and suggestions for further research

The qualitative character as well as the choice of projects and interviewees has implications for the result of the present study. A quantitative approach including a larger number of projects, also from other building commissioners in the public and private sector, might result in a higher degree of scattering of a perceived positive or negative effect of SC on project performance. Interviewing only people from the "SC-community" might have led to restrictions in critical responses, as they all have invested substantial time in SC. Further research should also include people in other positions with different perspectives.

This study can only provide a starting point into analysing the effect of SC. Existing studies have focused on the technical side (e.g. Nykänen et al., 2007; Turkaslan-Bulbul and Akin, 2006), not on its effect on project management performance. Further studies with more data, also in an international context, need to complement the present research. Taking the design team's, the contractor's or the customer's vantage points, would contribute to an improved insight on the effects of SC. Systematically measuring customer satisfaction and end user efficiency will be an important aspect to study when more projects with SC are completed. A quantitative approach can help to estimate the effects of SC on costs in the operation phase, e.g. by comparing energy data, cost of operations and change costs after project completion.

Even though the present study focusses only on one building commissioner, the results indicate a possibility for generalization, as central elements are in line with other studies: A systematic approach to completion/commission reduces errors at takeover (e.g. Mills, 2011a, Shirkavand et al., 2016). Collaboration and knowledge transfer between facility management and project management is essential to make it successful (e.g. Jensen, 2012 and Jensen et al. 2019).

5. Conclusion

RQ1. Which effect does systematic completion have on project management performance of public construction projects?

Those working actively with SC are convinced of its positive effect and its significance for completing a building within schedule, cost and quality. Savings through fewer errors, reduction of unnecessary costs and timely completion of the building offset higher investments early in the project due to more planning effort. SC also has effects on facility management as operations use less time and money for training and corrections, and there is a potential for systems optimization and energy savings in the operation phase through SC. This seems to be linked to a positive atmosphere in the project, fostering collaboration. Project 1 was completed on schedule, cost and with the defined quality with only minimal errors upon completion and high customer satisfaction. The building and all systems were smoothly transferred from the contractors to the building commissioner and to facility management without delay.

RQ2. What are the prerequisites to make systematic completion work?

The most important aspect to make SC work is the integration into the complete planning and construction process. Starting the process early in the engineering phase allows choosing a design apt for easy completion, writing good functional descriptions with corresponding test procedures, and including SC into contractual agreements. A systematic test regime is also an integral element. Transparent processes involving both facility management and the users of the building are essential. Formal structures in the project, such as a dedicated project manager for SC at a high level of the project hierarchy, as well as a strategy paper and procedures contribute to building up a project culture for SC.

RQ3. What are the learning effects from systematic completion?

SC fosters individual learning, especially by involving facility management into the completion process. A main learning effect is to start the process earlier, put more effort into planning and engineering, and draw on peoples' experience from previous projects. Table tests can reveal unsettled issues with technical systems at an early stage and should be prioritized in future projects. However, time use for preparation of and participation in tests has to be balanced and the level for details for time schedules can be optimized. Also on the organizational level, learning occurs, both as an exchange of experiences between projects, and between project management and facility management.

This article cannot conclude with a directly measurable effect of SC, expressed as a specific amount of money or a percentage of project cost. However, extra costs for error recovery are avoided. When applied fully, SC will have positive effects in the presented projects, especially on completing the project on time, reducing flaws and assuring a smooth transfer to operations.

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PUBLICATION 2

Standardization and Industrialized Construction of Special Purpose Buildings

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Abstract

Purpose – The aim of the present study is to look into the potential of standardization of special purpose buildings, with the example of the Norwegian Directorate of Public Construction and Property Management (Statsbygg).

Design/Methodology/Approach – The present study uses results from a group workshop on the topic of standardization, suggesting building types suitable for standardization or modular construction. In addition, data from Statsbygg's project database is used.

Findings – There is a broad specter of special purpose buildings with potential for standardization, such as customs facilities, courthouses, university buildings and buildings with a high share of office functions. Even buildings with an individualized character, such as museums or government buildings, have a certain potential for standardization of functional or constructional elements. Modular construction can be used where and when appropriate.

Research Limitations/Implications – Being on a brainstorming level and limited to Statsbygg, the study provides a starting point for further research looking at other building commissioners working with special purpose buildings, or quantifying the potential for cost reduction.

Practical Implications – On the basis of the findings from this study, Statsbygg considers further standardization of their special purpose buildings, not only within building types but also across the portfolio or within a project, for example rooms or functional elements.

The authors would like to thank all the participants contributing with their ideas and experience during the group work.

Emerald Reach Proceedings Series
Vol. 2
pp. 25–31
Emerald Publishing Limited
2516-2853
DOI 10.1108/S2516-285320190000002003

Originality/Value – Research on standardization of special purpose buildings is limited. The article presents the results of a workshop with project managers, contributing to the topic based on their experience from the construction of special purpose buildings. Although on a brainstorming level, the research is a starting point for further research into this topic.

Keywords Standardization, Standards, Industrialized construction, Prefabrication, Modularization, Special purpose buildings, Public sector, Construction projects, Cost reduction

All papers within this proceedings volume have been peer reviewed by the scientific committee of the 10th Nordic Conference on Construction Economics and Organization (CEO 2019).

1. Introduction

Statsbygg, the Directorate of Public Construction and Property Management, is responsible for building special purpose buildings for the Norwegian state. A special purpose building is a "type of property [with a] unique design or layout, [...] or other features that limit the property's utility for purposes other than the one for which it was built." (US Legal, 2018). This includes e.g. university buildings, governmental buildings, customs facilities, courthouses, police stations, prisons and museums. Planning and construction of special purpose buildings differs from constructing houses or office buildings because every building's unique function and character needs to be addressed individually.

Despite this paradigm, Statsbygg and the Directorate of Norwegian Correctional Service (KDI) developed a standardized set of functional requirements for Norwegian prisons to meet the urgent need for extended prison capacity in Norway (Statsbygg, 2018). The standard facilitates planning and construction by proposing a standard prison concept with possible partial modular construction. Statsbygg has used the standard in four prison projects (two finished and two under construction). Positive effects on project performance, regarding both time and cost (Økland *et al.*, 2017), have inspired Statsbygg to look into further standardization, assuming potential savings through economies of scale and learning effects between projects. Standardization within construction projects is not a new topic, but for special purpose buildings built by Statsbygg, the unique character has been in focus rather than standardization.

This paper investigates the potential for further standardization of special purpose building along the following research questions:

(1) *Which types of special purpose buildings have a high potential for standardization?*
(2) *How can also buildings with a highly individual character benefit from standardization?*
(3) *What are the constraints when standardizing special purpose buildings?*

We will start by outlining the research method and the theoretical reference for the topic of standardization of special purpose buildings before presenting the results from a group workshop and drawing conclusions for the potential for standardization of special purpose buildings.

2. Method

This research is conducted at the beginning of a PhD-project on cost reduction in public construction projects. Further standardization of special purpose buildings can be one of the starting points for cost reduction. A qualitative case-study approach was taken, allowing for collection of in-depth information on a specific topic (Neuman, 2006) for a limited research object (Halvorsen, 2008) – in this case, Statsbygg.

As part of a seminar for Statsbygg's building commissioning department in March 2018, a group work on the cost-reduction in Statsbygg's construction projects was conducted. "Group discussion is a means of collecting data in one go from several people (who usually share common experiences) and which concentrates on their shared meanings" (Payne and Payne, 2004, p. 103), allowing ideas to develop through interaction among group members. The group work followed a presentation on the standardization of prisons. The approximately 120 group members were mainly project managers and other project staff members. They were split into 15 equally sized groups with different levels of experience from construction projects represented in each group. Staff from the department facilitated the group work, and the first author of this paper was a regular participant in one group. The response rate was 73 per cent; 11 of 15 groups reported results through a quest back form. The groups were asked to discuss the topic of standardization and suggest other types of projects for standardization and/or modular construction. The varied outcome reflects the open discussion question and the fact that the author did not direct groups into a certain direction. Answers also included suggestions for standardization of specific building elements and room types as well as comments on challenges with standardization (cf. Chapter 4.2).

Transferability to other building commissioners has to be verified, but it is assumed that results can be reproduced for other special purpose buildings. High internal validity (Johannessen *et al.*, 2011) is achieved as almost all employees in the building commissioning department contributed.

3. Theoretical reference

3.1. Standardization and industrialized building of special purpose buildings

Standardization is a concept including "the extensive use of components, methods or processes with regularity, repetition and a successful history" (Pasquire and Gibb, 2002, p. 3). Standardization is often also associated with processes, suggesting "not necessarily functionally or aesthetically distinct products from more conventional construction, but more routes toward the attainment of stated goals" (Craig *et al.*, 2000, p. 3). Subsequent similar projects can profit by re-using the same processes, functionalities, design or plans from previous projects. Standardization is often a prerequisite for a high degree of industrialized building, where parts or modules are produced in factories and being assembled on site (Berg, 2005; Berg, 2008). Buildings with many repetitive units, such as hotels, student housing, hospitals and prisons are considered as suitable for modular building (Kamali and Hewage, 2016; Grant, 2013). As mentioned in Chapter 1, special purpose buildings are properties with unique features appropriate for one type of use (US Legal, 2018). Research on the standardization of special purpose buildings is limited, as standardization is perceived as incompatible with the unique character of special purpose buildings, where every construction project has to be addressed in an individual way (Moum *et al.*, 2016). Nevertheless, standardization of processes and technical solutions, as well as reduction of variation is possible without compromising the individuality of each building (*ibid.*).

3.2. The effects of standardization

Standards make the technical state of the art accessible for the broad market (Blind *et al.*, 2011), reduce variation in product quality (Jones and Hudson, 1996), ensure safety, environmental and social standards, and allow collaboration by different suppliers (Viardot *et al.*, 2016). Technological standards lead to innovative efficiency and productivity in knowledge creation (Spulber, 2013). In the construction industry, standardization can contribute to improved performance (Pasquire and Gibb, 2002). Among positive effects

arising from standardization and pre-assembly are better planning and control, improved quality, an improved health and safety environment, higher predictability and the possibility for increased profitability through reduced costs, shorter lead times, less defects and higher productivity (Pasquire and Gibb, 2002). Dullness, lack of innovativeness (*ibid.*), failure to meet individual needs of the users and a lack of flexibility (Craig *et al.*, 2000) are downsides. When the standard is optimized through positive and negative experiences, standardization presents an opportunity for increased learning for future projects (Berg, 2008), e.g. by developing better tendering documentation based on the log of change request from previous projects.

Recent research by Økland *et al.* (2017) found mainly positive effects of standardization and modular construction of Norwegian prisons, including significantly reduced planning time through re-use of design and facilitated client/user participation. Parallelization of groundwork and module production shortens construction time. The standard facilitates learning from one project to the other (*ibid.*). Research also points toward a positive effect of modular building on project cost but somewhat limited by a shallow pool of contractors with experience of modular construction (*ibid.*).

4. Findings and discussion

4.1. Results from the group work

In the group sessions, the participants were given the instruction: "Discuss the topic of standardization and suggest other types of projects where standardization and/or modular construction can be of relevance." Engaging discussions led to extensive answers to the topic and to interesting side results beyond the original question.

Nine groups named educational buildings having high potential for standardization, followed by office and administration buildings (mentioned by seven groups) and court houses (mentioned by six groups). Five groups each reported traffic control facilities, customs facilities and children's homes. Other building types mentioned were governmental buildings, police stations, student accommodation and museums.

In addition, most of the groups also listed building elements with a potential for standardization. This is an interesting finding as it allows standardization of special purpose buildings on a more general level with standardized solutions for the whole portfolio. Figure 1 shows a full overview of the answers.

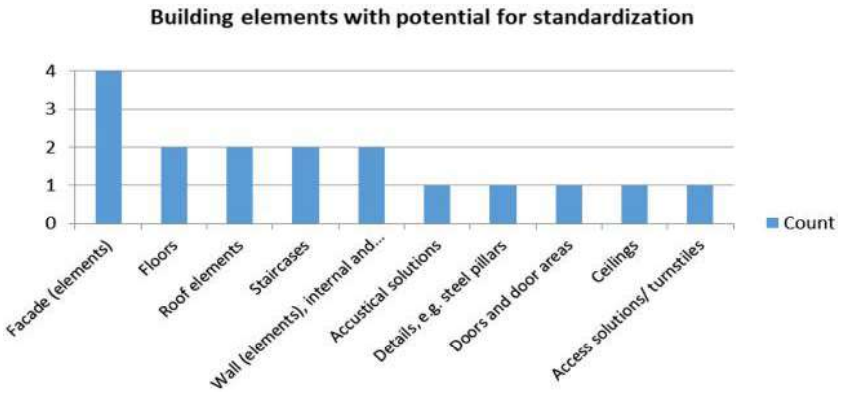

Figure 1.
Summary of Results: Building Elements with Potential for Standardization

Most of the groups also suggested room types to be standardized. Figure 2 shows room types mentioned by more than one group. In addition, one group each mentioned treatment rooms, parking lots, special rooms (of repetitive type), dog stables (e.g. at police stations), traffic control halls, weight control functions, emergency control rooms, court rooms, dormitories, shooting ranges, bicycle parking and vestibules.

The results show that the project managers see potential for standardization and modular construction for a broad specter of special purpose buildings. They even mentioned highly individual building types, such as museums, which on first sight do not seem to be suitable for standardization. Suggestions include a high degree of standardization of more common building elements.

Statsbygg has completed two standardized prison projects by now, with shortened project time, achieving cost savings of around 20 per cent through standardization and industrial building, compared to the last prison project completed before standardization. Considering that Statsbygg manages buildings with an area of 2.9 million m^2 worth 22 billion NOK and has 120 ongoing construction projects, with a total expected investment volume of 7 billion NOK for 2018, even a more tentative saving of 10 per cent through standardization on a portfolio level would mean reduction of 700 million NOK per year.

Suggestions for standardization of buildings, building elements and room types show that project managers see potential for standardization of special purpose buildings, although with limitations (cf. Chapter 4.2). This is in accordance with the literature, and going beyond it by suggesting that even construction projects without many repetitive units can be standardized to a certain degree. The results from the workshop are used internally to prioritize building types where a process toward further standardization will be initiated.

4.2. Additional results from the group sessions

As an additional result from the group sessions, participants state several challenges with standardization:

A. *Architectural challenges*: Standardization should not limit the possibilities of the architect to develop a unique architecture of every building. Standardizing functions

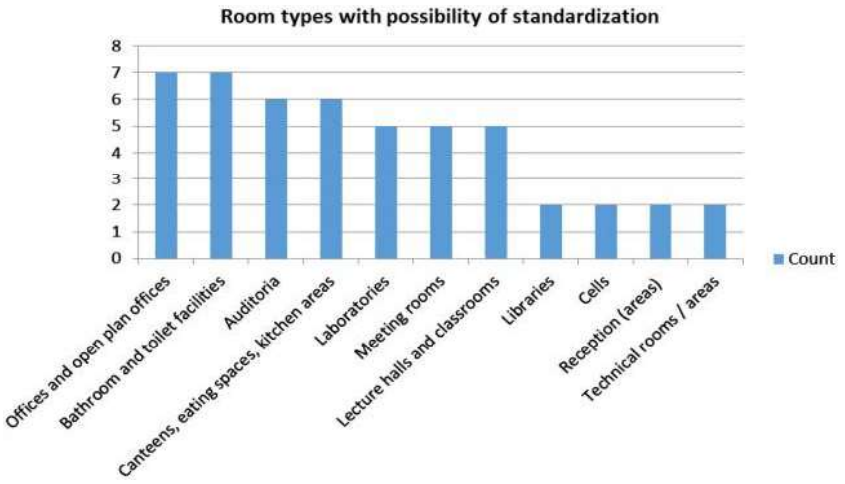

Figure 2.
Summary of Results: Room Types With Potential for Standardization (Room Types Mentioned by One Group Not Included)

or parts of the building should not compromise the architectural expression of each building.

B. *Acceptance challenges*: Users of special-purpose buildings tend to consider their building as unique. Thus, a challenge is to make them accept that less unique parts can be standardized or built with modules. A good and accepted standard is developed in collaboration with the client and the user of the building.

C. *Challenges toward the extent of the standard*: Complete standardization can be difficult, but it might be broken down into appropriate levels. A standard has to take into account adaptation to real estate differences, which are setting prerequisites for the geometry of the building on site.

Other suggestions included standardization across sectors, the standardization of user equipment to allow for standardized interfaces, the establishment of a standard with built-in flexibility, and further standardization of processes. Group members also mentioned the reduction of variation within a building (e.g. concerning wall thickness), the collection of a "drop-down menu" for standard room types or the adaption of room sizes to standard module size.

5. Conclusion and suggestions for further research

The findings from the group sessions indicate that further standardization of special purpose buildings is possible. On the basis of the present research, building types with the highest potential for standardization are customs facilities, courthouses, university buildings and buildings with a high share of office functions. Standardization even of buildings with a highly individualized character is possible when it comes to certain rooms and to constructional elements. Standardized solutions for building elements can be developed for the whole portfolio. Standardizing common features of the buildings allows focusing on unique elements for the present special purpose building. In this manner, standardization can contribute to faster project delivery and to more cost-efficient construction projects without compromising on the architectural expression and the individuality of special purpose buildings. Both literature and experience from projects suggests that standardization contributes to cost-effective construction projects, but it remains to quantify more exactly the potential for cost savings through standardization.

The present study provides a starting point. Results are on a brainstorming level, though from qualified and experienced participants. Further research might look at other building commissioners working with special purpose buildings, or focus on the extent, practicability and cost reduction potential of standardization, which is possible for the different types of buildings, and on approaches for implementation of a higher degree of standardization in the construction of special purpose buildings.

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PUBLICATION 3

Stakeholder influence on public construction project costs

Teresa Beste

Ole Jonny Klakegg

Abstract

The purpose of this paper is to help readers better understand stakeholders' influence on the costs associated with public construction projects. A two-fold systematic literature review and a case study investigating 21 projects undertaken in a public sector organization show a complex stakeholder structure. Stakeholders often have both positive and negative impacts on a project's overall costs, the most notable of which being the buildings' users. However, these users are not mentioned as being prominent stakeholders in the literature, while empirical evidence shows several instances where these same users have influenced project costs to a significant degree. The paper contributes to project management literature by presenting substantial empirical evidence that shows how stakeholders influence the cost of public construction projects. Practitioners and policymakers alike may include the insights from this study when adapting their project governance models to reflect a more conscious management style of stakeholder influence on project costs.

Keywords

stakeholders, public construction projects, project costs

PUBLICATION 4

Original Manuscript

The Journal of Applied Behavioral Science
1–26

DOI: 10.1177/00218863211033096
journals.sagepub.com/home/jab


Knowledge Transfer in a Project-Based Organization Through Microlearning on Cost-Efficiency

Teresa Beste[1]

Abstract

This paper investigates the role of microlearning on cost-efficiency on knowledge transfer in a project-based organization. As part of an action research study in a Norwegian public sector organization working with construction projects, a microlearning series was initiated to increase knowledge transfer on cost-efficiency. Seven microlearning lessons were distributed to 334 employees, including short questionnaires after the first and last lesson. The study reflects on the design process of the lessons, on the participation rate, and on how it contributes to an increase of knowledge. Microlearning was perceived as relevant by the participants. It makes knowledge transfer less arbitrary by providing a common body of knowledge to all project teams. For the organizational practice, this implies that microlearning also has potential for knowledge sharing on other topics in the project-based organization. Updating the microlearning series with further examples and new lessons is expected to contribute to continuous learning on cost-efficiency.

Keywords

Knowledge transfer/replication, knowledge management, organizational change, organizational learning, action research, intervention, learning, teams

Introduction

The high price tag and cost overruns of public construction projects are commonly known, and cost increases both in the planning stages and during construction are

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widely discussed in the media. An example for this is a construction project carried out by the Norwegian Parliament in which costs more than doubled from 1.1 to 2.3 billion Norwegian Crowns (NOK) during the construction phase (Schinstad, 2018). The list of cost increases in public projects is long: the new Berlin-Brandenburg airport, the Elbphilharmonie in Germany, or older projects like the Channel Tunnel or the Sydney Opera House. In the end, the taxpayers must pay the bill. This confronts public construction projects with the challenge to avoid unnecessary high costs. However, international studies found that cost increases in large construction projects have been constantly high during the last 70 years (Flyvbjerg, 2014). This indicates a need for and high potential to optimize knowledge transfer from previous projects to future projects in order to achieve higher cost-efficiency.

Cost-efficiency in construction projects means doing things right, producing an output (e.g. a building) in a competent way and with optimized use of resources (Zidane & Olsson, 2017). The term 'cost-efficiency' will in this paper be used to cover all aspects of reducing costs, thus also including cost-effectiveness (achieving the desired outcome with minimal costs, the degree of success or usefulness) (see Zidane and Olsson, 2017, for an extensive discussion of this topic).

This leaves us with the question how to achieve increased knowledge transfer between projects to avoid a reproduction of the same errors leading to cost overruns. It is important to consider the characteristics of a project-based organization in this context. According to PMBOK®, project-based organizations refer to organizational forms using temporary systems (here called projects) for carrying out their work. In a project-based organization, a lack of communication between projects can limit learning to the individual or to each project team. Although each project is unique, there are often project experiences, which are also valuable for other projects. Even if lessons learned from a project are relevant for other projects, a lack of routines and time constraints in the dynamic and hectic project workday hinder good knowledge transfer between projects. Consequently, it is hard to achieve synergies between projects, to transfer best practice examples to future projects and to assure learning from other projects' failures.

Knowledge transfer between projects can happen in a formal and structured way initiated centrally in the organization, or in an informal way. Training courses, the rotation of resources between project teams or databases to register project experiences are examples of formal tools enabling the transformation of individual knowledge to organizational knowledge. However, the success of a database is dependent on both timely and complete registration, and on project teams taking an active role in retrieving and using the provided information. Conversations with members from other project teams are an example of informal knowledge transfer between project teams.

Formal tools and training require the allocation of time to learning and thus leave the organization with the challenge to dedicate resources towards it. Therefore, it can be beneficial to explore new ways of knowledge transfer, using modern technology to reduce the time investment. The tool of microlearning, short digital action-oriented learning units, has emerged in recent years, both in the corporate and educational sector. Scientific articles on the use and effect of microlearning in an organizational context are still scarce. Microlearning is a tool for quick and effective learning, but

the shortness of microlearning lessons and the short duration limit its use for deep learning. Experience from businesses show that microlearning works well to get an introduction into a topic, and that design and content of the microlearning must be relevant for the project resources. Relevant content can include topics from similar projects, communicated in a way that other project teams can identify with. The idea is to provide a common knowledge foundation on cost-efficiency for the project teams. It is expected that the teams integrate elements from the microlearning into their own projects, either consciously or unconsciously.

The study is executed at a Norwegian public sector company, the government's key advisor in construction and property affairs, building commissioner, property manager, and property developer. The focus is on the company's activities as a building commissioner working with public construction projects. Although the organization is committed to cost-efficiency, knowledge transfer from one project to the other does not happen automatically, especially due to a lack of time during a busy workday and partly due to a lack of tools for sharing information. In the research context of a 2-year-long strategic project to increase cost-efficiency in the organization's construction projects, the researcher developed a series of microlearning on cost-efficient construction projects. In seven lessons, different aspects of the topic were presented to the employees, with a practical approach based on examples from the organization's own projects.

This paper is exploring how a project-based organization can tackle the problem of knowledge transfer on the topic of cost-efficiency. The author specifically investigates to what degree a microlearning series on cost-efficiency in construction projects can contribute to foster learning and eventually increase cost-efficiency in future projects. The following research questions (RQs) are addressed in this article:

RQ 1: What was the reception and perceived relevance of this microlearning series on cost-efficient construction projects?

RQ 2: How can a microlearning series serve as an enabler for continuous learning between projects?

RQ 3: To what degree can a microlearning series fulfill the needs of a project-based organization?

After an overview of the theoretical background of knowledge transfer and microlearning, as well as an account of the methodology used in this study, the results will be presented and discussed. Limitations and suggestions for further research and answers to the RQs conclude the paper.

Theoretical Background

Learning and Knowledge Transfer in a Project-Based Organization

The importance of organizational learning has been emphasized for several decades, especially after Senge (1990) coined the term of the "learning organization."

"A learning organization is a place where employees excel at creating, acquiring, and transferring knowledge." (Garvin et al., 2008: 110). This is achieved by the building blocks of a supportive learning environment, concrete learning processes, and leadership reinforcing learning (Garvin et al., 2008). Knowledge management comprises all the activities within an organization of how knowledge is handled. Ayas and Zeniuk (2001) point out the importance of an organizational culture conducive to learning especially in a project-based workplace. To work successfully in their projects, project managers need a supportive learning environment, allowing reflective practice and the possibility to question organizational processes (Ayas & Zeniuk, 2001; Garvin et al., 2008). At the same time, teams need common practices to experience a sense of belonging to the organization, especially if project teams are separated, both physically and through their work tasks.

Project teams need the "ability to create a network that will allow other teams to take action as well" to be able to engage in knowledge transfer transmitting both tacit and explicit knowledge to others (Fitzgerald, 2003). For projects, tacit knowledge can be described as the individual's competence arising from previous experience. Explicit knowledge is documented and formalized in documents, instructions, or reports, and thus made available for potential users (Liebowitz, 2001). In a project organization, networks are created within the project teams as well as on an organizational level. The individual team's local cultures of learning can differ to a high degree (Garvin et al., 2008). Rejecting the former idea of learning as sheer knowledge consumption, a learning organization rather should apply a more dynamic concept of "situated curriculum" as a characteristic of a specific community of practice (Gherardi et al., 1998). This means shifting focus from an overemphasis on teaching to the learner's perspective of effective learning (Dowson, 2016). To turn learning into action and to deliver real-world benefits, learning which is adapted to and relevant for the organization is crucial (Dowson, 2016). When learning also entails a habitual change, people and the organization develop simultaneously (Dowson, 2016).

Another challenge is the "stickiness" of knowledge, especially of socially embedded tacit knowledge. Stickiness is used as a metaphor for difficulties encountered in transferring knowledge and describes how much effort is needed to transfer knowledge (Von Hippel, 1994). There is a tendency that problems are only solved where the needed knowledge is available (Von Hippel, 1994). Translated to a project-based organization, relevant knowledge to solve a problem can be "sticky" to one project team and is not necessarily available for another project team to solve a similar problem. This is in line with the findings by Wiewiora et al. (2009) that there tends to be little direct communication of documented lessons learned between separate project teams in a construction company. However, in the public sector, people tend to remain in their positions and thus enable frequent interaction and knowledge exchange between team members from different projects (Wiewiora et al., 2009). Nevertheless, people might hold back information about their faults if there is a company culture where "bad news" is not welcome (Wiewiora et al., 2009). Findings of an analysis of internal stickiness of knowledge transfer "suggest that knowledge-related barriers —recipient's lack of absorptive capacity, causal ambiguity, and the arduousness of

the relationship between source and recipient—are most important impediments to knowledge transfer within the firm" (Szulanski, 1996: 37).

Although a project-based organization is conducive to individual learning as a lot of knowledge is created in projects, organizational "[l]earning is not a natural outcome of projects" (Ayas & Zeniuk, 2001: 64). Organizational learning is hindered by the projects' temporality and the exchange of key personnel (Jafari et al., 2011), as well as a lack of incentives and the absence of effective user-friendly systems for knowledge sharing (Ajmal et al., 2010). To achieve a state of reflective practice, knowledge created in one project must be diffused to others and lessons learned must be shared across projects (Ayas & Zeniuk, 2001). In that way, "projects may serve as practice fields for developing learning capabilities and cultivating effective habits of reflective practice that cross the boundaries of the specific project or project team" (Ayas & Zeniuk, 2001: 62).

In this context, it is necessary to mention that learning and knowledge transfer goes beyond the exchange of information. Whereas information can be described as patterned data, knowledge is the capability to act and "includes the set of facts and rules of thumb that experts have acquired over many years of experience" (Liebowitz, 2001: 1). The transfer of knowledge is more relevant and more challenging than transferring mere information.

Knowledge management is about creating added value from the organization's intangible assets (Liebowitz, 2001). In order to achieve this, knowledge management models aim at creating value-adding organizational processes leading to improved organizational operation (Jafari et al., 2011). The Fraunhofer IPK knowledge management model as described by Jafari et al. (2011) consists of the four elements of (1) creation, (2) storage, (3) distribution, and (4) usage. Likewise, Ordanini et al. (2008) describe the first three of the steps with (1) creation of new knowledge, (2) retention of embedded knowledge, and (3) transfer of shared knowledge, but they do not describe the fourth step of usage.

In a project-based organization, new knowledge is created through experiences in one project, and stored either as individual experience in the minds of the project resources, or in a formal database. Knowledge is then transferred to other projects and used by them. However, time constraints and unwillingness to share lessons learned inhibits effective sharing of knowledge in a project-based organization (Wiewiora et al., 2009). This is partly due to people hoarding information about their faults, or because they are reluctant to pass on their expertise wanting to keep control of the knowledge they possess (Wiewiora et al., 2009). To overcome time constraints and increase knowledge sharing, alternative and less time-consuming ways than traditional methods to share knowledge effectively among projects can be considered. Microlearning can be one of those options.

Microlearning

Microlearning is an emerging form of learning, especially in the corporate environment, which is more than just digital learning of short duration, but an action-oriented

learning with immediate relevance (Kapp & Defelice, 2018; Tipton, 2017). Maddox (2018) defines microlearning as "[a]n approach to learning that conveys information about a single, specific idea in a compact and focused manner" and as "[a] learning technique that operates within the learner's working memory capacity and attention span, providing just enough information to achieve a specific, actionable goal."

Through its multimedia approach and availability on multiple devices, microlearning is designed to appeal to all types of learners, giving them the possibility to decide what, when, where, and how much they want to learn (Gautham AS, 2018). Microlearning can either be an independent learning opportunity or integrated in a larger formal training program (Kapp & Defelice, 2018). It is also well suited to reach decentralized workforces (Paul, 2016). Dolasinski and Reynolds (2020) stress the advantages of microlearning over more traditional forms of learning: It is quick and effective, less time consuming for the learner, flexible, self-directed, and adapted to the short attention span of today's impatient learners. Possibilities for multimedia content and interaction make it playful, interesting, and engaging for employees (Fox, 2016). It is designed to deliver information in a way adapted to how our brain works as the quick experience of learning avoids mental fatigue (Selko, 2019; Shail, 2019). Complex or comprehensive material can be broken down into manageable units with one or two objectives each, sorted either by subtopics or in ascending order of complexity or detail (Kapp & Defelice, 2018; Shail, 2019). An instructional design with one idea at the time avoids excessive cognitive load (Paul, 2016). The presentation of small learning units in spaced intervals assures adaptation to an individual's learning curve, also making it possible to learn in otherwise unproductive waiting moments (Cai et al., 2017). Microlearning is usually comparably inexpensive and easy to customize for the respective business (Scaglione, 2019). Changes and updates are easily implemented to assure that microlearning lessons are up to date at any time (Paul, 2016).

A disadvantage of microlearning is, however, that microlearning is not suitable for deep learning due to the limited amount of knowledge, which can be conveyed (Kapp & Defelice, 2018). Therefore, it works best in contextual settings already familiar to the learner or as a supplement to what employees already know (Paul, 2016). Microlearning can be delivered in several e-learning modules, each on a specific aspect of the same topic delivered in memorable portions (Gautham AS, 2018). Several microlearning modules can constitute an organization's microlearning library (Dolasinski & Reynolds, 2020). Kapp and Defelice (2018) point out a caveat for microlearning sessions: A simple downsizing of existing traditional courses can give problems with design, leading to lower learning effectiveness.

The term nanolearning is often used synonymously to microlearning. Some define nanolearning as even shorter than microlearning with typically 3–5 min instead of 5–15 min (Gautham AS, 2018). The goal to deliver on one learning goal or topic is often more specific for nanolearning due to its shorter duration (Gautham AS, 2018). In the present paper, the more general term microlearning is used, even if the organization used the term nanolearning when sending out the module.

To assess the effect of microlearning, Paul (2016) suggests monitoring the access rate to the microlearning and include quick follow-up questions after the microlearning

course. For microlearning with a very practical approach, it can also be assessed if the knowledge acquired in the microlearning is practiced afterwards.

The author could not find any literature on the use of microlearning specifically in a project-based organization. However, the hypothesis seems likely that microlearning can contribute to an increased knowledge transfer between projects as it is a less-time consuming way to convey knowledge and easy to use in an organization, where project teams are dispersed in different locations.

The Research Context of This Study

The present research on microlearning is conducted as one element of a larger action research project on improving cost-efficiency in public construction projects.

Arising from the need to achieve higher cost-efficiency, a Norwegian public sector organization working with public construction projects initiated a strategic project during the years 2018–2020. The organization works on ∼150 construction projects at any point of time, with a total annual investment volume of ∼7.5 billion NOK (≈716 million EUR) in 2019. The defined objective was reducing investment cost by 20% (until 2025) without increasing life cycle costs of the buildings or decreasing customer satisfaction. The aim of the initiative was also increased innovation, forming a more professional and value-creating and knowledge-sharing organization. Stand-alone actions in single projects, such as using new technologies, the use of different contractual approaches or a more effective use of area, had been used in the organization before. Even though these actions can contribute to delivering a valuable project at low cost, this might not be enough to reduce cost significantly and permanently. The challenge is to transfer relevant experience between projects to improve the cost performance of a project portfolio in the long term.

As part of a small team working on this project, the author engaged into the strategic project as an internal practitioner-researcher. The researcher was well immersed in the organization before she became an active participant in the strategic initiative and was thus aware of the organizational preconditions and constraints. Engaging into an internal project trying to solve a practical problem and aim at improvements combined with research on the project makes the overall research project an action research project.

Different activities have been performed during the strategic initiative. On the organizational level, targets for cost-efficiency were included into the key performance indicators, ensuring managerial focus. On the project level, engaging practitioners in the cocreation of measures for cost-efficiency was essential. In total, meetings with 75 project teams (mainly project managers and project controllers) were conducted. In the meetings, so-called "value cards" were established for each project with the purpose of maximizing the value generated by the project while minimizing project costs. On the cards, cost-reducing actions for the respective project were categorized along the topics of "analysis of needs/concept," "standardization," "new contractual models," "technology/digitalization," "engineering costs," "cost estimation and control," and "project organization." The cards were used in practice for reference, follow up, and information sharing among the projects. However, a need for broader

distribution of both information on cost-efficiency and on concrete measures taken in the projects arose from these "value meetings".

As one attempt to increase knowledge sharing on cost-efficiency, a microlearning unit with seven sequential lessons was created, executed, and evaluated. This microlearning unit is investigated in this study.

Methodology

Action research is an approach of applied research "designed to find the most effective way to bring about a desired social change or to solve a practical problem, usually in collaboration with those being researched." (SAGE, 2020). A parallel process of organizational change and research serves as "a means of both changing the system and generating critical knowledge about it" (Susman & Evered, 1978: 586). Action research is contextual in nature and as such deeply rooted in the reality of the organization. In this type of "situated inquiry," research is considered more as a process than as a product, might not be replicable under other circumstances, and thus does not aim at generalizability (Law, 2004). For the validity of the research, this implies "to make the best possible use of these tools [research methods] within the constraints of the workplace" (Somekh, 1995: 341). Action research of high validity helps practitioners to make better-informed decisions based on a deepened understanding of complex situations (Somekh, 1995). Reflectiveness of the process and awareness of choices can assure the quality of action research and its validity (Reason, 2006).

With this methodological background, the researcher developed a series of microlearning lessons on cost-efficiency as part of the larger action research project in a public sector company. The research presented in this paper focuses on the verification of how a microlearning series can contribute to knowledge sharing and is as such not explicitly an action research study, even if the microlearning series has the practical aim of improving the knowledge on cost-efficiency.

In each of the seven lessons, one aspect of the topic of cost-efficient construction projects (see Table 1) was presented to the employees, with examples from the organization's own projects. The lessons were distributed weekly to all employees in four departments of the organization, 334 employees in total. The participants work with construction projects in all project phases, with the administration of buildings, or as technical specialists supporting both construction projects and operations and maintenance of the buildings. The targeted group comprised people in all age groups, career stages, and seniority, with slightly more female than male employees. The vast majority has higher education in the form of a master's degree or similar. Their professions included mostly project managers, engineers, architects, project controllers, technicians, and administrative personnel. All employees were familiar with microlearning as they had been exposed to small microlearning units about other topics for about a year, but with a smaller scope (with one to three lessons). Each lesson took ~5 min to complete. Participation was voluntary but was encouraged by management. The central topics as well as the content of the lessons including examples from recent

Table 1. Participation Rates for the Microlearning Lessons (Junglemap Nanolearning, as of June 23, 2020).

Lesson/topic	Started	% Completed
1. Cost-efficiency—introduction	75%—250 people	97%
2. Cost-efficiency in early project phases	68%—227 people	98%
3. New contractual approaches	66%—220 people	98%
4. Standardization	62%—205 people	100%
5. Technology and digitalization	57%—190 people	99%
6. Cost estimation and cost control	51%—171 people	95%
7. Knowledge transfer and learning	47%—157 people	98%

construction projects were based on information obtained in meetings with project managers during the past year.

The participation rates vary from 75% (250 people) for lesson 1 to 47% (157 people) for lesson 7, with decreasing rates for each new lesson. After each end lesson, the last page of the lesson gave the participant an overview of which lessons of the course they had already completed. The idea was that the participants take the lessons in sequence, one lesson each week. However, it was not mandatory to complete all lessons in sequence, and the overview gave the participants an idea of their progress and made it possible to complete previous lessons at a later stage. Of those completing lesson 7, only three respondents had omitted previous lessons. Of those having started a lesson, almost all also completed it (with rates ranging from 95% to 100%). Table 1 gives an overview over the participation rates for each lesson.

At the end of the first and seventh lesson, the learners were asked to answer a short quest-back form. A total of 250 respondents answered three questions after the first lesson focusing on the prior knowledge of and attitude to cost-efficiency. A total of 157 respondents answered four questions after the seventh lesson focusing on the learners' perception of the microlearning series. In most of the questions, answers were required on a 5-point Likert scale, where the participants express the degree to which they agree to the statement. The question concerning the relevance of the microlearning series was a closed question with yes or no as alternative answers. After ended microlearning, the researcher analyzed participation rates for each lesson and the answers to the quest-back form questions and evaluated them with basic statistical methods. The significance of the differences was tested with a paired samples *t*-test to test if the knowledge on cost-efficiency and on the perception of organizational tools and systems changed significantly. The test was performed on all complete datasets, that is, in those cases, where participants had answered both the questions after first and seventh lesson ($n = 153$). Data from the quest-back form were used to answer RQ 1.

To assure a combination of practical relevance and reflectiveness, the answers to RQs 2 and 3 are based on the researcher's reflection in the design phase of the microlearning, as well as on feedback from participants and other involved colleagues. For each lesson, the

researcher collected both relevant information from literature and examples for cost-efficiency from meetings with project managers. These were then put together in short lessons and reflected on with colleagues with expert knowledge on the respective topic. An employee from the internal training department assisted with reflections on the design of the lessons, focusing on the presentation of content and language.

The researcher had the role of initiating the microlearning and creating the content of the lessons. Reflectiveness and quality control were increased by involving several people into the creation of the lessons. The researcher also engaged in a dialogue with the heads of department to encourage participation in the microlearning. As the researcher was an insider employed in the organization and an active team member in the larger organizational strategic project, this entailed previous knowledge of the organization and thus a certain degree of bias. However, in an action research context, this is rather considered an advantage as it allows to focus on the problem at hand and build on the researcher's closeness to the organizational setting while simultaneously take a researcher's distance to see things critically and make change possible (Coghlan, 2007). This also allowed for easier customization of the design and content of the microlearning to the needs of the organization. A high level of reflectiveness on both actions and analysis of the results aimed at reducing bias in the research process.

Results

The Design of the Microlearning and its Desired Effect

Design and Practical Aspects. In the process of developing the microlearning, practical aspects were of high importance to engage as many of the recipients as possible. The researcher worked closely together with resources responsible for internal training, considering the aspects of timing and length, design elements and accessibility, and commitment.

Timing and Length. The series of seven microlearning units was scheduled in the weeks between winter break and Easter, with one weekly lesson. No other microlearning campaign for the same target group was conducted at the same time. The links to new lessons were sent out each Tuesday at 7:30 am, as it was expected that it would be easiest to catch the attention of the recipients at the start of their workday. Lessons were kept short, with an estimated maximum execution time of 5 minutes. This also allows to use otherwise unproductive time spans, such as travelling to work by public transport, or short waiting periods, such as time until a meeting starts, to complete a lesson. Progress is logged to facilitate completion of a started lesson at a later point of time. In addition, after the first lessons, the Covid-19 lockdown put the majority of the participants into home office. Whereas all courses with presence in the classroom were cancelled, the digital online lessons could continue as planned.

Design Elements and Accessibility. Lessons were created with a maximum of seven pages, with each page focusing on one aspect of the topic. Poignant and clear language

as well as good illustrations or pictures were important. Some lessons also contained a short video-clip (30–60 seconds). Video and sound enhance the user experience, but it was made sure that they had subtitles to allow to completion of the lesson independent of sound or the availability of headphones. Easy accessibility was assured by providing the microlearning on a flexible platform without extra log-in, allowing access from both PC and mobile devices. Short lessons and intuitive layout also contributed to smartphone-friendliness. Distribution happened through automated mailing from the platform, including automated reminders if participants had not completed the lessons within a set number of days. The threshold to start a lesson was kept as low as possible as lessons can be accessed directly through the link from the invitation e-mail. When the participants had completed a lesson, a page displayed if there were any available lessons which they had not completed yet. This should make it easier for them to turn to and complete any outstanding lessons.

Commitment. Participation of the relevant departments was clarified with the departmental manager beforehand. Managers were asked to encourage their employees to participate in the microlearning. The start of the microlearning was also announced on the organization's intranet just before the launch of the first lesson.

Content. The microlearning series was part of a larger program to increase cost-efficiency of the construction projects. The guiding principle when developing the lessons was relevance of the presented cost-efficiency measures for most of the projects. This entails that the lessons had to cover topics of general interest. The choice of overall themes is based on the previous experience from construction projects as well as 1 year of meetings with ongoing construction projects, identifying measures for cost reduction.

To assure high quality of the content of each lesson, the researcher involved specialists in the elaboration of each topic. The aim was to write the lessons with a balance of a general introduction into the topic at hand, but with many concrete examples from the construction projects. To avoid lengthy lessons, the content was written as compact as possible and links to documents or websites were provided for those who wish to immerse themselves more into the topic.

Desired Effect. The desired effect of the microlearning campaign was two-fold: One aspect was the direct transfer of information and knowledge from previous projects to ongoing projects. Participants could enlarge their knowledge of areas where cost reduction is possible and get to know concrete examples, which worked in other projects. The other aspect, which goes beyond pure knowledge transfer, was to arise attention towards cost-efficiency in construction projects. Microlearning can help to enhance corporate messaging, making it obvious for the employees that this is an important topic for the top management. Scaglione (2019) summarizes the desired effect of microlearning: "Employees not only receive a quick burst of content that is relevant to their jobs, they're also reminded that you [i.e. the management of the organization] value" the addressed topic.

After the microlearning campaign, the lessons were also made accessible in the internal central learning platform. In that way, also employees who want repetition or who are new to the organization can use the lessons in the future. This also gives the possibility to update the lessons with new information or to add new lessons to emerging topics.

The Topics Covered in the Microlearning Lessons

The topics covered in the microlearning lessons (see Table 1) were chosen based initial internal studies on cost drivers in construction projects and on topics emerging in meetings, which were held with each ongoing construction project in the course of the previous year. In these meetings, participants discussed which measures for cost-efficiency the project had taken, which measures could be initiated, and which effect the chosen measures are expected to have on the costs of the project. The measures were then assembled and grouped according to topics to make it easier for other projects to learn from them. The following topics were found to be most popular, reflect the whole life span of the construction projects, and have the highest impact on cost: (1) cost-efficiency in the early project phases, (2) new contractual approaches, (3) standardization, (4) digitalization and technology, and (5) cost estimation and cost control. For each topic, the researcher picked best practice examples from the meetings with the projects and included them into the microlearning. These five topics formed the core of the microlearning as the central lessons. The first lessons served as an introductory lesson on cost-efficient construction projects in order to set the scene, and the last lesson on knowledge transfer and learning served to round up the topic and give a perspective into how the organization works now with transferring knowledge between projects and how this can be improved in the future.

The Reception and Relevance of Microlearning

Approximately half of the target group completed the seventh lesson, and a higher number completed the earlier lessons, with the highest participation rate (75%) for the first lesson (see Table 1). As the microlearning series was designed to give participants full anonymity, no conclusions on the demographics of those having participated versus the whole target group are possible. In order to assess the relevance and the learning effect of the microlearning campaign for the participants, small quest-back forms constituted the last page of the first and last lesson. Lessons were only registered as completed when all questions were answered. At the end of the first introductory lesson, three questions served to assess the level of knowledge and the attitude of the participants towards the topic of cost-efficient construction projects. After completion of the course (lesson 7), four questions were asked to evaluate how the course affected the participants and if it changed their attitude towards cost-efficient construction projects. Table 2 gives an overview of questions and distribution of answers both after the first and seventh lesson.

Table 2. Questions and Answers After the First and Seventh Microlearning Lesson.

	Likert scale						
Questions after lesson 1	1	2	3	4	5	n/a	Average
How do you assess your level of knowledge about cost-efficiency before the course? *(1 = no knowledge, 5 = very good knowledge)*	11	42	91	74	21	—	3.2
To which degree do you think the organization has sufficient systems and tools to deliver more cost-efficient projects? *(1 = very low degree, 5 = very high degree)*	10	46	117	59	7	—	3.0
To which degree do you contribute to cost-efficiency in your own projects? *(1 = very low degree, 5 = very high degree, "n/a" = no possibility to contribute)*	2	11	76	84	27	39	3.6
Questions after lesson 7							
The course in cost-efficient construction projects was relevant for me. *(1 = yes, 2 = no)*	134	13	—	—	—	—	91% yes
How do you assess your level of knowledge about cost-efficiency after the course? *(1 = no knowledge, 5 = very good knowledge)*	0	11	61	64	12	—	3.5
To which degree do you think the organization has sufficient systems and tools to deliver more cost-efficient projects? *(1 = very low degree, 5 = very high degree)*	0	26	66	51	4	—	3.2
To which degree can you use the content of this microlearning course in the projects you are working with? *(1 = very low degree, 5 = very high degree, "n/a" = no possibility to contribute)*	9	21	55	44	8	11	3.2

The scores on the 5-point Likert scale give an indication of how the respondents assess their own knowledge of and attitude towards cost-efficiency in construction projects. The scores of all questions illustrate that the respondents on average assume to have "medium" knowledge of cost-efficiency before the course, and that they are passably content with the organization's tools and systems to deliver more cost-efficient projects. The average score of 3.6 for people's own contribution to cost-efficiency indicates that most of the participants contribute to deliver cost-efficient projects to a medium to high degree. For the first two questions, the mode of the answers is 3, which corresponds to the mean (or average) score of 3.2 and 3.0, respectively. The third question has a higher mode of 4. When asked about the degree of their contribution to cost-efficiency in their projects, a larger number of participants evaluate their contribution as quite high as those evaluating their contribution as quite low. Nevertheless, 39 people answer that this is not applicable for them, i.e. that they have no possibility to contribute to cost-efficiency.

At the end of the course, 91% of the learners evaluated the microlearning-course as relevant for them. This is a high share given that the learning module was sent out to everybody in the chosen departments. It indicates that the lessons have covered relevant topics and communicated them in a way, which was perceived as relevant for the respondents. Although the assumption seems likely that a higher share of that those answering that they have no possibility to influence cost-efficiency in their construction projects have not completed the whole course, this is not the case: A 66.7% share of this group completed all lessons, which is not significantly different from the 66.5% completion rate for the group assigning themselves a certain degree of influence on cost-efficiency. However, a higher share of respondents from the "no possibility to influence" group evaluated the microlearning course as not useful for them (19.2% compared to 8.5%).

For the next two questions, the average result is slightly higher than at the start of the microlearning: The average level of knowledge about cost-efficiency was assessed to be at 3.5 of 5, which is on average 0.3 points higher than before the microlearning, and the mode has moved from 3 to 4 for this question. Considering only the participants having answered this question both after the first and last lesson ($n = 153$), the mean changed from 3.25 to 3.56. The paired samples means difference tests show that the change in perception of the knowledge level is significant at a 0.05 significance level, meaning that there is a significant increase in knowledge for those having completed the microlearning series. Concerning the degree to which they think that the organization has sufficient tools for cost-efficiency, the average value has slightly increased with 0.2 points from 3.0 to 3.2. For those having answered this question in both the first and last lesson ($n = 152$), the change was from 2.97 to 3.23. The paired samples means difference tests show that this difference is significant at a 0.05 significance level, meaning that the participants have a more positive perception of the organizational tools for cost-efficiency after having completed the microlearning. The last question concerned the degree to which the participants can use the content of the microlearning in the projects they are working with. This gave an average result of 3.2 of 5 points, or a medium degree to which people think that they can implement the newly acquired knowledge in their projects.

Discussion

Based on the theoretical background, knowledge transfer between projects within the organization is crucial. This can happen as a consequence of direct contact between the source and the recipient of information. However, individual knowledge transfer is an arbitrary process. Direct transfer will not always be possible, especially in large organizations with many separate project teams. The knowledge base of individual knowledge of a project-based organization is almost unlimited, but people's own initiative to share and demand knowledge will determine the amount of knowledge shared. An intermediary can help to systematize knowledge transfer and assure that knowledge transfer is not limited to those projects with strong relations and a good network.

A centrally initiated microlearning on relevant topics seems to be able to serve as an intermediary. The disadvantage is the limitation of information, which is conveyed. However, if effort is put into selecting the most relevant topics and examples, microlearning can contribute to a less arbitrary process of knowledge sharing, as everybody has the chance to receive the same information in a structured way. The reception of the microlearning shows that the majority of the recipients have accepted the offer to participate in at least some of the microlearning lessons. Of those who completed the last lesson, the overweighing majority evaluates the microlearning as relevant for them. The initiative targeted complete departments and was thus not aimed at a very specific target group. Therefore, a variance in relevance of the microlearning series can be expected. This is also reflected by the spread of the answers: While cost-efficiency might presumably be highly relevant for both project managers and project controllers, it might be less relevant for specialist project staff contributing to projects with their specific (technical) expertise. However, as mentioned before, the anonymity of the microlearning does not allow for such conclusions.

Connecting this study on microlearning to the literature on knowledge sharing in a project-based organization, this particular study can be seen as one tool in a learning organization (Senge, 1990), comprising all the building blocks of a supportive learning environment, concrete learning processes, and leadership reinforcing learning (Garvin et al., 2008). Especially in a project-based organization, building networks that allow other teams to repeat actions from one team is very important (Fitzgerald, 2003). The microlearning lessons can contribute to building bridges between the project teams. Learning from examples from previous projects through the microlearning lessons can make it more natural for other project teams to share knowledge, also tacit, openly with others also in other fora. This can reduce the stickiness of knowledge (Von Hippel, 1994; Szulanski, 1996). In that way, individual knowledge from the projects can be transformed to organizational learning as a natural outcome of projects, despite (or maybe because) the temporality of projects (Ayas & Zeniuk, 2001). For the topic of cost-efficiency, a higher degree of learning from other projects even has the practical implication of potential economic savings for the public. As the examples are taken from the context of the organization, it makes it possible to turn learning into action directly (Dowson, 2016) by applying acquired knowledge to the new projects. However, microlearning should rather complement than replace direct communication of lessons learned between project teams (Wiewiora et al., 2009).

Looking back at the literature of knowledge management, Ordanini et al. (2008) identifies three central elements of knowledge management: knowledge creation (new knowledge), retention (embedded knowledge), and transfer (shared knowledge). Jafari et al. (2011) summarize the knowledge management steps as creation, storage, distribution, and usage of knowledge. Figure 1 integrates those elements into a framework together with some of the key outcomes from the presented study and shows the difference between managing tacit versus explicit knowledge. In addition to the elements named by Jafari et al. (2011) and Ordanini et al. (2008), the researcher also integrated the extra step of "acquired knowledge" between "sharing" and "using" knowledge, to stress the fact, that sharing knowledge does not automatically entail

an acquisition of knowledge by the recipient and that knowledge can be acquired by the recipient without being used at once. In that way, the framework visualizes how microlearning can contribute to formalize the retention, distribution, and acquisition of knowledge. This framework can also help to understand how much knowledge is transferred or lost in the different stages, in order to avoid stickiness in the knowledge transfer process (Szulanski, 1996).

If we assume that a certain amount of knowledge is created and remembered by those who have experienced it, this will be available stored in the individual minds. When registering this new knowledge formally, you will have to concentrate on the most important topics and some knowledge will be lost. The same is true for

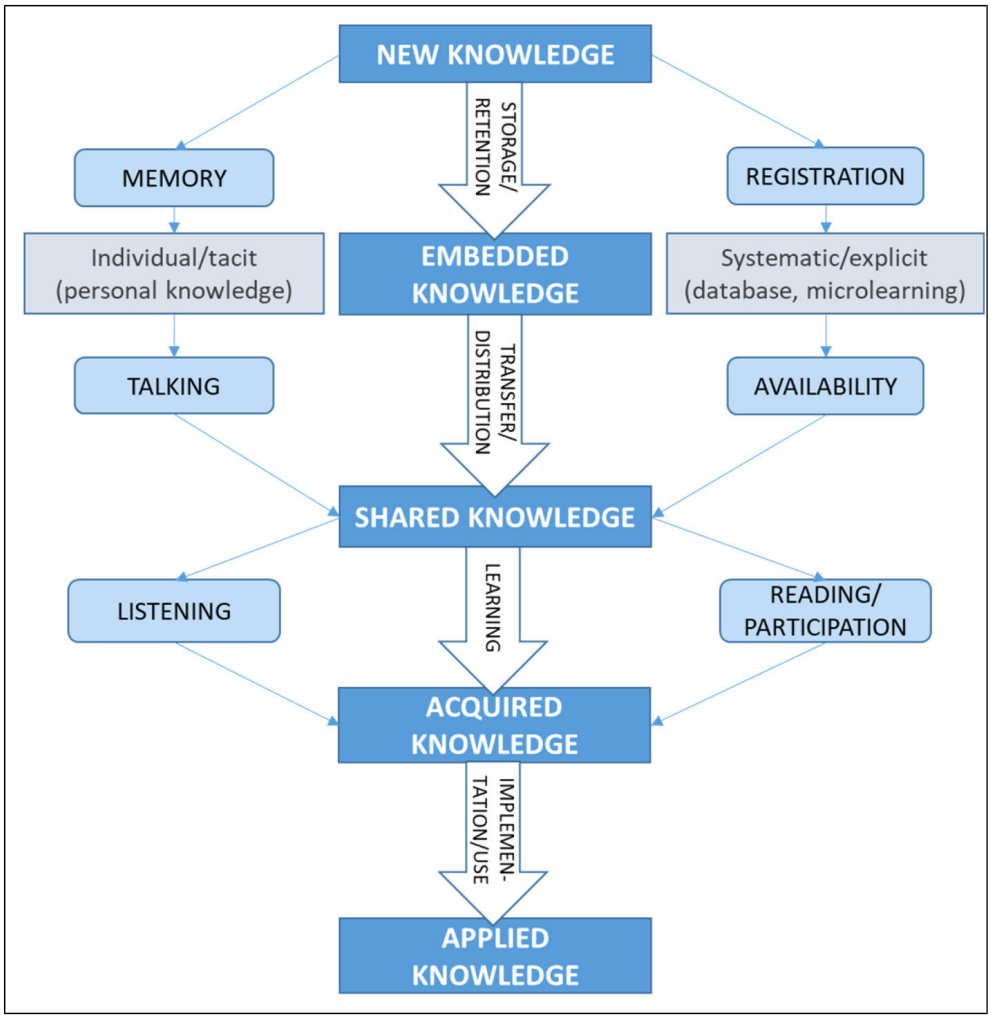

Figure 1. Adapted knowledge management model (based on Ordanini *et al.*'s (2008) knowledge management key outcomes and Jafari *et al.*'s (2011) knowledge management steps).

microlearning, as you can only include the most important information into the lessons. The important difference happens in the distribution step: While individually stored information is only conveyed in an arbitrary way to other individuals and thus will have limited effect for the application in future projects, the condensed information conveyed through microlearning will reach a much higher number of people. In the form of databases or microlearning, the knowledge will also be available for others on a more permanent basis than tacit knowledge. In the present study, almost 50% of the recipients have completed lesson 7. This means that the limited amount of new knowledge is made accessible to a much larger share of the organization and that there is a higher chance that the new knowledge will be applied in other projects in the future. This assumption is supported by the fact that most of the participants assume that they can use the learning outcome in their projects (medium score of 3.2 of 5).

Literature on microlearning suggests creating short and compact lessons each covering one topic at a time (Kapp & Defelice, 2018; Shail, 2019). The content should be relevant and practical, enforcing a topic which the recipients were already familiar with to a certain degree (Paul, 2016). The results from the microlearning support a certain degree of familiarity with the topic of cost-efficient construction projects, confirmed by an average score of 3.2 out of 5 how participants assess their own level of knowledge on the topic, and an average score of 3.6 out of 5 for the self-assessment by the participants on their personal contribution to cost-efficient construction projects. The integration of links to further reading integrated into the microlearning lessons attempts to counter the disadvantage that the tool itself is not adapt for providing deeper learning (Kapp & Defelice, 2018). In addition, the participants are encouraged to contact the relevant project teams to engage into a dialogue about actions in the projects presented shortly in the microlearning. This should provide an opportunity to increase the take-away from the microlearning lessons for those interested to gain more specific knowledge on some aspects touched upon by the microlearning lessons. For future microlearning, one option would also be to provide optional lessons on more specific topics to increase deeper learning. According to Tipton (2017), microlearning is a just-in-time learning with immediate relevance for the learner, which is confirmed by the study result that more than 90% of those having completed the whole course agree on the its relevance. In addition, the average score of 3.2 for the question if the participants can use the content of the course in their own projects is a good score predicating the relevance of the course, given the quite broad target group of the course.

According to Paul (2016), the effect of microlearning can be assessed by the fact how often the material is accessed and by including quick follow-up questions. In the present study, approximately half of all the recipients have accessed the complete microlearning, and 75% have participated in at least one lesson.

The participation rate is acceptable, but as the aim is to educate all the participants on the topic, a participation rate closer to 100% would be desirable. For further microlearning series, several actions for increasing the participation rate could be taken. Small time slots in mandatory departmental or team meetings could be provided, giving the employees time to complete the lessons. Although this might lead to high

participation rates, it however contradicts the idea of microlearning to fill otherwise unproductive time spans, and that everybody can proceed in the lessons at their own speed. Furthermore, the microlearning series could be distributed as a mandatory course for the target group through the internal learning platform. In that way, the employees are reminded of the course, and managers will be informed if the course is not completed by the allocated deadline. Another possibility is to remind employees of the microlearning lessons in other ways than by e-mail, e.g. in person, in team meetings or by pop-up notices. And lastly, the content of the lessons could be a topic in team meetings to give those employees an advantage who have completed the course—and thus provide an incentive to complete the lessons to be able to participate in the discussion.

These possible actions have been shared with the organization and will be taken into consideration when the microlearning is updated and launched again. Integration into the internal learning platform has already taken place, making the lessons accessible for everybody at any time.

The short follow-up questions integrated into the first and last lesson showed a slight self-perceived learning effect on the topic of cost-efficient construction projects through the microlearning, as the score increased from 3.2 to 3.6 (of 5), which is a statistically significant increase suggesting a learning effect through the microlearning series, although other potential reasons for the increase cannot be eliminated at this point. Other explanations might be different personal scales on assessing the level of knowledge (as the assessments were some weeks apart) or the effect of other campaigns on the same topic in the organization. A certain degree of the mood at the specific day cannot be eliminated, but there were no other central initiatives on the topic aimed at the same target group, apart from initiatives aimed at specific projects, so this factor is unlikely to influence. The slight increase of 0.2 points in the score of the participants' self-assessment of the systems and tools the organization has for cost-efficient construction projects indicates that the microlearning has educated some, but not many, participants on systems and tools they were not aware of before. In addition, the researcher has heard of participants using examples from the microlearning series in other fora, for example in workshops and presentations, which also points towards the relevance of the course.

When taking a closer look at the data, especially the connection between completion of lessons and answers to the questions, it is interesting that the assumption of not being able to influence cost-efficiency does not have a correlation with the total completion rate of the lessons. Assumably, the majority of participants either are interested in the topic nevertheless or feel an obligation to participate. The larger share of those with no perceived possibility to influence evaluating the course as not useful (19.2% compared to 8.5% of the total) points towards a correlation between those two aspects. However, in the reverse conclusion, this also means that over 80% evaluate the course as useful for them, even if they perceived they have no possibility to influence cost-efficiency in their projects. This signals that the course has influenced their perception of cost-efficiency.

There are some interesting aspects in the details of the questionnaire data: 19 respondents assess their level of knowledge as lower after the course than before.

Five of them assessed the course as not relevant, but it is however unlikely that the course itself should have led to a knowledge loss. A possible explanation would be that those people were in a different disposition/mood in the two instances and thus applied the scale in a different way. This might however also be true for all participants and includes an error source in all subjective questionnaire questions. Another reason would be that they realized during the course that their first answer was overoptimistic and that the topic is wider than they originally were aware of. The same explanations could be true for the 26 participants giving the tools and systems a lower score after the course than before. They might either be influenced by a different disposition or get the impression during the course that the organization handles cost-efficiency in construction projects not as efficiently than they thought.

Having a closer look at the change in knowledge level, it can be observed that those with a comparably low score (below 3) after the first lesson experience a higher knowledge increase than the average for the total of the participants (+ 1.32 points compared to + 0.3 points). When comparing to the group with a high score of 4 or 5 after the first lesson, those report a lower average level of knowledge after the last lesson (−0.3 points). This indicates that the microlearning course is best fit for those with a comparably low knowledge level on a topic. Thus, it cannot be the only form of learning in an organization but needs the combination with other methods of knowledge transfer. Microlearning can only give a condensed version of each topic and is thus a good method to trigger ideas for one's own project. Based on that, microlearning can be followed by a more informal learning approach talking to people from the respective project team to get a deeper insight into the matter at hand. In a more formal approach, the organization can provide internal training courses on specific topics, which can be used to get more background knowledge on the relevant topics.

Another interesting aspect is in how far microlearning can constitute a tool for continuous knowledge transfer between projects. The present study analyzes the microlearning series as a "one-off" event, giving only an instant view on the status at a specific point of time. However, when using microlearning in a strategic way, it can continuously contribute to challenging and updating best practice and to encouraging innovation. In the following, some suggestions are given how microlearning could contribute to continuous knowledge transfer.

By creating a feedback-loop as illustrated in Figure 2, it is possible to keep the microlearning up-to-date and relevant for the projects. In the present action research project, there are other actions to achieve higher cost-efficiency in construction projects. Some of the participants, especially the project leaders among them, had been part of the so-called "value meetings" for their respective project. These meetings serve as an arena to discuss and document measures for cost-efficiency for the concrete project. Some of the examples for the microlearning were taken from these meetings and it is expected that future meetings can generate new examples. In that way, the existing microlearning series can serve as the basis for further development of sharing knowledge on cost-efficiency. In regular intervals, for example once a year, new good examples of cost-efficiency measures are continuously included into the existing lessons, and new lessons can be created as new topics emerge. This might

also contribute to a positive effect on the projects, as they might be eager to have their examples included into the microlearning lessons distributed widely in the organization. However, this feedback-loop requires resources for conducting further meetings, choosing suitable new examples, updating the microlearning lessons and creating new modules, for keeping the microlearning available for the recipients and encouraging them to participate.

This study investigates a microlearning series in a project-based organization, as part of an action research project. Until now, microlearning has mostly been explored in managerial literature, but not so much from an academic perspective. The researcher has not found any previous studies analyzing the effect of microlearning through small questionnaires integrated into the microlearning lessons or investigating the relevance of microlearning. Therefore, this study constitutes an important contribution to the academic research of microlearning tools and can be a good start to investigate the learning tool of microlearning further. In addition, this study gives reflections on using microlearning as a continuous learning tool for a topic, not only a one-off event.

As this study is part of an action research project within one organization, there is not claim for generalizability of this research. Nevertheless, the microlearning concept could supposedly also be used in other project-based organizations in the same way. However, the research has also shown the importance of context for assuring high relevance of the microlearning series. This entails that the microlearning has to connect to issues familiar to the participants and take details and examples in the lessons from the organization itself.

The novelty aspect of the presented study also lies in the fact that it is conducted as one element of an action research project. In action research, solving a practical problem is in the foreground. This means that a microlearning series should foremost be designed and perceived as a real learning experience, not a mere data collection in a research project. The microlearning itself constitutes one element of the organizational

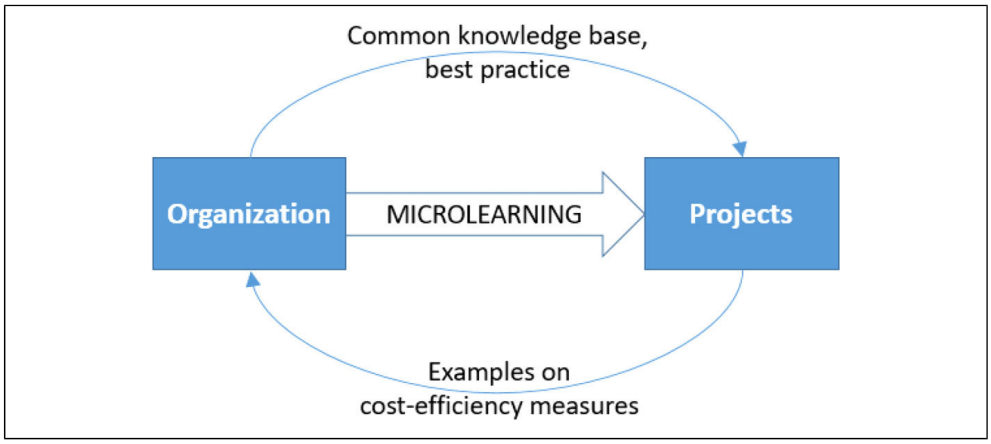

Figure 2. The microlearning feedback-loop.

intervention within the action research project. Previous work in the action research project provides the input to the microlearning by identifying relevant topics and good examples from the projects, which the participants can relate to. The subsequent work can profit from the microlearning in the way that all participants have a common basic understanding of cost-efficient construction projects, that they have heard of examples from other projects, and that they are more familiar with the topic, and thus might have a higher awareness. A future activity in the action research project could be to identify new topics and examples to be integrated in a follow-up of the microlearning.

Conclusion

RQ 1: What was the reception and perceived relevance of this microlearning series on cost-efficient construction projects?

The reception of the microlearning series was good, with almost 50% of the recipients completing the whole series and 75% of the recipients at least completing the first lesson. A lack of time or that fact that those participants, who evaluate the course as not relevant for them, stop after first lesson, might explain the decreasing participation over seven modules. Of those who started a lesson, almost all also finished it. This indicates that the short lessons were of interest for the participants. This is also confirmed by the fact that 91% of the participants respond that the microlearning series was relevant for them. The answers to the integrated follow-up questions show a slight but significant learning effect from the first to the last lesson (+ 0.3 points), which is especially high for those with a low initial level of knowledge. Also the perception of the systems and tools for cost-efficiency of the organization is slightly more positive after the course (+ 0.2 points). The score of 3.2 of 5 for the question if the participants can use the content of the course in their projects indicate an acceptable degree of practical relevance. However, this could be improved in future microlearning series by including the participants wishes, what they would expect from a microlearning course with high practical value for them. In that way, the microlearning series can be updated from time to time to keep the content up to date.

RQ 2: How can a microlearning series serve as an enabler for continuous learning between projects?

The presented microlearning is not only planned as a one-off learning event but is intended to be used continuously to remind the participants of the topic and to communicate new knowledge. However, the presented study cannot fully answer the question, to what extent continuous learning between projects is achieved, as the study was performed after providing the microlearning series once. Several actions were taken or suggested to guide the direction towards enabling continuous learning between projects through microlearning: Accessibility is assured as the microlearning is made

available on a central learning platform within the organization after the campaign. A feedback-loop is suggested, in which new examples and new topics are continuously added to the microlearning (see Figure 2) and which can provide up-to-date learning, challenge current best practice, and encourage innovation in the projects. Practical and up-to-date examples with high relevance for other projects can enrich the lessons. The continuous use of microlearning is also expected to contribute to an organizational culture, where the central topic of cost-efficient construction projects is an integral element to consider during the project. However, microlearning has to be seen as one factor contributing to continuous knowledge transfer between projects. Other complementary methods include project databases, formal trainings or seminars, and the establishment of arenas encouraging informal knowledge transfer between projects.

RQ 3: To what degree can a microlearning series fulfill the needs of a project-based organization?

In a project-based organization, learning can be challenging due to decentralized project teams and time constraints in a hectic project workday. Microlearning contributes to overcoming this by enabling flexible digital learning for teams in dispersed locations. It is possible with a very limited investment of time by the participants. In contrast to informal learning where tacit knowledge is shared or formal training courses, microlearning gives the possibility to share experiences from various projects broadly in the organization, increasing the number of people in different project team, which can benefit from the knowledge. Transferring relevant knowledge becomes less arbitrary, making a common body of knowledge available to all project teams. Acceptable participation rates and good scores on perceived relevance suggests that there the microlearning series could contribute to fulfilling a need for increased sharing of knowledge.

Implications for Practice

This article is written from a practitioner-researcher's perspective as part of an action research project within the organization. This implies that a practical approach has been guiding the research process. Implications of the study for practice are summarized in this section to give practitioners both working with organizational development or training in project-based organizations recommendations for their own practice.

The article addresses the problem of knowledge transfer on the topic of cost-efficiency in an organization where project teams work separately from each other and knowledge is not automatically dispersed to other project teams. Findings of the study include a positive reception of the microlearning. From a business perspective, it is recommendable to continue the focus on cost-efficiency established by the microlearning series. This can both include consecutive microlearning with new lessons and more examples from best practice, but also other methods such as seminars where

project managers present successful cost-efficiency measures from their projects or interdisciplinary workshops, where the participants actively collaborate on finding actions for cost-efficiency for a project. Although the effect might take some time to show, this is expected to result in an organizational culture where cost-efficiency is a "built-in" attribute in all construction projects.

As to the microlearning series itself, it would be beneficial to make it more attractive to increase the participation rate in future microlearning campaigns. The participation rate is acceptable but can still be improved. One option would be increased gamification of microlearning to encourage learning with high motivation, commitment and fun, aiming at a higher completion rate and better retention of content.

Limitations and Suggestions for Further Research

This study is limited to one organization and thus does not claim generalization of results, although there is no indication that a similar approach cannot work in other organizations as long as the microlearning lessons are adapted to the respective organization. However, this is a microlearning on construction projects, so further research is recommended to investigate if the same approach also is applicable in organizations working with other types of projects.

Practical limitations include the fact that microlearning only constitutes one element of engaging people into learning. A variety of measures will be necessary to enrich a culture for learning between projects.

Another limitation in the theoretical part of this paper is the fact that most literature sources for microlearning are from managerial magazines, due to the limited amount of academic studies on microlearning and the lack of academic papers on this issue in peer-reviewed journals.

Concerning the collected data, it would be beneficial to have more data measurement points in the lessons to be able to assess the learning progression after each lesson. However, in this action research approach with the main objective of increasing the awareness and knowledge of cost-efficiency, the amount of questions for data collection was attempted to be kept to a minimum in order to prioritize practicability and learning over data collection and not to deter respondents from participating in the microlearning.

From an academic point of view, it will be interesting to assess the further implementation of cost-efficiency measures into the construction projects based on the microlearning series, and the reception of future microlearning lessons, adapted with new topics and new examples. A new study after a second or third microlearning campaign would be able to provide more thorough answer to RQ 2 if microlearning enables continuous learning between projects.

The present study shows that microlearning can contribute to a more effective knowledge transfer in a project-based organization. This paper also provides suggestions for future microlearning series, for example to increase the participation rate. It is excepted that microlearning will have an even stronger effect when used in a continuous process and in combination with other methods of knowledge transfer.

Acknowledgments

The presented research study is part of an action research project at the presented organization. The action research project is jointly financed by the organization and the Norwegian Research Council. The author would like to thank Ole Jonny Klakegg and Jørgen Kjetil Knudsen for contributing with their ideas and their constructive feedback on drafts of this article.

Declaration of Conflicting Interests

The author declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: The author is an employee of the presented organization.

Funding

The author disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Norwegian Research Council as part of a public sector PhD-project.

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PUBLICATION 5

International Journal of Project Management 40 (2022) 372–384

Contents lists available at ScienceDirect

International Journal of Project Management

journal homepage: www.elsevier.com/locate/ijproman

ategic change towards cost-efficient public construction projects

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T I C L E I N F O

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A B S T R A C T

The cost of public construction projects is a central topic in project management. However, studies have primarily focused on cost at the project level, not on cost management at the portfolio level. In this paper, we take the perspective of a government agency, conducting a strategic initiative to increase cost-efficiency in their portfolio of construction projects. We use an action research approach to investigate the dynamics of the initiative and the implementation of resulting actions to achieve lasting change towards cost-efficiency. Co-creating actions for cost-efficiency together with the project teams was important for the success of the strategic initiative. For successful implementation, alignment of the objectives of the initiative with organizational strategy, and knowledge transfer between projects is central. This study expands the project management literature regarding strategic cost management of portfolios of construction projects and provides practical guidance for organizations.

ntroduction

ny project-based organization (PBO) that wants to achieve lasting ge needs to take action. For a lasting effect, the changes need to be utionalized, which implies learning from temporary actions to anent practices. A wide specter of challenges that occur in such ngs, has been studied in the literature (e.g. Saunders et al., 2008; aker et al., 2008; Kunisch et al., 2019; De Melo et al., 2020). ever, these studies tend to focus more on theory than on what ens in reality. This study responds to the need for more tice-based research in the field that explores the reality of strategic tment through a project portfolio (Clegg et al., 2018) and uncovers ges between practices, organizational learning and change net, 2019). Additionally, Klessova et al. (2020) ask for more rical studies to understand the processes that influence knowledge ration in the context of innovation projects.

n this paper, we report on an empirical study concerning how a ic organization conducted an initiative to lower the overall cost of construction projects. Project cost is a complex issue and influd by many factors. However, it is relevant to all types of projects as n be a decisive factor in whether to invest at all, when choosing een project alternatives, or in a client's decision of which organin will conduct a project.

ext, although cost reduction practices often reveal themselves in idual projects, they still need to be leveraged into a complete project portfolio. This can greatly increase an organization's cost performance and competitive advantage. Few researchers have, however, transformed the cost perspective from an individual project into cost as a strategic factor at the portfolio level. Achieving cost-efficiency in individual projects might be challenging enough on its own, but achieving permanent cost-efficiency at the portfolio level is even more challenging. How can a PBO reduce costs at this level on a permanent basis? As PBOs organize most of their activities in temporary organizations to perform project tasks (Lundin & Söderholm, 1995; Hobday, 2000), they have to transfer successful project practices to subsequent projects (Sydow et al., 2004).

Nevertheless, organizational learning is not a natural project outcome (Ayas & Zeniuk, 2001). The lack of having an automatic transfer of lessons learned between projects (Wiewiora et al., 2009) makes it difficult to achieve lasting change towards higher cost-efficiency throughout the portfolio. The nature of projects being temporary organizations can even lead to the creation of silos that prevent knowledge transfer; the organization must therefore intervene to support learning between projects.

To tackle this challenge, a PBO might implement a strategic project to increase and formalize the use of successful project practices, thereby taking full advantage of the cost-efficiency potential at a project portfolio level. This type of initiative is an attempt to achieve organizational transformation and strategic goals (Ponomarenko et al., 2016). The term 'strategic initiative' will be used throughout this paper to distinguish

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//doi.org/10.1016/j.ijproman.2022.04.006
ved 31 May 2021; Received in revised form 6 April 2022; Accepted 8 April 2022
able online 9 May 2022

this study s strategic organizational project from the construction projects completed by the organization. This term has been used by project management research scholars to describe how strategic decisions are integrated into either transformation projects or overall organizational development (Whittington et al., 2006; Gemünden et al., 2018). According to Saunders et al. (2008), a strategic initiative signals important changes in an organisation, affecting its long-term direction and the scope of its activities , while a strategic project is more task-oriented, having a specific outcome and implementation that uses pre-existing structures.

Against the background of organizational transformation towards cost-efficiency in construction projects, we conducted research in a Norwegian public sector organization working with public construction projects. Between 2018 and 2020, the building commissioning department of the governmental agency conducted a strategic initiative to increase the cost-efficiency of their construction projects. The organization deals with approximately 150 construction projects at any given point of time, with a total annual investment volume of approximately EUR 730 million in 2020. For a public sector organization managing collective funds in a situation where the availability of public resources seems to be becoming scarcer, achieving cost-efficiency will be vital to its survival and success.

Previous initiatives in the organization had focused on stand-alone actions in individual projects. Examples of such actions include innovative use of contractual approaches, more effective use of area and standardization. Yet even if these actions contributed to the delivery of successful individual projects at low cost, it was not enough to reduce the total costs significantly and permanently at an organizational level. Improving a project portfolio s long-term cost performance requires the transfer of relevant experience between projects. The organization therefore started a strategic initiative to bundle the efforts made in previous projects in order to fulfill the need for increased cost performance and achieve lasting cost-efficiency. The initiative s objective was to reduce the investment cost of its project portfolio by 20% by 2025 without either any life cycle cost increase or any decrease in customer satisfaction. The initiative is strategic in the sense that it is both business-critical and transformative, with the aim of leading to substantial organizational change (Martinsuo et al., 2020). The initiative can be characterized as both intra-organizational (it is executed in one organization) and inter-organizational (it works across construction projects). The inter-organizational aspect is given by considering projects are temporary organizations embedded in the permanent organization with a certain degree of independence and strong project cultures (Sydow & Braun, 2018).

The initiative was accompanied by a research project designed to gain academic insight into the initiative. This included a study of how organizational change happens from a building commissioner s perspective that was comprised of the following research questions:

What challenges did the organization encounter when conducting their strategic initiative to increase cost-efficiency in public construction projects?

Based on the results of the strategic initiative, what actions can organizations take to effectively deploy the results?

This paper draws on theories from the field of organizational sociology in order to make a contribution to project management theory. It identifies the challenges that strategic public construction initiatives face when trying to transfer learning from the temporary to permanent organization. One particular contribution is the investigation of the construction projects role in the strategic initiative. To the authors knowledge, this aspect has not been emphasized in project management literature before. Further, the study aims to expand on the research findings of Willems et al. (2020) on the influence of strategic initiatives autonomy on transmitting results to the permanent organization by adding the perspective of a project-based organization. Based on the empirical data, a framework for the implementation of strategic project cost-efficiency measures in the permanent organization has been established.

The paper starts with a review of the literature in Section 2 on cost performance of public construction projects, strategic initiatives and portfolio management in PBOs, learning in PBOs and on how temporary strategic initiatives are deployed in permanent organizations. The methodological action research approach used in the study is outlined in Section 3. This is followed by a presentation of the empirical results from the strategic initiative in Section 4. In Section 5, an analytical model is presented and applied to the results, followed by answers to the research questions. The study s implications for both theory and practice as well as limitations and suggestions for further research are outlined in Section 6.

2. Theoretical background

2.1. Cost performance of public construction projects

Project cost is a popular topic in the discipline of project management, and different facets of the topic have been investigated in depth. A search for project and cost(s) in the title, abstract or keywords of the International Journal of Project Management alone yields 412 papers published between 1983 and 2021 (Scopus search, 17th April 2021). These papers primarily focus on the individual project as a unit of research and examine factors such as cost estimation, cost development, cost overruns and/or other factors affecting project cost.

Cost performance can be measured using two important components: (1) cost growth from a baseline (estimate) to the final cost, or (2) cost per unit of work completed, usually measured by either square meters or other units, for example the number of students (Sullivan et al. 2017). Large sums are invested in the construction of public special purpose buildings such as schools and university buildings, museums, prisons, libraries, hospitals, or government buildings. In these expensive public projects, it is important not to overspend scarce public resources. Further, projects challenges and cost overruns in both the public and private sectors are well documented (Volden & Samset, 2017). Love et al. (2015) distinguish cost escalation, an increase of project cost due to market forces, from cost overruns due to e.g. project content changes. Public construction projects face the challenge of operating within a political environment of multiple stakeholders who have different objectives, and face difficulties in measuring success (Volden & Samset, 2017; Klakegg & Volden, 2016). In addition, internal challenges unique to the public sector include weakness in strategic vision creation, lack of skilled resources and poor coordination between different project actors (OECD, 2015). Flyvbjerg (2005) argues that to ensure building approval, large public construction projects strategically underestimate costs and overestimate benefits at the front-end. This leads not only to large cost overruns in public projects but also lopsided decisions being made either for or against an investment.

In a literature review, Doloi (2013) categorized the influence on project cost into factors related to: project, contract, project management team, quality, planning, market, and contractor. Cheng (2014) identified scope definition in the contract, cost control and contract disputes as the factors that have the greatest influence on cost. In contrast, Love et al. (2015) highlighted project-internal attributes such as technical issues (changes in scope, change orders, errors in contract documentation and rework) as being central reasons for cost increases. Finally, in their literature review Adam et al. (2017) identified the following root causes of cost overruns and time delays in large public construction projects: communication, financial, management, material, organizational, project complexity, duration as well as psychological and weather conditions. Flyvbjerg et al. (2018) considered the external factor of human bias to be the root cause of cost overruns.

Many studies of cost drivers and reasons for cost overruns are found in the academic literature, particularly studies undertaken from a specific geographical perspective. Less research has been done on success factors behind positive cost performance or the mitigation of cost overruns in construction projects. As an example, Asiedu et al. (2017)

conducted research on how to avert cost overruns in construction projects, listing preventive, predictive and corrective approaches for countering cost-driving elements in construction projects. Construction project cost performance can also be examined from a value creation perspective. For instance, Klakegg et al. (2018) conducted six case studies of value creation in Norwegian public construction projects and concluded that project costs are largely determined in early project phases where owner decisions have the highest impact on project cost. Then, the selection of a competent project team, construction concept and project delivery model are the most important factors in the next phase. Other important aspects include specific area requirements as well as the systems and material choices made by the design team and contractors.

With this background on project cost in mind, what is done on the strategic level to tackle the problem of cost escalation in projects?

2.2. Strategic initiatives and portfolio management in PBOs

Grundy (1998) advocated thinking strategically about project management, not just at project but also at portfolio level. Artto & Wikstrom (2005) discovered in their bibliometric study the importance of strategically managing the *permanent* organization. They found organizational theory and the logic of value creation to be influential for PBO development. Strategic management at this level must be in relation to the internal and external context in which the project portfolio is managed (Martinsuo & Geraldi, 2020; Martinsuo, 2013). Engaging in strategic initiatives at the portfolio level (Martinsuo & Geraldi, 2020; Chinowsky, 2000) and aligning the project portfolio with the firm s strategic objectives (Paquin et al., 2016) can supplement business strategy (Grundy, 1996; Shenhar, 2004). This notion is confirmed by the findings of Kopmann et al. (2017), who, in their study of 182 firms, suggest that strategic management at the project portfolio level is important for the successful management of emergent strategies in an organization. Likewise, in their study on how strategic intentions are managed in a multi-project context, Dietrich & Lehtonen (2005) found that it is necessary to align strategic initiative objectives with an organization s strategy. Success factors for strategic initiatives include implementing a common project management process or project model that works at both the single and multi-project levels.

Kock & Gemünden (2019) called for exploratory projects which may contribute to increased value creation and project success throughout the project portfolio by creating strategic options to be exploited by successive projects. Recent research by Sergeeva & Ali (2020) has stressed the role of a project management office (PMO), supporting collaboration across projects to improve project performance. This includes managing lessons learned from previous projects to explore innovative solutions for future projects. For instance, Bredillet et al. (2018) found PMOs to be instrumental to leading strategic change throughout a portfolio of projects. Similarly, Müller et al. (2019) advocated using organizational project management as a complement to project, program and portfolio management in order to enable a joint delivery of beneficial change by conceptualizing both the role of projects and their interaction.

The high cost level of (public) construction projects requires strategic project cost management, as managing cost in each project separately does not seem to be sufficient. One suggestion involves using simultaneous top-down and bottom-up strategies. Top-level management is responsible for creating the basic process outline; while it also has the ultimate authority to make decisions, employees are encouraged to participate at all levels of the decision-making process (Himme, 2012). Training programs for planned changes can ensure employee readiness for change and enhance cost consciousness. Based on practical evidence, Lavingia (2003) advocates the application of a structured project management process, which should ensure top management s commitment to applying best practices. Furthermore, total cost management should integrate the management of cost at all portfolio, program and project levels to improve the project portfolio s overall profitability.

A systematic manual search of all articles published during the last five years in the leading journals in the field, The *International Journal of Project Management* and *Project Management Journal*, showed that little of the academic literature focuses explicitly on strategic cost reduction initiatives in a construction project portfolio. However, related research on project governance systems has been carried out earlier. For example, Klakegg et al. (2008) compared project governance frameworks for public investment projects in Norway and the United Kingdom, concluding that the frameworks increase (cost) control and transparency. In a similar fashion, Volden (2019) studied the quality of cost-benefit-analyses in Norwegian state projects, concluding that a deficient handling of non-monetary considerations early on in the projects might make decision-makers overestimate a project s potential benefits. Moreover, Caffierei et al. (2018) conducted research on the Strategic Asset Management Framework in Western Australia and found that the controls established by the framework contribute to reducing human bias and avoiding cost growth in major public projects. For their part, Shibani & Gherrbal (2018) investigated the use of a balanced scorecard in construction projects as a strategic management system used to counter both time and cost restraints. This balanced scorecard integrates four dimensions: financial, customer, internal process and innovation (Kaplan & Norton, 1992).

2.3. Learning at the interface between temporary and permanent organizations in strategic initiatives

Strategically approaching cost management in projects at a portfolio level requires knowledge of learning processes in PBO projects. Cost is a central concern in PBOs; consequently, the lack of automated cost-efficiency knowledge transfer between projects calls for strategic initiatives to tackle the cost issue at a portfolio level. Further, although project teams are often separated in the PBO in both a physical and organizationally, a supportive learning environment that includes common practices and arenas can create a knowledge transfer network between projects (Ayas & Zeniuk, 2001; Garvin et al., 2008; Fitzgerald, 2003).

Project cost knowledge includes actions in one project that are used to avert cost overrun, which might be useful to other project teams. ‘Sticky knowledge might occur, where tacit knowledge within one project team remains hidden to other project teams, who may need this knowledge to solve a similar problem (von Hippel, 1994). Interestingly, Wiewiora et al. (2009) found that in many construction companies, lessons learned are not communicated between project teams. Factors inhibiting the exchange of these lessons are time constraints and people s reluctance to share information that might weaken their personal position (Wiewiora et al., 2009), a lack of incentives, the absence of knowledge-sharing systems (Ajmal et al., 2010) and the projects temporality (Jafari et al., 2011). However, Yap et al. (2017) concluded from their study on design change management that capturing and sharing reusable project experiences is essential for increasing the speed of learning and adding value to future projects.

Organizations that successfully provide effective knowledge-sharing opportunities also allow projects to serve as practice fields for developing learning capabilities and cultivating effective habits of reflective practice (Ayas & Zeniuk, 2001, p.62), which can in turn be transferred to subsequent projects. Berggren (2019) underlines the cumulative power of incremental innovation in projects by transferring best practices done at the project level to the organizational level.

The compilation of literature on learning in PBOs highlights the central role of projects in organizational learning processes and the implementation of organizational strategy (Musawir et al., 2020). In other words, projects and organizations mutually constitute each other (Soderlund & Sydow, 2019). Furthermore, project actors react to institutional changes: Their underlying practices can be influenced by organizational strategy, or vice versa, when projects experiment with

new forms of governance and thus influence organizational strategy (Hetemi et al., 2021; Clegg et al., 2018). Actualities from the projects shape strategy in the organization (Lowstedt et al., 2018) and can ultimately impact institutionalized tools (Brunet, 2019). Likewise, De Melo et al. (2020) stress the importance of vanguard projects to build systematic capability for organizational development. Therefore, even if this topic has been the focus of recent research, there is still the need for further empirical research on bi-directional interaction between the permanent organization and its temporary units (Mahura & Birollo, 2021).

2.4. From temporary to permanent-implementing results from strategic initiatives

Driving change within an organization is inherent to each strategic initiative, the aim being to transform the organization in a way that enhances organizational success or the fulfillment of strategic objectives (Martinsuo et al., 2020). A central element of strategic initiatives is the provision of their capacity for change and innovation. Strategic initiatives must therefore have a certain degree of autonomy from the permanent organization if innovation is to be fostered. On the other hand, integration mechanisms must be in place to ensure connection to this same permanent organization (Willems et al., 2020) and prevent the strategic initiative s isolation (Lehtonen & Martinsuo, 2009; Willems et al., 2020). To explore this idea further, Lowstedt et al. (2018) studied strategy as-it-is-practiced in large construction PBOs. They discovered that project actualities shape the implementation of strategy and play a larger role in organizational strategizing than typically portrayed in the literature. Similarly, Artto et al. (2008) concluded that project strategy, i.e. the strategy of an individual project, can take various positions in relation to its environment and the permanent organization s strategy. A project does not necessarily replicate the parent organization s strategy but can take a more independent role in establishing its own robust culture and strategy.

Prado & Sapsed (2016) have investigated the adaptation of organizational changes in PBOs. This transition from the temporary to the permanent is achieved either through management commitment or the effectiveness of the innovations themselves. Systems such as databases can mediate transition, and IT-artefacts can facilitate knowledge transfer. The actions must, however, ultimately be adopted by other projects. This issue is approached by Stensaker et al. (2008), who highlighted the necessity of sensemaking through action when implementing change activities. One challenge associated with implementation is the temporary organization s rapid dissolution at the end of a strategic initiative. Members are assigned new tasks before any new knowledge or actions are fully integrated into the parent organization (Stjerne & Svejenova, 2016; Swan et al., 2010; Sydow et al., 2004). To avoid this situation and ensure successful change, a good plan for implementation should therefore be put in place before any strategic initiative ends.

3. Methodology

3.1. Action research

Action research is a type of applied research designed to find the most effective way to bring about a desired social change or to solve a practical problem, usually in collaboration with those being researched. (SAGE, 2019). The aim is both changing the system and generating critical knowledge about it (Susman & Evered, 1978, p. 586). Instead of one theoretical research method, action research is an applied research approach that links theory and practice to generate a solution (Azhar et al., 2010). It is a methodology for introducing change (or ‘action), and critically understanding that change to produce new knowledge (‘research) within a social setting (Sexton & Lu, 2009, p. 688). A unique aspect of action research is the participative and democratic process, research not being conducted *on*, but *with* the participants, empowering them to engage in inquiry and knowledge creation (Dick & Greenwood, 2015; Reason, 2006).

This paper s first author engaged in action research as a practitioner-researcher. As she was an employee of the organization and was aware of the organizational preconditions and constraints, she could assume the twin role of researcher and practitioner. Additionally, her participation in the internal project also legitimized access to data for academic analysis. The rationale for selecting action research was the opportunity it gave to combine the organization s objective of higher cost-efficiency with an in-depth investigation of the researched subject. In addition, the organization had no tradition of implementing long academic research projects with a high level of proximity to projects conducted by external researchers.

The objective of the larger research project was to examine the process towards achieving higher cost-efficiency in the organization s portfolio of construction projects. The researcher participated in a small project team and examined different elements of the strategic initiative: concrete actions taken in individual projects, the influence of stakeholders on project cost, and knowledge transfer processes. This paper is a meta-analysis of what happened in this strategic initiative and focuses on the interface between the strategic initiative and permanent organization at the initiative s conclusion.

The concept of *engaged scholarship* was used in the research project: Engaged scholarship is defined as a participative form of research for obtaining the different perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) in studying complex problems. (Van de Ven, 2007, p. 9). This enables the accommodation of fragmented academic and practitioner goals along with the production of insightful knowledge (Van de Ven, 2007; Van Marrewijk & Dessing, 2019). Explicit epistemic scientific knowledge and tacit practical knowledge complement each other in engaged scholarship: While the academic perspective allows a bird s eye view of the organization and a high degree of reflexivity, the practitioner perspective focuses on the reality and constraints of the organizational context. Practical knowledge is considered to be a distinct mode of knowing, not just a derivative of scientific knowledge (Van de Ven, 2007). The organization represents an idea factory, or a learning workplace, where researchers and practitioners engage in reciprocal relations (Van de Ven, 2007; Van Marrewijk & Dessing, 2019).

3.2. Methods and analysis

In the strategic initiative, the first author conducted meetings to engage practitioners in the co-creation of cost-efficiency measures. Co-creation is the joint, collaborative, concurrent, peer-like process of producing new value, both materially and symbolically (Galvagno & Dalli, 2014, pp. 644). The researcher and the project managers used the meetings to create and discuss cost-efficiency actions. Lindhult (2019) calls this kind of collaboration democratic dialogue , acknowledging that all research participants, both academics and practitioners, have significant capacity for knowledge generation.

The participants in the 75 meetings were mainly project managers of the construction projects, in some meetings also being joined by project controllers or other project team members. Additional demographic information about the participants was not collected in order to maintain the business as usual character of the meetings. The researcher acted as a colleague during the meetings to allow unhindered information flow about both positive and negative aspects of the projects various cost developments.

The researcher used the meetings as an important method in the research study. She took notes during the meetings and established so-called ‘value cards for each project (see chapter 4.1). Cost-reducing actions for each project were categorized on these cards according to the following topics: (1) analysis of needs/concept (2) standardization (3) new contractual models (4) technology/digitalization (5) engineering costs (6) cost estimation and control, and (7) project organization.

On a practical level, the cards were used to log and quantify potential cost reductions as well as follow up and share information between projects. In the research project, these cards were used for content analysis.

The actions from the strategic initiative and the results were disseminated in the organization using a number of means: A micro-learning series on cost-efficient construction projects and the integration of cost-efficiency measures into an existing project database to which every employee in the organization had open access. Regular meetings in the organizations were used as arenas to communicate the results from the value meetings. Project managers had the opportunity to exchange ideas and discuss cost-efficiency actions. These arenas could be departmental meetings (with participants from across the project management teams), management meetings, as well as in-person and online innovation seminars with a broader audience across the organization.

To ensure triangulation of methods (Neuman, 2006) in the action research project, quantitative analysis of project data for completed and ongoing projects in addition to qualitative methods, including document analysis and interviews, were used. Document analysis is particularly relevant to the part of the research project presented in this paper. The first author performed thematic analysis (Fereday & Muir-Cochrane, 2006) on the following documents: the value cards, her notes from the value meetings, the presentations to the strategic initiative s steering committee, the initiative s implementation strategy and the strategic initiative s final report. Thematic analysis was carried out to uncover themes in the documents which are relevant to the study s research questions. The themes that emerged included the immediate results of the strategic initiative, its dynamics and challenges, the co-creation of cost-efficiency actions and the implementation of actions from the strategic initiative. Quotes from the meetings are based on the researcher s notes and have been translated into English by the first author.

3.3. Validity and relevance of the chosen methodology

Action research assumes a messy reality in which research is more a process than a product (Law, 2004). A diverse set of mixed methods that are heterogeneous and based on the research setting must therefore be applied. As this type of situated inquiry is context related, the research result might not be replicable under other circumstances. The validity of action research therefore lies in making the best possible use of these tools [i.e. research methods] within the constraints of the workplace (Somekh, 1995, p. 341). Action research of high validity produces practical wisdom that is relevant to the organization by using research methods that allow the exploration of multiple determinants of (inter) actions. This deepens practitioners understanding of complex situations, allowing them to make better informed decisions. This intertwinement, however, makes it impossible to draw a clear line between research data and work-related data. The interpretation of results in the light of prior practical knowledge can therefore be problematic (Reason, 2006).

The value of action research is mainly defined through its practical relevance to the organization, i.e. the practical goal of solving the problem at hand. The goal of the strategic initiative is to achieve greater cost-efficiency in construction projects, an aim motivated by the need to maximize benefits from construction projects while minimizing the cost to the taxpayer. Data emerges directly from the strategic initiative and is therefore an authentic and reliable record. In addition, the data s reliability and credibility can be validated through project final cost accounts (upon project completion). A situated inquiry into the organizational context, however, lacks direct external validity and makes no claim of generalizability; nevertheless, the study s results might be applicable in a wider perspective.

The first author was the key resource for collecting and analyzing the data, a factor which ensures strong data ownership but might cause bias. Researcher triangulation would have benefited the study s rigor. To limit bias and ensure a high degree of reflection, the meeting results were discussed with both non-researcher members of the strategic initiative and external researchers during the analytical process and writing of this paper.

4. The results of the strategic initiative

This section provides insight into the strategic initiative, its dynamics, results, and challenges during and at the initiative s conclusion. Special focus is given to the post-initiative challenges of implementing cost-efficiency actions in the permanent organization.

4.1. Co-creation of actions for cost reduction in ‘value meetings

A central activity that emerged during the initiative was the direct involvement of the construction projects in the strategic initiative. As an interactive method to collect and generate cost-efficiency action in projects, 75 so-called ‘value meetings were held with over 100 project managers and other construction project personnel. The researcher engaged in a dialogue with the project managers, focusing on the particularities of the project at hand. This was possible as the meetings were held in connection with one project at a time at which one to three people from the project team were present the project manager and, in some cases, the assistant project manager or project controller. Most of the participants were eager to talk about their projects cost issues and the cost-efficiency actions they had already implemented. The majority were also open to suggestions made by the researcher. However, a lack of time was mentioned as an important limitation: *We have enough tasks in the project as it is, can we please spend as little time as possible on this?* Some were hesitant to mention cost issues that arose from organizational constraints, e.g. the unavailability of internal specialists to the project.

The meetings were characterized by active interaction with each project. Actions could be initiated, and information could be collected in real time. However, the meetings were a resource-intensive method, requiring the researcher to call, prepare and follow up the meetings. As the meetings concerned one project at a time, this meeting format did not allow direct contact between construction projects to exchange their experiences with cost-efficiency measures. However, as more meetings were held, the researcher could draw parallels between the projects and connect those projects with similar planned actions for cost-efficiency.

To promote a structured discussion, the researcher proposed the following topics at the beginning of each meeting: analysis of needs, standardization, new contractual approaches, technology/ digitalization, engineering cost, cost estimation and control and project organization. These topics had emerged from an initial analysis as being important. The project managers were allowed to choose the topics that seemed relevant to the project at hand.

The actions that were developed during these meetings were documented on so-called *value cards* (see Fig. 1), which were used as a tool to visualize and summarize actions. The cards could be used as a reference point for projects to follow up actions and as an information source for other projects. All 75 value cards were made available to everybody and could be shared between project teams. The researcher also suggested creating connections between projects with similarities to assure cost-efficiency action knowledge transfer.

Fig. 1 shows the template of the value card on the topic of standardization. The inner circle on the template provides facts about the topic: how it is measured, potential actions and how the strategic initiative can support the construction project. Planned actions and their intended effects were listed during the meeting in the table on the card. The outer circle could be used at a later stage to summarize the actual effect of actions and e.g. note the amount of cost reduction achieved by the measures.

This paper does not aim to provide a detailed account of the wide range of actions developed during the meetings. Examples include

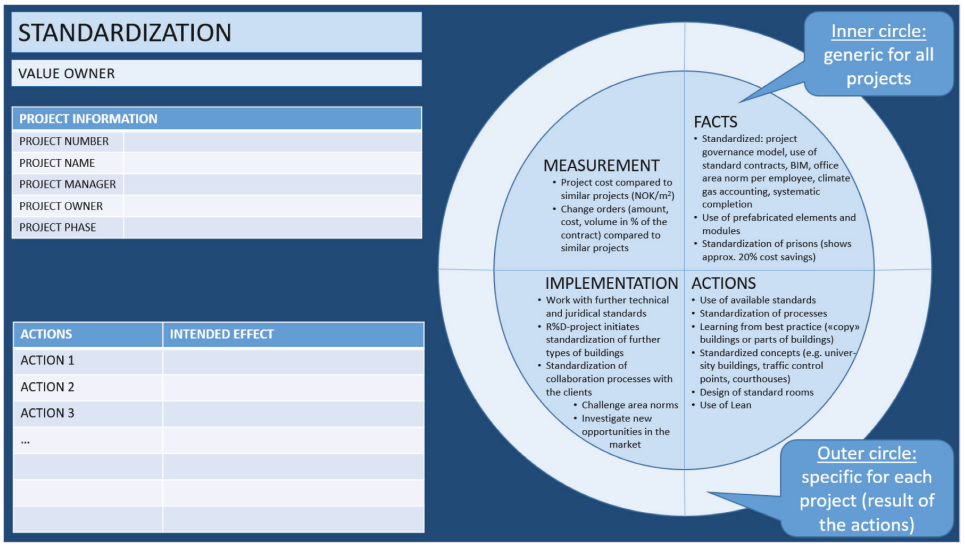


Fig. 1. Template of the project value card on the topic of standardization.

antial area reductions in the conceptual phase through a thorough ysis of client needs, the standardization of prison buildings, use of al reality for visualization and travel minimization or using early actor involvement to benefit from the contractor's expertise. A of real-life examples from the projects is provided in Appendix 1, h illustrates the width of the cost-efficiency actions and documents ess stories on the project level.

onducting 'value meetings' in connection with each project was a positive experience, both as a pedagogical activity to stimulate the ification and implementation of cost reduction actions in the con- tion projects and as an implementation tool. The initiative has as a catalyst for the further implementation of cost-efficiency ac- in construction projects.

Immediate results of the strategic initiative

he strategic initiative's final report points out that the initiative esented an important start towards implementing a strategic oach to achieve cost-efficiency in construction projects. The long- effect of the actions in the strategic initiative remains to be seen, ost of the participating projects are still being executed. Other cts had progressed too far at the time of intervention to create tive cost-efficiency actions. The cost objective status at the strategic ative's conclusion was as follows: The average final cost of the olio of projects completed between 2010 and 2018 (baseline) was of the cost estimate at the time the decision to build was made. ner, while the final cost of projects completed in 2019 shows a inal improvement to 97%, the prospect for ongoing projects ned this cost to 98%. The majority of average-sized projects ach- lower costs than before the initiative, but the largest projects ed a cost increase.

here is no indication of an increase in life cycle costs due to in- ment cost reducing actions. This is in line with prerequisites defined e strategic initiative. However, several years must pass before evi- e on how the actions really affect life cycle costs can be collated, as cts have long durations and buildings have long expected lifetimes. nother prerequisite was that reductions in project costs should not tively affect customer satisfaction levels. The customer satisfaction x in 2020 was 71 points, which is almost unchanged from the score of 70 in 2018 (before the strategic initiative). This result suggests that cost-efficiency actions had no significant effect on customer satisfaction. However, on closer examination of the results, the index for the department that handles the earliest project phases (business case, evaluation of needs, concept) increased from 62 to 75 in the same time span. This indicates that the work on cost-efficient project concepts has contributed to higher customer satisfaction levels in projects' earlier phases.

In the meetings, good collaboration with the customer and the user was mentioned as essential, especially in early project phases: "*We had a very knowledgeable client, who was easy to collaborate with and find good solutions*." The overall customer satisfaction index did not change much from 2018 despite satisfaction being substantially higher for this specific department. This can be explained by a slight reduction in customer satisfaction levels for the operations department, and that the results for the department in early project phases is weighted less than other departments due to the lower number of projects in those phases and thus fewer answers from customers. The index for the building commissioning department, where most of the projects are managed, showed no significant change.

4.3. Challenges in the strategic initiative

At the beginning of the strategic initiative, the team and steering group discussed if a simple strategy could be a flat budget cut of 20% for each project. This idea was not popular with the project managers, as they were skeptical about cost reductions *per se*. Therefore, an approach of working together with the individual projects on concrete cost-efficiency measures was taken. It was believed to be important to give each construction project a certain degree of autonomy to find their level of cost-efficiency and develop effective actions, even though this could result in projects achieving different degrees of cost reduction. As one project manager expressed: "*We're working with design to cost and have already scaled the project back as much as possible, so now what's left is only what's really essential*." Changing the focus from the term 'cost reduction' to the more positive 'cost-efficient value creation' contributed to a greater acceptance of the strategic initiative. This was also reflected by the name 'value meetings' and using the term 'cost-efficiency' instead of 'cost reduction'. The aim of the meetings was

therefore to find actions that could maximize the value generated by the construction projects without increasing the cost or create actions which saved costs without reducing value.

The organization s top management group had mandated the initiative, whose objectives were therefore linked to the organization s overall strategy. There was, however, a gap between the construction project teams project objectives and those of top management. While cost reduction was very important to top management, project managers had no real incentive to reduce costs beyond meeting the set cost frame, although some of them pursued that goal due to their own motivation: *You shouldn t stick to the cost frame but base your steering on the contractor s price plus an acceptable buffer* or on *what s reasonable for the project* . Another project manager had set his own personal goal to *end up 10% under the internal cost frame, and at least not to use the project owner s reserve* . To align the objectives of the construction project managers with those of top management, cost reduction was permanently included in a key performance indicator (KPI). Even though an additional KPI was not popular in the organization, the KPI contributed to formalizing the objective of cost reduction by increasing both project managers and project owners commitment to the objectives of the strategic initiative and their incentives to work on cost-efficiency. However, integrating the created value into the KPI to fully align it with the initiative s objectives is still a challenge.

Another challenge was top management s diminishing commitment to the project, as the steering group turned to other urgent tasks after the strategic initiative s official period was over. This inhibited a thorough and timely implementation of remaining actions from the initiative in the permanent organization. Initially, there was a plan to provide project support in order to pursue the identified cost-reducing actions. Yet due to a lack of resources in the initiative, the projects had to follow up the actions themselves. This situation made it more arbitrary if and how the initiated cost-reducing actions were to be continued in the construction projects. With better access to resources, especially at the initiative s conclusion, it would have been easier to assist the project managers when implementing their actions and control mechanisms if these actions had been in line with strategic policy.

Achieving a mindset change is difficult. Reducing investment cost by 20% without loss of customer satisfaction and increased life cycle cost and measuring the effects of this reduction, has proven to be more complex than expected. A diversified portfolio contains a number of projects with different preconditions, which inevitably results in different costs per square meter. Another cost reduction indicator that can be used is the ratio of final cost and the project s cost estimate when the decision to build was made (cost frame). While this indicator shows construction phase cost performance, positive or negative cost development in earlier project phases before the decision to build has been taken must also be accounted for. Working towards a solution which solves the client s needs in a less expensive way can be very cost-efficient.

However, data on projects cost development before the decision to build is not easy to capture. There is often no complete record of cost development in early project phases, at least not one that is easily accessible at the portfolio level; moreover, it is difficult to consider cost development in relation to value creation. There is also the possibility that increasing cost estimates might be caused by higher value creation, which, although it can be seen in individual projects, is difficult to achieve and measure at the portfolio level. Having the ability to fulfill a client s needs at lower cost creates a great deal of potential for cost savings at this stage; however, additional data on early project phases scope and cost development must be registered in a central database to allow the project portfolio to be fully measured.

The cost performance of the project portfolio shows a positive trend for projects that have a normal size. The current trend towards megaprojects (with an estimated cost of over EUR 2 million) is, however, moving in the opposite direction with respect to comparing the (expected) final cost to the cost frame. The strategic initiative concluded that the dynamics in megaprojects seem to be different; subsequently, an initial focus on these projects should be initiated. At the same time, cost increase in megaprojects seems to be a generic problem not limited to the case study organization, as pointed out by Flyvbjerg (2014). Zaman et al. (2021) found that authoritarian leadership has a negative impact on public megaprojects success rates, as incremental negligence due to project team members silence can hinder megaprojects from reaching their goals (an aspect which can be explored further).

Project managers appeared to think that making incremental changes towards cost-efficiency was easier to accept than taking more radical actions with unknown consequences (by for example using new contract formats). As one project manager commented during a value meeting, *You always tend to choose the well-known strategies because you feel comfortable with them* . Most project managers have a conservative approach to new ideas and show a high degree of risk aversion, a characteristic that makes them hesitant to use their project as a pilot project for testing new contractual models. Also, a lack of external pressure to try new models contributes to this reluctance. There might be a need to educate project managers information on how other organizations use these types of contracts to make them more comfortable with trying out new contract formats. A reward (or punishment) system for trying out these formats might also contribute to a higher number of project managers choosing them.

Next, while cost-efficiency actions also show a varying impact on project costs, not all actions are easily quantifiable. For instance, it is relatively easy to evaluate the effect of actions such as constructing prison buildings in a standardized and industrialized manner, which leads to shorter construction times and cost savings (kland et al., 2017), selection of turnkey contracts with design proposals, or a reduction of building area by reusing existing buildings. However, it is difficult to quantify the more diffuse effect of making changes to the project team s organization or investing in new technology. Furthermore, some actions can be expensive to run in pilot projects and may only show their effects in subsequent projects.

4.4. Implementing measures from the strategic initiative

An implementation strategy was established towards the end of the strategic initiative whose aim was to ensure an implementation of activities which would have a positive effect on project cost in future construction projects. The strategy was also meant to ensure a prioritization of further strategic cost-efficiency work that was anchored in the permanent organization after the strategic initiative had concluded. At the start of the initiative, a continuous implementation of changes was planned. However, analyzing the status of cost-efficiency, creating and testing actions and implementing them during the two-year period of the strategic initiative proved to be a goal that was too ambitious to achieve. This was mainly due not only to a lack of time and resources in the initiative but also to the long duration of most construction projects. It therefore became necessary to establish an explicit implementation strategy that assured the deployment of successful actions, including after the conclusion of the initiative.

As part of the strategic initiative s overall plan, a PMO was established in the organization whose aim was to gather expertise on project governance in one unit. The PMO was to counter the problem of a lack of resources and provide better support to all project management teams. The initiative s project team and steering group decided in the end to place the ownership and future responsibility for coordinating cost-efficiency activities in the newly established PMO. The implementation strategy document, which was established during the initiative period, gives an overview of strategic and operational tasks designed to continue the work towards achieving cost-efficiency, including clear task ownership and responsibility for execution as well as the need for any additional staff. The PMO was designated as the main force behind any further implementation of strategic initiative actions.

In the final report, a number of actions are proposed for the

permanent organization to continue to implement. Some of these actions have already been approved and integrated into the governance system including mandatory creation of a benefits realization plan, use of a systematic completion approach (cf. Beste, 2020) and more precise requirements for making a thorough analysis of needs in early project phases. Other actions have not been included in the project s governance system, either because their relevance for the majority of projects is limited (e.g. subsequently refurbishing similar buildings) or because they lack maturity and so their implementation has not been prioritized (e.g. using alternative contractual approaches). There is also a plan currently under development to include the interactive process of developing cost-efficiency actions as a standard checkpoint into a digital, process-based project governance system.

Project managers and team members gather valuable experience when working on a project. As one project manager expressed it during a value meeting: *Based on what happened in this project, I d definitely include this point in the specifications of the next project.* To avoid stickiness of knowledge to single persons and enable diffusion of information to other projects, it is essential to implement organizational learning as a central element in strategic initiative measures. Following the strategic initiative, the PMO worked towards registering cost-reducing actions together with the project managers and thus improve the quality of an internal project database. The database allows for continuous knowledge sharing between the projects and serves as a central tool for sharing best practice approaches.

Another tool for knowledge transfer is a microlearning series that was developed during the initiative. Seven short thematic lessons on cost-efficiency were distributed weekly to 334 employees of the organization (Beste, 2021). Almost half of the employees completed all the lessons, which were perceived as being relevant by over 90% of this group. There was also an increase in their perceived knowledge on cost-efficiency after completion, especially for the employees having a low level of perceived knowledge before taking the microlearning lessons. These lessons were made available to all employees via the organization s online training platform; additionally, the PMO plans to further develop them in the future.

5. Discussion

5.1. An enhanced analytical model

Cost-efficiency actions in the organization partly reflect the factors either found by Flyvbjerg (2005) and Klakegg et al. (2018) or collected by Doloi (2013) and Adam et al. (2017), particularly the insight that project costs are largely determined in early project phases. The strategic initiative s objectives were aligned with the strategy of the organization (Dietrich & Lehtonen, 2005), and strategic considerations from the initiative led to an adaptation of a future organizational strategy. An initial top-down strategy implemented by top management was later augmented by a bottom-up approach (Himme, 2012) of involving construction projects in the co-creation of cost-efficiency actions. The actions from the projects were compiled and analyzed to determine what actions had a general relevance to all projects, which in turn allowed shifting focus from the individual project to the entire project portfolio (Martinsuo & Geraldi, 2020). Inter-project learning is also an important aspect in the strategic initiative. In addition to informal knowledge transfer, this type of learning also includes formal elements such as value meetings, databases and microlearning. These tools can help to make the tacit knowledge gained from projects visible to other project teams (von Hippel, 1994; Wiewiora et al., 2009) thereby creating a knowledge transfer network between projects (Ayas & Zeniuk, 2001; Garvin et al., 2008; Fitzgerald, 2003).

In the following, we will look at how the temporary strategic initiative translates to the permanent organization. Modelling the elements which are important for implementation can help us structure relevant factors and provide guidance also for other organizations that are intending to implement strategic initiatives.

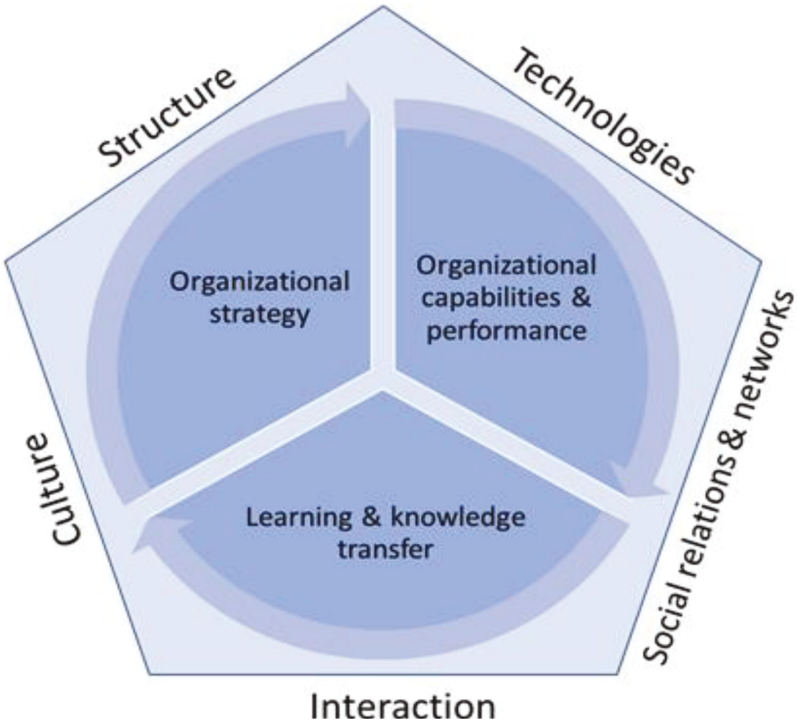
The dynamics of the implementation process at the interface between a strategic project and permanent organization is as much an organizational as a project management issue. Looking at the organizational sociology domain may therefore be useful when approaching this issue, as proposed by Artto & Wikstrom (2005). The Pentagon model is an organizational model with a holistic system perspective. It provides a way of considering the different dimensions to successfully developing organizational capabilities and performance through considering the organization as a socio-cultural system (Rolstadås & Schiefloe, 2017). The model is made up of five main dimensions:

(1) "structure (defined roles, responsibilities and authority in the formal organization, defined procedures, regulations, and working requirements);
(2) technologies (different tools and infrastructures the members of the organization use or are dependent on to perform their activities);
(3) culture (language/concepts, values, attitudes, norms, knowledge and established ways of working);
(4) interaction (management, leadership, work processes and information flow connected to communication, cooperation, and coordination); and
(5) social relations and networks (the informal structure and the social capital of the organization, i.e. trust, friendship, access to knowledge and experiences, informal power, alliances, competition and conflicts). (Rolstadås & Schiefloe, 2017, p. 302).

The model has been previously applied in project management contexts, for instance as a tool for modelling project complexity (Rolstadås & Schiefloe, 2017), analyzing completed megaprojects (Rolstadås et al., 2014) and to develop the project management organization and assess its performance in the course of project delivery (Rolstadås et al., 2014, p.638).

The Pentagon model was considered to be useful for structuring the dimensions in the investigated strategic initiative and implementing initial results in the permanent organization. Some important elements which are needed to reflect the presented study s results are, however, missing in the original model. Inspired by Saunders et al. s (2008) framework listing both soft and hard factors for the deployment of strategic initiatives, the elements organizational strategy and learning & knowledge transfer were therefore added by the authors. These elements facilitate placing the strategic initiative into the context of the permanent organization. Fig. 2 shows the adapted model, which is inspired by the original Pentagon model and conceived by the empirical data.

The core of the model is characterized by a continuous interplay of these three elements: (1) organizational strategy, (2) organizational capabilities and performance, and (3) learning and knowledge transfer. The strategic cost reduction initiative was developed based on the organizational strategy to develop organizational capabilities in order to increase the organization s construction project cost performance at a portfolio level. As a result of the strategic initiative, the future organizational strategy was changed to better accommodate a continuous focus on cost-efficiency. The new strategy for the period 2021-2025 explicitly reflects cost-efficiency in the objective: We deliver cost-efficient public buildings. This study relates to one of the objective s sub-ordinate targets: We ensure good project management and conduct cost-efficient construction projects. Clear annual milestones combined with the KPI are expected to ultimately result in a 20% cost reduction by 2025. Learning through actively sharing knowledge from projects also has the potential to increase organizational cost-efficiency capabilities and performance. Organizational capability is created by enabling project managers to take actions in their projects and by establishing a PMO to support the construction projects towards achieving cost-efficiency.



2. A framework for implementing a strategic initiative in a project-based organization (based on Rolstadås & Schiefloe, 2017, augmented by the authors with nts from Saunders et al., 2008).

he strategic initiative showed that the construction projects are not a part of the problem to be solved, but also a key contributor to the ion. The enablers of change are situated in the lower part of the agon within the 'soft' dimensions of culture, interaction, and social ons and networks. The value meetings were characterized by action with the projects through the co-creation of actions for cost- ency. Networks were established between projects by actively nunicating cost-efficiency actions between them. The initiative fore prepared a foundation for accepting changes and a mindset e cost-efficiency is an important factor in project execution.

he 'hard' dimensions of structure and technologies can be classified nablers or tools that facilitate efficient cost reduction work in the cts. Based on the meeting results, necessary structures included lishing both a KPI and a mandatory checkpoint for cost-efficiency e project governance system to replace the resource-intensive ings. Supporting technologies are dashboards used to show nuous cost performance measurements, a project database to reg- cost-efficiency actions and microlearning tools for communication earning.

ased on this study's findings, all these dimensions are needed to ase cost-efficiency successfully and permanently in the organiza- This assertion confirms the findings by Dietrich & Lehtonen (2005), g that managing strategic intentions entails the necessity to de both formal procedures and informal and invisible processes.

he augmented Pentagon model is based on experience from this fic strategic initiative in one organization. However, it should be cable to other project-based organizations as well, as the model s organizational context and individuality into account.

5.2. Answering the research questions

The study presented here has investigated a strategic cost-efficiency initiative in a public sector organization that works with construction projects. This paper presents how an organization can learn and profit from conducting a strategic initiative – and thus achieve lasting change. Having examined challenges in the strategic initiative and the implementation of results in the organization, we can now answer our research questions.

What challenges did the organization encounter when conducting their strategic initiative on increased cost-efficiency in public construction projects?

The objective of a strategic initiative is to bring about change in an organization (Ponomarenko et al., 2016). In this transformational process, the organization can encounter a number of challenges on the organizational level as reactions to the strategic initiative. Operational challenges with cost-efficiency measures in single projects are not discussed here.

As Paquin et al. 2016 point out, strategic initiatives must conform to organizational objectives. The challenge of non-aligned objectives also manifested in this initiative: Initially, the strategic objective had to overcome the problem, that the objectives of the initiative were not clearly aligned with organizational objectives.

There was both a varying degree of acceptance with respect to actions taken to promote cost-efficiency and reluctance to employ unfamiliar actions with a higher (perceived) risk level. Therefore, continuous focus on participation of the projects and more information about more comprehensive actions for cost-efficiency is needed to increase employee readiness (cf. Himmel, 2012). However, also incremental changes can have cumulative power when transferred from project to the organizational level (Berggren, 2019), something the strategic initiative focused on.

Previous research has pointed to the problem of team members of a strategic initiative being assigned new tasks directly (Stjerne & Svejenova, 2016; Swan et al., 2010; Sydow et al., 2004), thus being unable to follow up the results. The same was revealed in this research, as the individual value meetings with the construction projects participants were a resource-intensive approach, taking time for administration, facilitation and follow-up. After the end of the strategic initiative, no resources were available to continue this approach in the same way.

Despite the steering group s expectations regarding the initiative, its success is not shown directly due to long duration of the construction projects and the need for a mindset change by the project teams. Whereas many cost-reducing actions have been initiated in normal-sized projects, this is a challenge in the megaprojects of the organization. In addition, measuring cost reductions at the portfolio level proved to be more difficult than expected.

Based on the results of the strategic initiative, what actions can organizations take to effectively deploy the results?

The strategic initiative showed that explicitly addressing the topic of cost-efficiency with each individual project team brought many positive cost reduction actions to the surface. Earlier studies point out well-working integration mechanisms for the institutionalization of change (Willems et al., 2020) and the importance of establishing a common project model (Dietrich and Lehtonen, 2005) as a success factor for the implementation of strategic initiatives. The organization already has an established project governance model. But to institutionalize the practice of investigating possibilities for cost reduction, a suggestion from the strategic initiative is to integrate a cost-efficiency checkpoint into the project governance model.

In line with the findings by Bredillet et al. (2018) on a PMO being instrumental for leading change and Sergeeva and Ali (2020) on a PMO facilitating collaboration between projects, a newly established PMO in the organization has the mandate to continue to focus on cost-efficiency after the conclusion of the strategic initiative. The PMO provides resources, systems and effective tools to do so (cf. Prado and Sapsed, 2016), including a well-developed project database and microlearning in order to share best practices with other projects. Further, using a KPI ensures continued focus on more cost-efficient construction projects.

The organization has also realized that change was not only about reducing project costs in each individual project, but much more about changing a mindset. Considering the reality of the temporary organization of construction projects and involving stakeholders has been crucial to align strategic objectives and create persistent change in the initiative. Successful collaboration with the project teams in this initiative confirms the importance of projects in the implementation of strategy (Lehtonen and Martinsuo, 2009; Himmel, 2012; Lowstedt et al., 2018). Likewise, change is always carried out in the context of the permanent organization (Martinsuo & Geraldi, 2020; Martinsuo, 2013). The presented study combines the two elements of considering the organizational context and the need to involve the projects when creating change.

When deploying the results of the strategic initiative, the Pentagon model (Rolstadås & Schiefloe, 2017) can be applied to give guidance on the different dimensions to consider. This includes the hard dimensions of structure and technologies, as well as soft dimensions of culture, interaction as well as social relations and networks. However, the empirical evidence from this study led to an augmented core to this framework, based on Saunders et al. (2008): In order to develop organizational capabilities and performance, a continuous focus on learning and knowledge transfer and aligning with organizational strategy is necessary.

The presented study confirms many aspects investigated in relevant literature before. But in contrast to previous research focusing on single aspects of implementation, this study gives a more comprehensive picture from the practical realm of a PBO when implementing results from a strategic initiative.

6. Conclusions

In the previous chapter, we have discussed the results of this study and answered the research questions. In the following paragraphs, we will present the study s contribution to both theory and practice and discuss the validity of the study as well as suggestions for further research.

6.1. The study s contribution to project management knowledge

This study contributes to the project management literature by providing a rich empirical account of a strategic cost-efficiency initiative in a project-based organization, which has not been previously focused on in the literature. Applying an organizational sociology perspective to the initiative shifts the focus from individual projects to the portfolio as a unit of analysis. The observed dynamics of the strategic initiative align with previous research on the necessity of sensemaking through action in the implementation of change activities (Stensaker et al., 2008). It also adds the dimension of a project-based organization to the findings by Willems et al. (2020) with respect to how the autonomy of strategic initiatives influences the implementation of results in the permanent organization.

The active involvement of construction project teams in the strategic initiative work contributed to increased ownership of the movement towards greater cost-efficiency. Actively engaging the project teams as contributors makes the study an example of avoiding isolation of the initiative from the permanent organization (Lehtonen & Martinsuo, 2009). The study supports the theory concerning the importance of adapting organizational changes to match the context of the project-based organization using empirical evidence, which helps project workers find value in the innovations to their ongoing work (Prado & Sapsed, 2016, p. 1811).

On a methodological level, this study answers the need for a more practice-based approach to project management research (Oddane, 2015). It also represents an example of the importance of including practical knowledge in organizational learning (Cicmil, 2006). The augmented Pentagon model, as shown in Fig. 2, provides a methodological tool for project management researchers and practitioners to structure the dimensions of a strategic initiative, especially in the initiative s implementation phase.

6.2. The study s contribution to practice

This study is an action research study inspired by a real-life problem: The contribution to practice is therefore inherent. Through investigating opportunities and initiating actions for achieving cost reduction in the project portfolio, the example of the strategic initiative provides guidance for project management practitioners on how organizations can cultivate a higher cost-efficiency focus (cf. actions listed in Appendix 1). Both cost-efficiency actions in the construction projects and concrete actions for organizational development are highlighted in this study. Practitioners are invited to replicate the interactive approach of creating cost-efficiency actions together with the project teams. The approach also includes incorporating the cost reduction objective into the key performance indicators (KPIs) and strengthening knowledge transfer on cost-efficiency actions. Microlearning and other ways of communication can also be used to contribute to the creation of a cost-efficiency culture. It is recommended to continue using the cost reduction KPI introduced during the strategic initiative. In addition, this study s results will help the organization to continue its cost-efficient construction project work, even after the strategic initiative is over. Other organizations can benefit from the experiences gathered in this study by applying the same principles to similar strategic initiatives.

6.3. Research validity and suggestions for further research

This research project uses an action research approach in a single organization, entailing a high internal validity and practical relevance to the organization in question. Methodological rigor is, however, limited due to the lack of researcher triangulation and the methods being developed during the research to adapt to the dynamics of the organizational context. Further, the fact that the researcher was employed in the organization and acted as a facilitator in the meetings may have caused research bias. Taking all of this into account, generalizability to other strategic initiatives may be limited.

Conducting further research in other organizations or using different methodological approaches than action research is suggested to verify the results, preferably using researcher triangulation. Nevertheless, experiences from the study may be useful either in other contexts in PBOs with similar challenges or with other objectives than cost-efficiency. For example, the importance of linking the objectives of the strategic objective to the organizational strategy, co-creation of cost-efficiency actions, and adapting governance structures in the permanent organization to allow a sustained continuation of actions could also be applicable in other organizational contexts. As most of the data for this study was collected before the Covid-19 pandemic, its effect is not seen in this study. It would be interesting to conduct further research investigating the pandemic s effect on the cost-efficiency of the organization s projects.

The presented study also touches upon some aspects of managing strategic projects in projects-based organizations, which inspire to undertake further research: Examples are focusing on the investigation of the role of PMOs in the management of strategic projects (cf. Sergeeva & Ali, 2020; Bredillet et al., 2018; Müller et al., 2019) or how the nature of the projects in the portfolio (e.g. type, size, length) impacts how strategic projects of programs are successfully managed (cf. Martinsuo & Geraldi, 2020; Martinsuo, 2013).

On a practical level, control measures for further development of project cost reductions in combination with maintaining customer satisfaction can even increase value creation in the future. Furthermore, this initiative identified the need to start a new initiative that specifically investigates cost development in megaprojects.

Language editing of the manuscript was done by Alasdair Graham-Brown (first version) and Speakwrite Communications (revision 2).

Declaration of Competing Interest

The first author is employed in the presented organization and her PhD-project related to the presented strategic initiative is jointly financed by the organization and by the Norwegian Research Council (Grant No. 286373). No competing interests are declared for the co-author.

Acknowledgements

The authors would like to thank Jack Meredith and Miia Martinsuo as well as the other participants in the paper development workshop for this special issue for their constructive comments and valuable suggestions for improvement of this paper. The authors also thank the anonymous reviewers as well as co-editor Jack Meredith for their valuable contributions.

Appendix 1

The following table presents real-life examples of actions for cost-efficiency in construction projects, developed and collected during the value meetings with the construction projects.

Topic & project type	Action and its (potential) effect on project cost
Reduction of area in a courthouse project	By reusing parts of concepts used in other courthouses, planning for co-use of areas by different users and planning with a potential future expansion, it was possible to reduce the area of the planned building by 31% compared to early design proposals. By additionally differentiating the level of quality in public versus internal areas of the building and eliminating cost-driving elements (change from parking garage to protected outdoor parking lot, reduction of ceiling height), the total expected project cost could be reduced by over 30% (≈10 million EUR).
Analysis of needs in an office building project	Even though the client ordered the addition of a new floor to their existing office building, the project team took a step back. By optimizing the area in the existing building to adapt to the changed needs of the client, it was possible to realize the client s needs without extra area. The potential savings are estimated to 3-6 million EUR.
Standardization of prison buildings	Together with correctional services, guidelines for a standardized prison concept were developed. The standardized concept was piloted in two projects, and the revised concept applied in the following two projects. Benefits included saving time and money in the planning and engineering phases of the project and simplifying collaboration with the client/user. The invitation for tender could be optimized, avoiding costly changes in the execution phase. This action, combined with a favorable market situation at the moment of tender, led to cost savings of 36% compared to the expected cost for the two most recent prison projects (equaling savings of approx. 60 million EUR.
Use of technology in an office building refurbishment project	The combined use of virtual reality, BIM and a 360-degree view of the building contributes to a better understanding of what has to be done and makes it easier to involve the users of the building in the planning. It also minimizes time and cost for travelling, which is important as the building is located remotely in Northern Norway. This action reduces the refurbishment of the building to what is necessary and adds value for the user.
Cost estimation and control in a prison refurbishment project	In a large prison refurbishment project, one action was to refurbish the two similar buildings in sequence and include both the refurbishment of building no. 2 as well as other works as options in the contract with the contractor. This enabled the commissioner to execute very tight cost control and the contractor could apply learning from the first building to the second. These actions led to a final cost of the project 10% below the already very tight cost frame.

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ISBN 978-82-326-5912-8 (printed ver.)
ISBN 978-82-326-5936-4 (electronic ver.)
ISSN 1503-8181 (printed ver.)
ISSN 2703-8084 (online ver.)

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