Interventions using digital tools to improve students' engagement and learning outcomes in higher business education

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Dedications

This dissertation is dedicated to my wife Margrete, for always supporting me and for never giving up on any project which she takes on, and to our three sons Bernhard, Magnus and Sigbjørn for always being honest with us.

Tromsø, July 2016

Bernt Arne Bertheussen

Contents

Acknowledgements

By and large, this research and development project has been a longstanding solo effort by me, the author of this dissertation. I have not only developed the course design and its interventions but also taught the course and conducted research on the course interventions. In other words, I have been the inventor, implementor and evaluator of the interventions. However, during the approximately 15-year process, I have received critical assistance from several important sources. The most important persons contributing to this development project are listed in Table 1.

Table 1. Persons with significant expertise who have contributed to this project.

Person(s)	*Contribution*
Students	Providing formative feedback on the course design.
Student assistants	Providing formative feedback on the workshops.
Faculty	Permitting and contributing to the implementation of a digital examination procedure and arranging staff to facilitate the digital assignments and digital examinations.
Referees of the scientific journals	The blind referees contributed to the overall quality of the scientific articles. I would also like to emphasise the significant input from the referees of the Journal of Accounting Education.
Svein Halvorsen	Chief software developer at Datakvalitet AS, Tromsø.
Leif Krane	Software developer at Datakvalitet who resolved the issue on how to deal with concecutive errors in automatic marking algorithms.
Svein Ottar Olsen	Professional input on the tentative theoretical framework.
Espen Sirnes	Co-responsible teacher in the course and co-author of the textbook. Sirnes also contributed to the data algorithms of the digital examination procedure.
Øystein Myrland	Co-author of the article titled, 'Relation between academic performance and students' engagement in digital learning. activities'.
School of Business and Economics UiT	The research community at the business school has inspired me to become a more active participant of their research practice.

Summary

The purpose of the present study was to develop interventions using digital tools to improve student engagement and learning outcomes. The empirical context was an undergraduate finance course wherein digital learning and assessment interventions were important features of the course design.

When designing the interventions, the development activities were underpinned by pedagogical principles based on cognitive and sociocultural learning perspectives. Special emphasis was placed on integrating spreadsheet usage into all learning and assessment activities and constructively aligning course targets, assessment tasks and learning activities with the overall goal to foster an active and engaging learning environment. In addition, rooted in a pragmatic research paradigm, the methodology utilised includes many similarities with interventionist action research, which has gained a foothold in qualitative management accounting research.

This interventionist research project includes two main contributions. The first is its impact on practice by designing and developing interventions to solve complex problems in an authentic classroom setting. Consequently, six practical educational interventions are discussed in this dissertation. The second contribution is theory building, which advances our knowledge regarding the characteristics of the interventions and the process of designing and developing them. Consequently, a total of eight refereed scientific articles have been produced during this research and development project.

As outlined in this study, the development of the digital formative feedback intervention, is in line with research stating that, in higher education, traditional paper-based feedback is being supplemented with and in some cases replaced by innovative use of ICT. Moreover, software algorithms can effectively provide detailed and helpful individual formative feedback to students regarding their learning processes and outcomes.

This study strongly supports the claim that it is problematic to use technology to enhance learning without recognition through assessments. The digital summative assessment intervention reported is regarded as a precondition for establishing a spreadsheet user-culture in the subject, especially as it served as an ‘icebreaker’ for other learning interventions that were integrated into the course design.

The intervention processes discussed have been through several iterations and their stepwise development and implementation have emerged through negotiating, compromising and resolving tension between the practitioner researcher, students and institution. The resulting compromises resolved tensions which sometimes resulted from limited physical resources. As the students valued the outcome from engaging in the digital learning and assessment interventions, they had a flexible attitude and deployed their private infrastructure (laptops) within the learning environment. Consequently, a vital part of the institution's infrastructure was transformed from a fixed asset (number of PCs available in a data lab) to a flexible asset in the theatres. This compromise that was negotiated between the institution, the practitioner researcher and the students was essential for the digital educational interventions to work and progress.

The overall theoretical research findings from this study are presented in the form of a tentative framework, which can help bridge the gap between the intervention practice and theory. A central conjecture in the framework is that tool usage that is integrated into interventions can be influential on learning activity and engagement and consequently on students' learning outcomes. Moreover, the framework supports the notion of ICT as a mediating cultural tool that provides a new type of affordance that can extend the mind and promote an active and engaging learning environment. In particular, integrating a spreadsheet tool in learning of management accounting subjects can offer opportunities for learners to rapidly construct financial models, enable simulations using the completed models and stimulate subject reflections based on the functions of the models and their results.

The practical outcome of this study has been emphasised through the development of artefacts that aim to support practitioners intending to integrate spreadsheet usage within their subject teaching and learning. By publishing and sharing the artefacts, the current research project is capable of informing future development and implementation decisions by guiding practitioners in similar pedagogical contexts.

List of research papers

Papers published or accepted in refereed scientific journals:

Paper 1: Bertheussen, B. A. (2015). Cultivating spreadsheet usage in a finance course through learning and assessment innovations. *Int. J. Innovation in Education, 3*(1), 1–13.

Paper 2: Bertheussen, B. A., Myrland, Ø. (2016). Relation between academic performance and students' engagement in digital learning activities. *Journal of Education for Business, 91*(3), 1–7.

Paper 3: Bertheussen, B. A. (2013b). Er handelshøyskolene innelåst i historiske pedagogiske spor? *Magma, 16* (5), 40–48.

Paper 4: Bertheussen, B. A. (2012a). Ruteark eller regneark. Kognitive utfordringer med å løse finansoppgaver på papier og PC. *Uniped, 35* (3), 87–101.

Paper 5: Bertheussen, B. A. (2016). Validating a Digital Assessment Practice. *Journal of Financial Education* (article in press).

Paper 6: Bertheussen, B. A. (2014a). Power to business professors. Automatic grading of problem-solving tasks. *Journal of Accounting Education, 32* (1), 76–87.

Paper 7: Bertheussen, B. A. (2014b). Automatisk formativ feedback kan gi god motivasjon og læring. *Uniped, 37* (4), 59–71.

Paper 8: Bertheussen, B. A. (2013a). Revitalizing plenary finance lectures. *Beta, 27* (1), 78–92.

List of artefacts contributing to practice

Artefact 1: Bertheussen, B. A. (2014d). *Automatic formative grading of problem-solving tasks in a spreadsheet.xls*. Open source system available from the author: bernt.bertheussen@uit.no.

Artefact 2: Bertheussen, B. A. (2014e). *Automatic summative grading of problem-solving tasks in a spreadsheet.xls*. Open source system available from the author: bernt.bertheussen@uit.no.

Artefact 3: Bertheussen, B. A. (2014c). *Implementation Guide*. Supplement to article published in Journal of Accounting Education, 32 (1), 76–87. Open source document available from the author: bernt.bertheussen@uit.no.

Artefact 4: Bertheussen, B. A., Sirnes, E. (2012). *doIT Finans. Praktisk innføring i investering og finansiering*. Cappelen Damm Høyskoleforlaget. Oslo.

Artefact 5: Bertheussen, B. A. (2015). *Interactive micro-lectures in basic finance*. Open source documents available from the author: bernt.bertheussen@uit.no.

Artefact 6: Bertheussen, B. A. (2012b). Slik kan regnearkmodellering revitalisere læring av klassisk bedriftsøkonomi. *Dybde 1/2012*, Publication at School of Business and Economics, UiT–The Arctic University of Norway.

List of tables and figures

Chapter 1: Introduction

1.1 Background and purpose

Plenary lecturing as a teaching method and utilising individual examinations as an assessment procedure may be suitable tools for cost-effective mass education at business schools (*Paper 3*). The additional teaching cost by having another student attend a lecture is virtually zero as long as the capacity limit of the auditorium is not affected. It is also efficient for a teacher to resolve their teaching obligation through plenary lecturing as the time spent preparing lectures becomes less every time the same lecture notes are used. Some additional students in the auditorium do not add significantly to the workload for the teacher.

Moreover, individual examinations can also be produced cost-effectively on a large scale. Alone, and without any other tools than a paper and pencil, the students work in an examination environment that is not analogous to what they will later encounter in the workplace (*Paper 5*). Business students work silently in large examination halls, being monitored by cheap labour (i.e. pensioners) who make sure that no one is cheating. However, the major emphasis on cost-effective volume production can compromise the quality of the education as the teaching and assessment methods used may only promote surface learning and not in-depth learning (*Paper 3, Paper 4*).

Moreover, one of the clearest findings from educational research is that feedback has a significant impact on learning (*Paper 7*). In a large auditorium with many students, however, feedback is usually absent (*Paper 3*). Such a learning environment invites inaction, which does not promote quality learning. Furthermore, it is the student's ability to remember and reproduce subject matter theory that is assessed at the final examination. If the claim is true that business schools are strategically 'locked' in historical pedagogical paths (*Paper 3*) such as plenary lectures and individual exams, the results may be that business students will achieve inadequate learning outcomes compared to those who participate in alternative learning and assessment interventions. There is also a risk that dropout rates can be influenced by educational programmes that are not engaging (Heimly & Bertheussen, 2016a).

Against this backdrop, it may be legitimate to ask whether business education has lost its relevance. Accordingly, the purpose of the present study was to develop interventions using digital tools to improve student engagement and learning outcomes in a finance subject in higher business education.

1.1.1 Integrating digital tools into subject teaching and learning

At present, business students at universities have already mastered certain aspects of computer technology, as evident from their use of social media (e.g. Facebook and Twitter) and search engines (e.g. Google). Nevertheless, many have not been trained to use spreadsheet technology in general (Awasthi et al., 2010; Stoner, 2009) or as a tool to address business problems (Bradbard et al., 2014; Kyng & Taylor, 2008; Treadwell et al., 2013).

A significant issue exists in the distinction between teaching about and teaching via ICT (information and communication technology) (*Paper 1*). If ICT has the status of a discrete subject in the curriculum, then it is often taught by an ICT specialist in an ICT suite and it is rarely integrated into subject teaching (Somekh, 2007). However, a recent study on technology integration into subject matter uncovered how programmes emphasising the development of knowledge and skills in an isolated manner are 'doomed to fail' (Koehler et al., 2014). In many of the less successful cases of integrating ICT into subject cultures, the teachers did not orchestrate a knowledge community, seemingly believing that knowledge was somehow embedded within the software, and that the technology itself would perform the teaching (Sutherland et al., 2004; Phelps, 2014).

Moreover, assessments have the potential to undermine educational innovations (*Paper 1*). In this regard, existing paper-and-pen practices of assessment are inflexible and they restrict the innovative usage of ICT. Thus, learning processes and goals can only change if assessments change (Redecker & Johannessen, 2013). Furthermore, assessment systems that utilise digital systems are necessary to address new sets of skills and knowledge which ICT can help develop (*Paper 5*). There is also strong evidence that pedagogical innovations can be quickly introduced if they are in line with changes in assessment practices (Somehk, 2007).

The present study rejects the view that ICT should be studied in isolation and argues for a holistic approach of integrating ICT into subject matter education (*Paper 1*). In other words, the integration of ICT must be grounded within the broader con-

text wherein it is situated (Chai et al., 2014). A combination of e-learning and face-to-face teaching was used in the present study, which consisted of a corporate finance course at undergraduate level. In the course design, innovative spreadsheet use was embedded within all of the practical learning activities, which focused on the application and integration of financial knowledge and spreadsheet skills (*Paper 1, Paper 2*). To determine the transference of the applied spreadsheet emphasis to the summative assessments, an innovative digital examination practice was developed (*Paper 5, Paper 6*).

The blending of ICT into teaching and learning of management accounting subjects requires a cross-disciplinary approach. In practice, mixing subject matter teaching and learning with ICT is difficult because these diciplines embrace different competencies, yet they have to work together to produce and maintain the learning outcome of the students (*Paper 4*). To develop constructs that reflect everyday teaching and learning concerns, we need to develop frameworks that bring insights from different theoretical disciplines (i.e. management accounting, pedagogy and ICT) and accept the necessary loss of conceptual refinement this requires when seen from a single disciplinary perspective.

One important aim with this dissertation is to further the understanding of how ICT, i.e. spreadsheet technology, can be integrated into subject matter learning in engaging ways while implicitly developing students' ICT skills. In this case study, the emphasis is on the development and evaluation of digital learning and assessment interventions within higher business education. Thus, the first research question in the study is as follows:

Research question 1:

What characterises interventions wherein finance students develop relevant ICT skills at the same time as they learn subject matter theory?

1.1.2 Opening up intervention and research opportunities

The objective of the present research and development project was to both advance practice and to build theory. The study is a longitudinal interventionist case study that was conducted by a practitioner researcher. Interventionist research (IR) is located where practice and theory meet (Kasanen et al., 1993). The aim of IR is to investigate and solve practical problems that gives sense and that results in theory

building (Jönsson, 2010). That melting point between theory and practice, we can perceive as an academy of practice (Westin & Roberts, 2010). If the use and the explanation match, we can both use the object in practice and provide a reason for how and why it is used. We have, in other words, made a full epistemological contribution (Westin & Roberts, 2010).

Interventionist work may be one of a rare available research methods for studying issues that are 'bubbling under' or that have not been extensively adopted by real-life organisations (Suomala & Lyly-Yrjänäinen, 2012). Moreover, the act of intervention can be used for validating the results during the process of research to support both the relevance and efficiency of theory production (Jönsson & Lukka, 2007).

An interventionist researcher has to straddle between the emic (insider) world that is followed during the empirical phase in particular, and the etic (outsider) world that requires reflection and for deriving broader theoretical implications based on the empirical evidence. The contributions from an interventionist study tend to emerge around these dynamic tension-based processes (Suomala & Lyly-Yrjänäinen, 2012). Moving between the etic and emic domains may provide opportunities for new insights, as the researcher strive to develop solutions that work in the field and at the same time return with findings and conclusions of theoretical significance (Jönsson & Lukka, 2007). Thus, the second research question in this study is as follows:

Research question 2:
How were tensions and problems between and within the etic and emic domains managed and exploited in this study?

1.1.3 Constructing theory from practice

There is a trend emphasising the significance of social science to society (Schultz & Hatch, 2005). This trend also resonates to management accounting research, as for decades there has been a request for research that is relevant to accounting practice (i.e. Jönsson & Lukka, 2007; Kaplan 1998; Kasanen et al., 1993; Labro & Tuomela, 2003; Suomala & Lyly-Yrjänäinen, 2012; Westin & Roberts, 2010). Furthermore, traditional educational research has also long been criticised for not being relevant for educational practice (i.e. Baughman, 2008; Bichelmeyer et al., 2006; Gutiérrez & Penuel, 2014; Plomp, 2009; Reeves, 2011; Winn, 2003).

At the crossroad of management accounting, education and information technology there are expectations of relevance that come from students, businesses and politicians. As researchers, their appeal for practical relevance poses challenges for the way we construct our theories and how we conceive their implications (Jönsson & Lukka, 2007; Schultz & Hatch, 2005; Westin & Roberts, 2010). In striving to maximise the benefits of rigour and relevance, the above researchers urge us to move into the domain of practical action. Unfortunately, existing institutional systems and professional expectations often generate more restrictions than incentives to create such relevant or actionable knowledge (Argyris, 2003; Hoffman, 2004).

The dynamic world of IR implies continuous participation in doing research in practice, to know 'what is going on', as Hastrup (2005) suggests: 'We can not get in touch with reality without making ourselves part of it.' Cook & Brown (1999) treat practices as actions informed by meanings grounded in specific contexts. Accordingly, knowledge is viewed more as a recursive dialogue between practice (action) and meanings (cognition). Hence, learning from practice is a main ingredient in arguing why intervention research could play an important role in educational management accounting research and also how it could be conducted (Westin & Roberts, 2010). In the present thesis, the relationship between theory and practice was turned upside down in order to enhance the relevance of educational management accounting research. Instead, of defining research as a process of translating theoretical knowledge into practical solutions, this research and development project tapped into practical knowledge in order to produce better theories. A significant issue is how we theoretically grasp what is going on in practice when involvement entails a subjective human part and when the objects to be studied are not under control and are complex to measure and express. The main task here is to make a reliable translation between practice and theory. Thus, the third research question in this study is as follows:

Research question 3:
How can the interventions, the retrospective analysis and the papers resulting from this study be translated into a tentative theory on student engagement and learning?

1.2 Research philosophy

In every stage of research, assumptions are made about human knowledge and the nature of the realities encountered (Crotty, 1998). These assumptions inevitably shape how to understand the research questions, the methods used and how the findings can be interpreted (ibid.). The present study is situated within a pragmatic research paradigm. For pragmatists, the importance of a research finding is its practical consequences, i.e. concepts are only relevant when they can support actions (Kelemen & Rumens, 2008). There are many different ways of interpreting the world and undertaking research for a pragmatist, and no single viewpoint can provide the entire picture because multiple realities exist (ibid.). The research philosophy 'pragmatism' rejects the notion of absolute dualism such as objectivism versus subjectivism. Johnson and Onwuegbuzie (2004) stated that pragmatism 'prefers more moderate and common sense versions of philosophical dualisms based on how well they work in solving problems'.

In addition, pragmatism acknowledges fallibility and views truth as a matter of degree (James, 1975). Accordingly, research conclusions can never be viewed as absolute. Furthermore, the pragmatist John Dewey (1998) argued that the purpose of research was to 'fix' situations. The philosophical and methodological middle ground offered by pragmatism empowered this study to draw upon both quantitative and qualitative methods in order to address specific research questions. Table 1.1 sums up the ontology (the nature of reality), the epistemology (what is considered acceptable knowledge) and the axiology (the role of values) that underpin the present study.

Table 1.1. Ontology, epistemology and axiology of the pragmatic research paradigm underpinning the present study*

Ontology	*Epistemology*	*Axiology*
Truth and reality are contemporary, ever-changing and a matter of degree determined by their real effects and practical consequences. Views chosen to best answer a research question.	Knowledge is an essential plan of action, which proposes practical ends to be attained. Focus on practical applied research by integrating different perspectives to help interpret the data.	Values play a significant role in interpreting the results. The researcher adopts both objective and subjective viewpoints.

* Building on Luo (2011) and Saunders et al. (2011).

1.3 Walking the narrow line between bias and objectivity

The author has held multiple roles in this research and development project. In particular, I developed the course design and prepared most of the learning materials distributed to the students: interactive problem-solving tasks, interactive micro lectures and a textbook (with a colleague). In addition, I also taught the course and created the digital examination papers, which were automatically scored. As an insider researcher, I cannot claim that the research process was unbiased due to my proximity to the situations being researched. Thus, in the present dissertation summary, I will use the first person to denote my closeness to the research process. The insider position is in line with anthropological researchers and with many forms of qualitative research.

However, some qualitative proponents argue that the researchers themselves are the best research tools with their biases, insights and deep understanding of the context. Anderson and Shattuck (2012) argued that this inside knowledge adds as much as it detracts from the research validity. Good research demands 'scepticism, commitment and detachment', but interventionist action research also requires comradeship, enthusiasm and a willingness to actively support the intervention (Norris, 1977). Thus, certain wisdom is necessary to walk the narrow line between bias and objectivity.

Action research accepts the more realistic prospect of a teacher as a reflective practitioner by not enforcing an artificial line between researchers and subjects (Kelly et. al., 2008). The role of the present author as a teacher, interventionist and researcher of the finance course became an important part of the authentic context of this study. In addition, it allowed me to intensively explore the problem, not only from an academic perspective but also from the perspective of a practitioner who has previously dealt with the problems on a daily basis. Practitioners, with their intimate knowledge of problems as well as their contexts and contingencies, can craft appropriate solutions (Herrington & Reeves, 2011) as 'the problem, solution and the cognition involved getting between the two cannot be isolated from the context in which they are embedded' (Brown et al., 1989, p. 36).

Another positive consequence of the author's multiple roles was that a greater degree of methodological alignment could be achieved because I taught the theory, developed the interventions as well as measured the outcomes (Hoadley, 2004). However, my proximity as a participant/researcher to the situation has (to some

extent) caused biassed collection, interpretation, analysis and reporting (Burns, 2000). Nevertheless, I attempted to be cognisant and conscientious of the fact that the research results should not be influenced in a significant way by my multiple roles.

1.4 Structure of the thesis

The remainder of this dissertation is as follows. Chapter 2 discusses issues related to inductive theory building from case studies and the research approach applied, which includes many similarities with interventionist action research. Chapter 3 is a 'thick' description of the interventions that were developed in the study. Chapter 4 is a retrospective reflective analysis of the intervention processes that took place. Chapter 5 reports on the scientific findings of the study in terms of the eight reviewed papers that have been published in scientific journals. Moreover, a tentative theoretical framework is presented at the end of Chapter 5 based on the practical framework (Chapter 3), the retrospective reflective analysis (Chapter 4) and the published papers. Finally, Chapter 6 integrates and synthesises the various issues and provides the conclusions of the dissertation.

Chapter 2: Building theory from practice

This chapter provides an outline of significant issues on constructing theories from practice which is essential in this study. Emphasis will be devoted to research highlighting theory building based on interventionist action research studies. Finally, objectivity and validity issues will be addressed.

2.1 Building theory from case studies

A motivation for theory building from case studies is the capability to bridge rich qualitative evidence to mainstream deductive research (Eisenhardt, 1989). Inductive case research is compatible with deductive research through its focus on developing constructs, measures and testable theoretical propositions. Whereas inductive theory building from cases can produce new theory from data, deductive theory testing can complete the cycle by using data to test theory (Eisenhardt & Graebner, 2007). Case studies are rich, empirical descriptions of particular instances of a phenomenon based on a variety of data sources (Yin, 2014). The basic idea is to use one or more cases in order to develop theory inductively (Eisenhardt & Graebner, 2007). In case studies, the theory is emergent in the sense that it is situated in and developed by identifying patterns or relationships among constructs and their underlying logical arguments (ibid.).

Replication logic is central to constructing theory from case studies as each case serves as a distinct experiment that stands on its own (Eisenhardt, 1989). Multiple cases are discrete experiments that serve as replications of the emerging theory (Yin, 2014). In contrast to laboratory experiments that isolate a phenomenon from its context, a case study underlines the rich, real-world context in which the phenomena occur (e.g. Chapter 3 of the thesis summary). The process of constructing theory occurs via recurring cycles involving case data, emerging theory and in later stages, existing literature (Eisenhardt & Graebner, 2007). Researchers, including classical scholars like Chandler (1962), have used cases to develop theory about diverse topics, as theory building from cases is an alternative method that takes advantage of rich empirical data. The process of building theory from a single case is summarised in Table 2.1.

Table 2.1. The process of building theory from a single case study*

Step	*Activity*	*Reason*
Getting started	Definition of research question	Focuses efforts
	Possibly a priori constructs	Provides better grounding of construct measures
Selecting case	Neither theory nor hypotheses	Retains theoretical flexibility
	Specified population	Constrains extraneous variation and sharpens external validity
	Theoretical, not random, sampling	Focuses efforts on theoretical useful cases
Crafting instruments and protocols	Multiple data collection methods	Strengthens grounding of theory by triangulation evidence
	Multiple investigators	Fosters divergent perspectives and strengthens grounding
Entering the field	Overlap data collection and analysis, including field notes	Speeds analyses and reveals helpful adjustments to data collection
	Flexible and opportunistic data collection methods	Allow investigators to take advantage of emergent themes and unique case features
Analysing data	Within-case analysis	Gains familiarity with data and preliminary theory generation
Sharping hypothesis	Iterative tabulation of evidence for each construct	Sharpens construct definition, validity and measurability
Enfolding literature	Comparison with conflicting literature	Builds internal validity, raises theoretical level and sharpens construct definitions
	Search evidence for 'why' behind relationships	Builds internal validity
Reaching closure	Theoretical saturation when possible	Ends process when marginal improvement becomes small

* Building on Eisenhardt (1989).

2.2 Interventionist case study research

There are many varieties of case studies, one of which is interventionist case research (Yin, 2014). Interventionist case research has many similarities with non-interventionist research as both aim at creating a meaningful conceptualisation of the phenomena they encounter in the field, at gaining an understanding of what is going on in the case and finally to develop explanations (Jönsson & Lukka, 2007). The theoretical targets include similar options and attempts toward theory contribution require translation of the findings to a more general level in both approaches (Lukka & Kasanen, 1995). The major differences relate to the fact that an interventionist researcher is directly involved with something that is going on in the case and they do not try to avoid having an effect. Instead, an intervention is applied as a research asset (Westin & Roberts, 2010).

A key advantage of interventionist research is the opportunity to collect data which are more difficult to access and more significant than what can be accessed through more traditional research methods (i.e. *Paper 2*, *Paper 5*). Interventionist research is not just theorising 'grounded in the data', but it means being 'grounded in action' (Jönsson & Lukka, 2007). One of the most important reasons to conduct interventionist research is to overcome the weaknesses of research where subjects do not have to commit to action and create a future that they themselves must become a part of (ibid.).

An interventionist researcher has an opportunity to examine what participants actually say and do in circumstances, which really matter to them, as compared to what they might say or do hypothetically (Eden & Huxham, 1996). According to Argyris & Schön (1974), this means getting an understanding of subjects' 'theory-in-use' rather than their 'espoused theory'. To put it in other terms, interventionist research approaches offer the researcher great potential to gain emic understandings of what is going on in the case organisation. An interventionist researcher typically participates in a change process that may lead to a new bundling of things together—construction of new realities—jointly with people working in the case organisation (Labro & Tuomela, 2003). Often interventionist research has a clear orientation to solve practical problems (Kasanen et al., 1993). The researcher will be able to enter another domain than that of academic knowledge: the realm of practical reasoning. Being able to do this successfully means that they are viewed as a serious participant

in this process and if so, will be treated and talked to like 'one of us' (Jönsson & Lukka, 2007).

Particular advantages of the interventionist research include that the examined issues bears practical relevance almost by definition and that there are normally few recollection problems because the core issues analysed take place simultaneously with the study (Baard, 2010). While the participant observation dominated phase of the research process requires an element of commitment– which generates a risk of the researcher 'going native' and thereby rendering their theoretical conclusions biassed– the final parts of interventionist research projects tend to be similar to those of non-interventionist studies, that is, analysing the materials the fieldwork has produced with an aim of developing a theoretical contribution.

This means analysing– unbundling– the issues that were at stake when the new reality was constructed during the fieldwork. It is likely that an interventionist researcher enjoys a relative advantage versus a non-interventionist researcher of getting deeper into the organisational realm due to their direct involvement in the daily life of the target organisation (Jönsson & Lukka, 2007). Significant features of the interventionist and the non-interventionist case research approaches are summarised in Table 2.2.

Table 2.2. The interventionist and non-interventionist case study research approaches*

Feature	*Non-interventionist*	*Interventionist*
Theory contribution	Aim at developing explanation of a phenomenon. Findings need to be generalised so that they are meaningful in other contexts (Lukka & Kasanen, 1995).	
Involvement	Outsider perspective, not directly involved in the study. Etic understanding.	Insider perspective, applies intervention as a research asset. Participates in a change process.
Understanding of the study (see Table 2.3)	Etic	Emic

Approach to rationality	Theoretical reason; classical rationality. Deducing whether a statement is true or significant.	Practical reason; 'What should I do in a situation like this?' Taking action and assuming responsibility for the consequences. Deliberation of appropriateness of end and means (Searle, 2001).
Data collection	Traditional research methods; espoused theory.	An opportunity to collect more subtle and significant data; 'theory-in-use' (Argyris et al., 1985).
Length of study	Short-lived	Long-lasting
Study takes place	Ex-post	Real time
Relevance of study	Theoretical per se, practical by deconceptualising theoretical findings.	Practical per se, theoretical by conceptualising practical findings.

* Building on Jönsson & Lukka (2007).

2.3 Interventionist action research

The present study is a longitudinal case study conducted by a practitioner researcher. The research approach utilised is rooted in a pragmatic research paradigm and includes many similarities with interventionist action research. The practitioner researcher's knowledge of scientific research methods emerged gradually in line with the research and development process and, accordingly, the research approach discussed is the result of a retrospective reflective analysis that concluded the project (see 4.3.2).

2.3.1 Characteristics of interventionist action research

Action research (AR) constitutes the origin of the IR approaches (Jönsson & Lukka, 2007). IR is a member of the AR family that can increase the relevance of management accounting research (Westin & Roberts, 2010). The essence of interventionist research is researching where practice and theory meet (ibid.). Drawing on Kurt Lewin's dictum of 'One of the best ways to understand the world is to try to change it' (Argyris, et al., 1985, p. xii), AR is today accepted as a complementary and significant research tool in management accounting research (Westin & Roberts, 2010). AR has

been extended, enriched and developed in various directions, all of them considering learning as a main ingredient for change and development in organisations (Argyris et al., 1985).

AR in management accounting is not an unknown methodological research approach (Westin & Roberts, 2010). Sten Jönsson launched his book *Accounting for Improvement* in 1996, which discussed the outcome of several doctoral theses and a number of articles based on AR projects. In 1998 Robert Kaplan published an article with a focus on creating new management theory and practice through 'innovative action research'. Carkhuff (1985, p. 163) defines an intervention when stating the following: '… an intervention is both a response and an initiative. It is a response to a situation that defines a need. It is a response to a deficit or to what is not present. At the same time, it is an initiative to influence that situation–to fill in what is not present, to transform the deficits into assets. In short, an intervention is an attempt to make a difference.'

Argyris et al. (1985) described intervention theory as a theory of action (theory-in-use), as did Kaplan (1993). IR draws from such areas as evaluation research, behavioural assessment, technology assessment, technological transfer, simulation and modelling, meta-analysis, knowledge utilisation, practice technology and system engineering (Baard, 2010). It is the configuring of these methodological elements into a system of action that create practical intervening innovations (Thomas & Rothman, 1994). Change is an inherent aspect of intervention research. Static situations with controllable subjects and objects are rarely a part of a dynamic practice (Westin & Roberts, 2010). Researchers intervening in organisational systems have dual objectives: to advance knowledge in their field and help improve the system under study (Baard, 2010). Interventionist research aims to narrow the gap between practice and academic theory (Jönsson, 2010; Jönsson & Lukka, 2007).

IR is a genre of applied research (Thomas & Rothman, 1994) and has two outputs: a knowledge product for both researcher and practitioner and a practice product or intervention developed for problem solution (Thomas & Rothmann, 1994). The aim of IR is to effectively improve a real-life context through the development of interventions. This involves a coordinated effort of all participants who are actually experiencing the problem. Apart from the generation of theoretical knowledge, the design and development of an intervention is the focal point of IR (Baard, 2010). IR is based on a case or field study.

Thomas and Rothman (1994) indicated that there is no one particular research technique that is employed in the design and development phase of the intervention. Both quantitative and qualitative research are used. Argyris (1974) encouraged researchers to apply traditional research methods for information gathering to promote the validity of the information on which intervention design is dependent. In line with Argyris, Kasanen et al. (1993) emphasised using case study methods in their constructive research approach (CRA). They also indicated that CRA may either be quantitative or qualitative or both. CRA is a variant of intervention research that focus on practical problem solving (Baard, 2010).

Responding to the claim that management accounting had lost its relevance (Johnson & Kaplan, 1987), Kasanen et al. (1993) proposed, in a seminal article, the constructive approach as a significant option for management accounting researchers. They argued that the academic literature has merely analysed and interpreted the innovations constructed elsewhere in retrospective, i.e. the ROI-measure in profit-centre accounting or the DCF-techniques in capital budgeting, and stated that almost all of such constructions have been developed in practice, i.e. within companies or consulting bureaus.

Kasanen et al. (1993) referred to constructions in general terms as entities which produce solutions to explicit problems. CRA refers to a 'construction' as an 'intervention' or 'innovation' (Baard, 2010). An important characteristic of constructions is that their usability can be demonstrated through the implementation of the solution, as it is 'always difficult, if not impossible, to assess the practical adequacy of any new construction prior to its implementation' (Kasanen et al., 1993). Another essential part of the constructive approach is to connect the problem and its solution with accumulated theoretical knowledge (ibid.). Labro and Tuomela (2003) describe CRA as a sequential process that addresses methodological aspects (validity and theoretical connections), while providing a practical focal point.

An intensive search for both a practically and theoretically innovative solution is the primary feature distinguishing constructive research from other types of action research (ibid.), as there are two products stemming from CRA: a novel construct (see *Artefact 1, Artefact 2, Paper 6*) and theory refinement, development, testing and abandonment (see *Paper 1, Paper 2, Paper 7*).

According to Jönsson & Lukka (2007), the purpose of CRA is to balance the problem-solving oriented practical starting point of an IR study and the potential for

theoretical contribution. Through intervention, the researcher develops in collaboration with the host organisation a new construction, tests its usability and draws theoretical conclusions based on the process. Fundamentally, CRA comes close to the original ideas of Lewin (1946) on action research (ibid.).

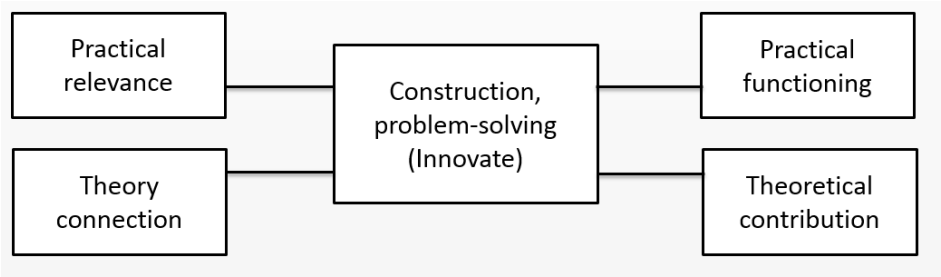

Figure 2.1. The main elements of CRA (in Baard, 2010; adapted from Kasanen et al., 1993).

IR is entrenched in AR and branded with AR derivatives such as action science, clinical research, design science and constructive research (Baard, 2010). Jönsson and Lukka (2007) and Aken (2004) also refer to design-based research (DBR) as an alternative form of IR. The term 'interventionist research' constitutes an umbrella over a family of interventionist-oriented approaches under various names (Jönsson & Lukka, 2007). In this study, CRA will be labelled under the generic term IR as it is considered an IR variant (Baard, 2010).

There are, however, several *design*-oriented IR variants: CRA (constructive approach–Kasanen, 1993; Labro & Tuomela, 2003), D&D (design and development research–Thomas & Rothmann, 1994) and DBR (design-based research–Van den Akker, 1999, 2006). Table 2.3 summarises typical characteristics represented in the different design-oriented IR variants.

Table 2.3. Characteristics of design-oriented IR variants

Interventionist	The research aims at designing an intervention in a real-world setting.
Process oriented	The focus is on understanding and improving interventions. In CRA, output measurement is more in focus.
Utility oriented	The merits of a design is measured in its practicality in real contexts. The practical value is more valued in the CRA variant.
Iterative	The research incorporates cycles of analysis, design and development, evaluation and revision. The iterative attribute is less voiced in CRA.
Theory oriented	The design is at least partly based on a conceptual framework and upon theoretical propositions. The systematic evaluation of consecutive implementations contributes to theory building and refinement.
*Involvement of practitioners**	The research involves practitioners' participation in the various stages of the process. This will increase the chance that the intervention will be relevant and practical and of successful implementation.

* In the present study, the researcher and the practitioner was the same person.

2.3.2 Phases of an interventionist action research process

Table 2.4 extracts the phases of the interventionist research approach (CRA) which, in retrospective, best resembles the approached utilised in this study (see 4.3.2).

Table 2.4. Phases of an interventionist research process*

Phase 1	
Find a practically relevant problem that also has research potential.	A practical problem lies at the core of any interventionist research problem. Moreover, the development challenge should also be directly relevant to decision-makers in the host organisation. The problem should also be theoretical significant, and there should not be any obvious solution available in literature.
Phase 2	
Obtain a general and comprehensive understanding of the topic.	To become familiar with both the practical and the theoretical underpinnings of the topic, the researcher needs ex-ante knowledge of theory in order to make informed interventions and to identify and analyse theoretical contributions of the study (Dickens & Watkins, 1999).

Phase 3 Innovate, i.e. construct a solution idea.	An intensive search for both a practically and theoretically innovative solution is the primary feature distinguishing interventions research from other types of action research. The innovation phase is creative, and often heuristic. Cooperative teamwork between the researcher and host organisation is crucial.
Phase 4 Implement the solution and test whether it works in practice	Interventionist research relies on the pragmatic notion of truth and, accordingly, the implementation phase is an elementary part of the research. It is critical to implement a construct, as even a failed trial may lead to theoretically interesting findings. A successful implementation means that the research process has been effective (at least partly) and that the construct is technically feasible.
Phase 5 Examine the scope of the solution's applicability.	In this phase, the researcher should consider the wider implications of the intervention, i.e. external validity. This involves discussing those aspect of the intervention that could be transferable to other organisations. In case of failed implementation, it is possible that problems are likely to emerge in other organisations.
Phase 6 Show the theoretical connections and the research contribution of the solution concept.	There are two primary ways of contributing to theory from interventionist studies. First, the construct itself is of such novelty that it introduces a new means to achieve certain ends (Mattessich, 1995). Second, an interventionist case study can serve the purpose of developing, refining or testing a theory (Keating, 1995).

* The table is compiled from Kasanen et al. (1993), Labro & Tuomela (2003) and Lukka (2000, 2003).

Most phases of the interventionist research process partly overlap with the previous and following phases. Labro & Tuomela's (2003) framework, which builds on Kasanen et al. (1993), has encompassed an extra phase on examining the potential for long-term research cooperation with the target organisation (Baard, 2010). This

phase was not included in the original work of Kasanen et al. (1993), and it is omitted from the above table. Nevertheless, gaining and maintaining a commitment from the case company is crucial for the research process not to be abandoned at a too early a stage (Lukka, 2000). In an IR case study the main issue is whether or not the case company has adopted the construct (ibid.). Nevertheless, IR case researchers should assess the transferability of their construct, at least to some extent (Labro & Tuomela, 2003).

Kasanen et al. (1993) and Labro & Tuomela (2003) provide transparency concerning validity issues (Baard, 2010) by making a case for market-based validation of managerial constructs. The *weak* market test is passed when the host organisation is willing to apply the construct to their actual decision-making problem. Lukka (2000) stated that the weak market test should refer to the actual implementation of the construct (as in the present study), rather than only being willing to implement it. The *semi-strong* market test is passed if the construct is widely adopted by organisations. Passing the *strong* market test requires that the organisations applying the construct systematically produce better results than those that are not using it. Phases 3, 4 and 5 are particular related to ensure internal validity, while phase 6 deals with external validity (Labro & Tuomela, 2003). The exact theoretical contribution can be elaborated on only in the final part of the research process (ibid.).

Interventionist research is not a monolithic concept, as a number of variations for different purposes can be identified (Suomala & Lyly-Yrjäinäinen, 2012). Jönsson & Lukka (2007) distinguish between studies that work through modest and strong interventions. Modest interventions are less intrusive and serve as facilitators for change or novel thinking through the mere presence of the researcher (Suomala & Lyly-Yrjäinäinen, 2012). Strong interventions aim either at changing the processes of host organisation by re-engineering the system(s) or by proposing alternative designs for the processes themselves. Strong interventions on the basis of active input by researchers are associated with a long-term view (for example three to six years) (ibid.). As will be described in the next chapter, strong interventions were applied in the present study, aimed at changing the design of teaching and learning processes.

In addition to intervention strength, Suomala & Lyly-Yrjäinäinen (2012) also adopt a classification on the focal point of the intervention. This refers to the extent to which the researcher is directly intervening in management accounting practices

or tools within this discipline and to what extent the focus of the intervention touches other disciplines. As will be discussed in Chapter 3, the present study is cross-disciplinary, embracing management accounting (i.e. corporate finance), pedagogy (i.e. learning of finance concepts and theory) and ICT (development of ICT tools to scaffold learning and assessment processes). In brief, the focal point of the present long-term interventionist study is not management accounting as practised in a commercial organisation, but learning and teaching of management accounting theory as practised at a business school.

2.4 The logics of the etic and emic perspectives

An interventionist action researcher deliberately seeks to make an impact on practice through interventions in order to gain knowledge. Hence, there is a need for the researcher to cross the border between the etic (outsider) and the emic (insider) perspectives (Suomala et al., 2014). Shifting between different logics provides opportunities for new insights, as the researcher wants to achieve solutions that work in the field and come back with theoretical contributions (ibid). Interventionist research has the potential to be meaningful from the empirical, situation-specific viewpoint as well as from a more general, theoretical perspective (Jönsson & Lukka, 2007).

When a researcher creates theoretical knowledge by observing practice as an outsider, they will be foregoing the intimate knowledge of the processes taking place within the organisation as they themselves are not an active participant (Glosvik, 2009). The researcher is wearing professional lenses, assuming that the fragments studied are representative of the current context (Sandberg & Tsoukas, 2010). Accordingly, it is likely to pay attention toward measurable phenomena with a focus on uncovering causal relations (Irgens, 2011).

However, general theoretical knowledge is insufficient for the purpose of practical application because the importance of the context of a practitioner is underestimated (Gjøsæter & Kyvik, 2015). Neither is the uniqueness of the situation that is typical of practical activities taken into account. Nor is the time frame included within theoretical knowledge due to abstraction. Time is, however, a key factor that a practitioner must consider when searching for solutions to problems and implementing them. A practitioner must adapt theoretical knowledge to their own context and the current situation in order to benefit from it (ibid.).

Practical reasoning deals with taking action and assuming responsibility for the consequences (Jönsson & Lukka, 2007). This is different from deducing that a statement is true or significant. When considering going into action we first deliberate and arrive at a prior intention (Searle, 2001). Next, we initiate action and thereby cause things to happen, before finally maintaining the effort until the action is done (Jönsson & Lukka, 2007). Our actions must be justifiable in terms of the appropriate goal set for the situation as we diagnose it. The key consequence of accepting appropriateness as the perspective of action is that the view on decision-making has to shift (March, 1994).

Instead of being a calculative, optimising activity, it is seen as deliberation on good, situated arguments for action. It follows that we have to be alert to justification in context. We need to study the particular– the solution to this problem in this situation. This is what we observe and deal with as interventionist researchers (Jönsson & Lukka, 2007). Individual actors as well as collectives communicate, interpret arguments in context and make sense of information by contextualising it (Glosvik, 2009).

An intervening researcher must understand the interaction between theoretical (etic) and practical knowledge (emic) to work well in a practical context (Grimen, 2008). By reflecting over the intervention practice, they can develop a greater scope of action (Mogensen, 2013). An intervening researcher must familiarise with the context and 'read' the unique of the situation. They must be capable of building relationships and make appropriate decisions within the time constrains and resources that are currently on hand (Brunstad, 2009). Theoretical knowledge may, conversely, contribute to reflections that empower an intervening researcher to view the problem from multiple perspectives (Sandberg & Tsoukas, 2010). An intervening researcher should be able to apply theoretical knowledge to analyse and understand the problems that have their origin in a practical context (ibid.).

If it is accepted that interventionist research means entry into the realm of practical reason, but that reporting results is to be done in the academic realm of pure reason, subsequently there is a translation problem (Jönsson & Lukka, 2007). During the critical phases of the empirical work, an intervening researcher has to apply practical reason that will require a careful and thoughtful adoption and mobilisation of the emic perspective (Westin & Roberts, 2010). However, any interventionist study culminates in the question of what was learned from the research project and what

precisely is the theory contribution one can make out of it. Hence, the researcher has to cross back to the realm of academic 'pure reason' and thereby adopt the etic perspective– something that any researcher has to eventually do to make the study academically interesting and justified (ibid.).

The context of problem solving usually encountered in interventionist research includes misunderstandings, faulty information, dead ends and differences in priorities as well as less skilful argumentation. This requires a 'thick description' (Geertz, 1973) to do justice (i.e. see Chapter 3). But thick description rarely constitutes a theoretical contribution. In order to render the findings a contribution to the relevant current discourse in research literature, the results must be reflected in that literature to make the contribution visible (Jönsson & Lukka, 2007).

IR has been suggested as one possible way to provide theoretical contribution and produce practically relevant management accounting research (Suomala & Lyly-Yrjänäined, 2012). The diverse contexts and problems to which interventionist research is applicable show a potential for bridging gaps between theories and practice (Baard, 2010). Table 2.5 reviews notable logics within the etic and emic perspectives.

Table 2.5. The logics of the etic and emic perspectives*

The etic perspective	**The emic perspective**
Knowledge is research-based and includes relatively stable and observable relationships between real phenomena.	Knowledge is based on experience, contextual and situational.
Knowledge is abstract, general and objective.	Knowledge is subjective and cannot be separated from the persons that possess it or from situations where it is learned and applied. Knowledge can be partly intersubjective through shared experiences or by communicating it to others.
Knowledge is publicly available and can be used by everyone.	Knowledge is related to personal and others' experiences in a profession and can be largely tacit. Often it is neither systematic nor documented.

Knowledge is developed from the outside by a researcher who does not participate in the processes themselves.	Knowledge is developed from the inside. The practitioner participates actively in the processes.
Problems are developed by the knowledge producers based on theoretical interests.	Problems are generated by the users of knowledge based on their real needs.
Knowledge is developed by studying discrete and separate small units.	Knowledge is developed by relying on a holistic everyday ontology.
An organisation is decoded as a large machine that can be optimised.	An organisation is interpreted as relational activities and processes.

* This table is based on Gjøsæter & Kyvik (2015), Grimen (2008) and Hyllseth (2001).

2.5 Objectivity

Participant research involves the active engagement of the researcher in the case being studied to the extent that they influence the activities and discourses which take place (Guba & Lincoln, 1994; Lincoln & Guba, 1985; Cohen & Manion, 1994). In studies where the researcher is 'intimately involved in the conceptualisation, design, development, implementation and researching of a pedagogical approach', ensuring that researchers make credible and trustworthy assertions can be a challenge (Barab, Squire, 2004). The core criticism of the participant researcher is that the close proximity of the investigator to the situation being researched can cause biassed collection, interpretation, analysis or reporting (Burns, 2000; Jönsson & Lukka, 2007; Kasanen et al. 1993).

One approach to resolving this issue is by drawing the researcher's perspective into the analysis by integrating it into existing theory (Barab & Squire, 2004; Labro & Tuomela, 2003). Through observing the recursive patterns of the researcher's framing questions, it promotes the understanding of the development of goals, the implementation and the analysis of the results. To this extent, in IR, the researcher can be encouraged to intervene wherever possible as a means to examine core theoretical issues and explore learning (Baard, 2010; Barab & Squire, 2004). Viewed from this perspective, the fact that this research is based upon real field work and it is conducted by a practitioner who has attempted to improve their practice through a methodological approach to research and development is a potentially valuable

aspect (Gutiérrez & Penuel, 2014). In other words, this research is hedged in a real-world context and it derives practice-based theories from experience. In taking this position, it is important to note that any claims made are based on researcher-influenced contexts and, as such, they may not be generalisable to other contexts in which the researcher is not involved (Barab & Squire, 2004).

2.6 Validity

Generalisation is related to the quantitative concept of external validity or to the extent in which the results of a study can be applied to other domains (Guba & Lincoln, 1994). Conversely, IR relies on techniques used in other research paradigms in order to promote validity, reliability and objectivity (Baard, 2010). In general, individual studies do not yield rich, detailed theory. Rather, individual studies contribute to theoretical understanding by providing scientific insights which constitute the building blocks of theory (McKenney & Reeves, 2012, p. 37). Multiple methods are often employed to study phenomena in complex authentic settings, thus retaining a high degree of ecological validity (Brewer, 2000). In an ecologically valid study, the methods, materials and settings are quite close to the real-life situation under investigation (Gutiérrez & Penuel, 2014). Moreover, the external validity of a study increases when conducted under real-world conditions (Baard, 2010; Jönsson & Lukka, 2007; Kaplan, 1998; Kasanen et al., 1993; Labro & Tuomla, 2003).

Similar to case studies and experimental studies, the findings in IR cannot be generalised to a larger universe (Baard, 2010) and there is no statistical generalisation from sample to population, as in the case of survey research (Yin, 2014). Moreover, in case studies and experimental studies, the researcher aims to generalise a particular set of results to a broader theory (ibid.), which is also the case in IR. According to Kasanen et al. (1993) and Labro & Tuomla (2003), the interventionist researcher should strive to generalise to some broader theory. However, in IR, generalisation concerns the ability to transfer both theoretical insights and practical interventions into other settings (Baard, 2010; McKenney & Reeves, 2012). As Brown (1992) stated: ‘We must operate always under the constraint that an effective intervention should be able to migrate from our experimental classroom to average classrooms operated by and for average students and teachers, supported by realistically technological and personal support’.

To some extent, generalisation can be enhanced by replication (Baard, 2010; Gravemeijer & Cobb, 2006; Cobb & Gravemeijer, 2008). Nevertheless, each context includes unique characteristics that require the theory to be used as guidance and direction, without giving 'certainties' (Plomp, 2009). It is in this context that Reeves (2006) cited Lee Cronbach: 'When we give proper weight to local conditions, any generalisation is a working hypothesis, not a conclusion' (Cronbach, 1975, p. 125). As there are so many factors at play when interventions 'go live', replication in IR is different from replication in the laboratory sense (Reinking & Bradley, 2008). There is also the need to explicate the 'local conditions' as an integrated element of the results of IR research (Hoadley, 2004; Reinking & Bradley, 2008; Tabak, 2004; van den Akker, 1999).

Furthermore, theories must be tested through replications of the findings in various contexts with the purpose that the same results should occur (Baard, 2010; McKenny & Reeves, 2013). Once such replications have been made, the results might be accepted for a larger number of comparable contexts. This replication logic is the same that underlies the use of experiments and allows experimental scientists to generalise from one experiment to another (ibid.). Yin (2014) referred to this as 'analytical generalisability', which is a process through which 'the investigator is striving to generalise a particular set of results to a broader theory' (ibid.).

The present study explicates the implications of context when integrating ICT in subject matter learning, as the practical ICT tools developed (*Artefact 1, Artefact 2, Paper 6*) have clear limitations. They are designed to support a business teacher who want to develop interactive problem-solving tasks in introductory or intermediate management accounting courses. This implies that the tasks must have a limited scope, a limited degree of complexity and are suitable to solve in a spreadsheet environment (*Artefact 3*).

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Chapter 3: Interventions

A significant objective with the present study was to research my classroom practice in order to improve it, inform the teaching profession, and provide support to teachers in higher business education in their effort to integrate ICT into teaching and learning of management accounting subjects. All my different roles required that I engaged with empathy in order to elicit genuine information (Jönsson & Lukka, 2007).

The resulting description provided in this chapter is 'thick' (Geertz, 1973), and has the form of narratives about how the intervention process materialised. Insights from the emic perspective plays a significant role in all analyses of case study methods when it comes to inductive theory building (Baard, 2010). Moreover, by offering a 'thick' description of the research and development process and the case context, another aim of this chapter is to provide readers with important guidance in making the judgement on transferability (Lukka and Kasanen, 1995; Labro & Tuomela, 2003). The objective with this chapter is to answer research question 1 of this study, which was presented in the introduction chapter of this study as follows:

> *What characterises interventions wherein finance students develop relevant ICT skills at the same time as they learn subject matter theory?*

3.1 Introduction

The introduction to this chapter provides an outline of my learning view and significant pedagogical theories which have underpinned the design and development of the educational interventions, which subsequently will be accounted for.

3.1.1 Learning perspectives underpinning the study

My view of learning is based on a pragmatic philosophy, which is in line with Mayes and de Freitas (2007), who identified three widely different perspectives on learning: 1) behaviourist (associationist); 2) cognitive; and 3) sociocultural (situated). They argued that each of these perspectives is incomplete, and that a principled approach to learning requires an understanding of all three aspects as distinct viewpoints on learning processes as the three perspectives can be viewed as analysing learning at different levels of aggregation. In this regard, the behaviourist perspective describes

the overt activities and their outcomes for individual learners, whereas the cognitive perspective describes the structures and processes which underlie individual performance. Finally, the sociocultural perspective aggregates a group of learners wherein individuals participate as members of communities.

Behaviourist learning perspectives

Behaviourist learning perspectives are based on the viewpoint that knowledge (empirical) exists outside the individual; it is objectively given and quantifiable and the focus is on changing a learner's external, observable, individual behaviour (Dysthe, 2001). Behaviourist theory requires subject matter to be analysed as specific associations which are expressed as 'behavioural objectives' (Gagné, 1965). Learning tasks are arranged in sequences (based on their relative complexity) with simpler elements as prerequisites for more complex tasks, as seen in previous research (Clark et al., 2006). To engage the learners and strengthen (or weaken) a certain type of behaviour or learning, behaviourists emphasise extrinsic motivation through reward and punishment (Dysthe, 2001). Since knowledge can be split into small quantifiable and measurable units, assessing knowledge through standalone decontextualized multiple-choice questions is a legitimate behaviour-based test format (ibid.).

Cognitive learning perspectives

Cognitive learning theories are rooted in a rational view of knowledge and focus on learners' internal cognitive processes and an individual's rational ability to construct understanding (Dysthe, 2001), which can be done in two ways: 1) through interactions with material systems and concepts in the domain and 2) via interactions wherein learners discuss their developing understanding and competence (Mayes & de Freitas, 2007). Mainstream cognitive perspectives towards learning have emphasised the assumptions of constructivism wherein understanding is gained through certain activities. In this case, new knowledge must be built upon the foundations of existing frameworks through problem-solving activities and pertinent feedback (Collins et al., 1989). To engage learners, cognitivists emphasise intrinsic motivation, which is created as learners gain new understandings and master new skills (Dysthe, 2001). Cognitive-inspired test formats call attention to whether learners understand general concepts and principles, and if they are able to apply relevant procedures to

solve problems which are more comprehensive than those exposed by multiple-choice questions (ibid.).

Sociocultural learning perspectives

Sociocultural perspectives view knowledge as always being embedded within an historical and cultural context; that is, it is situated (Dysthe, 2001). In this regard, learners are subject to influences from the social and cultural environment in which the learning occurs. Accordingly, sociocultural perspectives on learning focus on learning as participating in social practices (ibid.). Sociocultural learning theories are established on constructivist perspectives, but they underline that knowledge is constructed through collaboration and context, not primarily through individual processes (Dysthe, 2001).

A situative perspective focuses particularly on learning from authentic activities. These activities may be defined as those which prepare students for lifelong learning, such as promoting problem-solving skills and thinking through ICT tools, which are important in the real world (Putnam & Borko, 2000). To engage learners, sociocultural perspectives accentuate motivation, which is embedded within the expectations communicated by the culture where the learning occurs (Dysthe, 2001). To further motivate students, engaging learning environments should be created for learners. Through their participation, learners can be recognised as knowledgeable individuals who also are able to contribute to others in the learning community, which is motivating in itself (ibid.).

Assessments based on sociocultural learning perspectives emphasise the quality of the student's participation in the learning activities (Dysthe, 2001). Moreover, assessments should become an integrated part of the learning process. Consequently, more focus is placed on formative assessments rather than summative ones (ibid.).

3.1.2 The course design context

The context of this study is an introductory undergraduate finance course. A finance subject can be briefly described as a basic course in mathematics, statistics and economic theory applied to financial issues. The overall goal was to enhance both subject learning and students' development of digital skills. In order to achieve this goal, spreadsheet usage was fostered through innovative learning and assessment interventions. The subject design in Figure 3.1 has been informed by theory,

research-based evidence, teachers' craft knowledge, feedback from students and colleagues who continuously contributed to their learning experiences. This intervention research study has been in development since 2005, and involves iterative processes of design and redesigns.

The European Qualifications Framework as well as the Norwegian Qualifications Framework (NQF) are not only underpinned by Blooms Revised Taxonomy (BRT), but also by Biggs' (1996) principles of constructive alignment (Ottesen, 2012). Accordingly, the course design discussed in the present study is constructively aligned in the following three ways. First, a teacher should begin at the end when aligning a course constructively (*Paper 1*). Beginning at the end identifies where he/she wants the students to end up (i.e. what they should eventually know and be able to do in both school and work). Second, a teacher should design assessments which capture real-world applications of the students' knowledge and skills (*Paper 4, Paper 6*). Third, a teacher should develop and teach a curriculum which guides the students towards the demonstration of their knowledge and skills on the assessment tasks (*Paper 5*).

In other words, learning outcomes, assessments, teaching and learning methods are interdependent. To support student learning, assessments should not be disconnected from teaching and learning outcomes. Instead, they should be aligned with the overall learning process. Biggs' (1996) model of constructive alignment implies that in curriculum design, a well-crafted course should include the following: 1) learning outcomes that are clearly identified; 2) appropriate assessment tasks that are designed to directly assess whether each of the learning outcomes has been met; and 3) learning methods that empower the students to master the assessment requirements.

Both formative and summative assessment activities should be included in a course design (Knight, 2002; *Paper 1; Paper 5*). Assessments that certify achievement include a feed-out function since the grades can be treated as a performance indicator for the students. Such assessments are often referred to as 'summative' or 'assessments of learning' (Knight, 2002). Conversely, assessments may have a formative purpose that modifies learners' thinking or behaviour to improve overall learning (i.e. Evans, 2013; Shute, 2008; *Paper 6; Paper 7*). Formative assessments are known as 'assessments for learning'. Educational research has emphasised the

powerful influence on learning through formative feedback and assessments (Black & Wiliam, 2009; Evans, 2013; Hattie & Timperley, 2007; Shute, 2008).

Table 3.1 outlines the most important theoretical perspectives that underpin the present study (right column), while the theories related to the course design items are included in the left column (for an illustration of the course design intervention, see Figure 3.1).

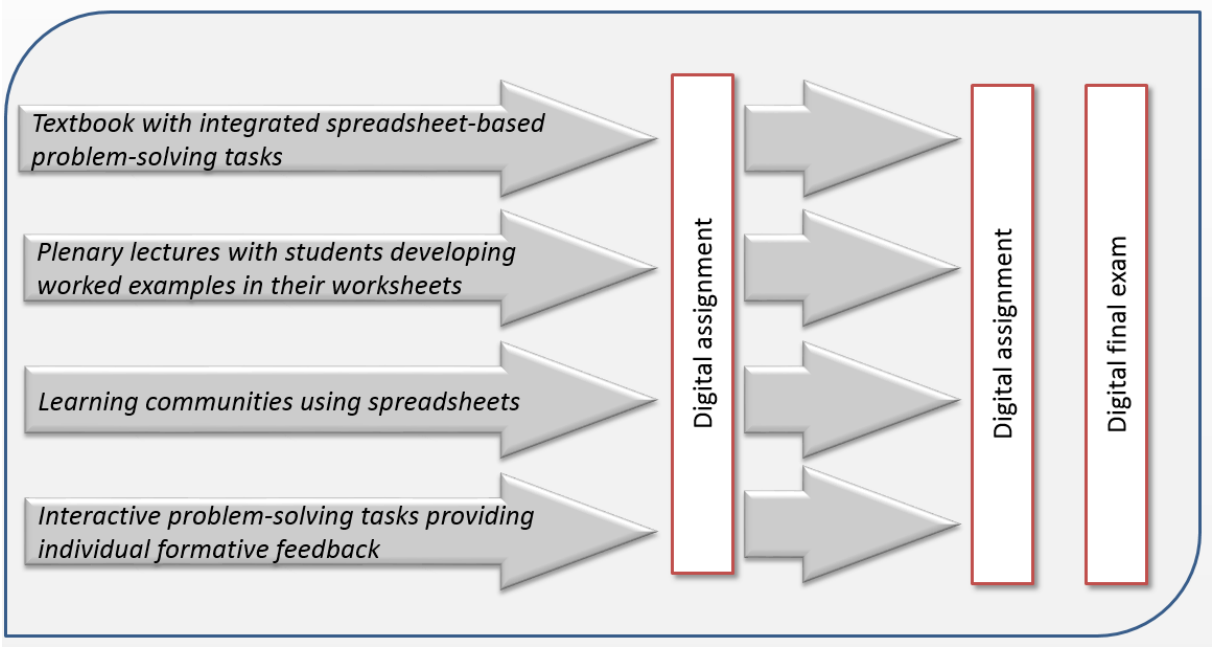

Figure 3.1. The course design intervention.

Table 3.1. Review of significant theoretical perspectives underpinning the study

Course design item	*Theoretical underpinning*
Embedding spreadsheet usage within the subject culture	Sociocultural perspectives of learning. The intention was to making the spreadsheet tool a cultural extension of the learning environment. Through this approach, it could 'stand back' and let the academic learning come to the foreground.
Aligning the course constructively	Cognitive perspectives of learning. Teaching materials, learning activities and assessments were linked and balanced in order to achieve the intended learning outcomes.
Fostering deep learning	Cognitive and sociocultural perspectives of learning. Learning tasks were constructed with the aim of challenging students and evaluating their higher-order thinking skills.

Promoting active learning	Cognitive and sociocultural perspectives of learning. Based on a pragmatic view of knowledge, learners (together) constructed knowledge by engaging in (more or less) authentic practical activities using relevant artefacts.
Textbook reading	Behaviourist and cognitive perspectives of learning. Learning tasks were arranged in sequences based on their relative complexities. However, spreadsheet-based exercises were embedded within the text to encourage a more active approach when working with the textbook.
Attending plenary lectures	All three perspectives of learning: behaviourist ('the sage on the stage'); cognitive (activating students through worked-examples); and sociocultural (creating a community of practice through subject discussions in plenum).
Watching interactive micro lectures	Behaviourist and cognitive perspectives of learning. Learning tasks were arranged in sequences based on their relative complexities. However, the videos could be replayed while watching and the spreadsheet-based exercises were embedded within the microlectures to encourage a more active approach.
Using interactive spreadsheet-based problem-solving tasks that provide learners with individual formative feedback	Cognitive and sociocultural perspectives of learning. In large classes, the teacher's capacity to provide high-quality individual formative feedback is insufficient, both verbally and in writing. In this context, spreadsheet-based problem-solving tasks provide formative digital feedback on learning process improvements and serve as a teaching supplement.
Learning communities	Sociocultural perspectives of learning. In learning communities, learners help, encourage and challenge one another in order to achieve greater results. Those participating in learning communities challenge one another's zones of proximal development and utilise one another for scaffolding.
Compulsory assignments	Cognitive (constructive alignment) and sociocultural perspectives of learning (persistent formative feedback and scaffolding for the final examination).

Summative assessments	All three perspectives of learning: sociocultural (authentic digital examination papers by allowing students to use spreadsheets); cognitive (constructively aligned through comprehensively constructed-response tasks); and behaviourist (some multiple-choice questions included in the examinations).

3.1.3 Macro cycles of intervention design and implementation

This section will briefly outline the broad macro-cycles of the design and development of the interventions. The main pedagogical goal was to integrate spreadsheet usage in all practical aspects of the course (both learning and assessment activities) so that the students were given the opportunity to become skilled spreadsheet users while learning finance theory. More details into the development cycles of each intervention are presented subsequent in this chapter.

The first macro-cycle of design, development and implementation

The initial cycle of development began in the spring semester of 2005 when I first taught the course at Harstad University College. Although the first term generally covers the traditional course contents, it did not take long before I decided to integrate spreadsheet usage into the practical learning activities. To develop a course aiming to foster a spreadsheet-user culture, I began by developing worksheet based, problem-solving tasks. These tasks were well-received by the students, but they still had room for improvements. In fact, the students requested that I write a textbook which reflected that they were always using spreadsheets when practicing. As shown in the textbook (*Artefact 4*), their request was honoured. In this first macro-cycle, I also stopped using the traditional blackboard and chalk approach in the auditorium and began using Excel.

Accordingly, I developed a plenary finance lecture format which integrated spreadsheet usage. In addition, all of the students brought their own laptops (with spreadsheet software installed), thus enabling us to develop worked finance examples as a group (*Paper 8*). In this development stage of the course design, the textbook was based on spreadsheet exercises and the students actively used spreadsheets during the lectures. Moreover, in this process, the students provided constructive

suggestions which helped shape the development of the course. At this point, I began to feel that the different parts of the course design were being integrated. However, there were several more cycles of development to complete.

The second macro-cycle of design, development and implementation

In 2007, I was asked to arrange the same compulsory corporate finance course at Tromso University College. Since there were more students at that location (ca. 100 versus 20 at Harstad University College), I did not have the opportunity or capacity to provide individual expert feedback to all of them, despite the fact that international metastudies have emphasised the importance of feedback for learning (e.g. Evans, 2013; Hattie & Timperley, 2007; Shute, 2008). The solution to the feedback problem was to add automatic feedback to problem-solving tasks. This was accomplished by integrating 'artificial intelligence' into the problem-solving tasks using Visual Basic for Application (VBA), which is a part of the Excel spreadsheet environment. During the design process of the data algorithms, I received critical external assistance from Svein Halvorsen and Leif Krane, who own and run the DataKvalitet software company in Tromsø. Using VBA code, I managed to automatically mark and grade the students' problem-solving tasks as well as provide constructive feedback interactively. At that point, each student was provided with personal feedback on his/her solution attempt without having me physically present.

However, the coding work was extremely laborious in this stage of development since the problem-solving tasks could be solved in many different ways. In addition, I had more than one hundred problem-solving tasks to oversee and evaluate. However, as discussed later, the data algorithms were substantially improved in the subsequent design and development cycles, which significantly lessened the coding burden (*Paper 6*). The examination constitutes the core of students' learning experiences and it defines what they regard as important in their learning (Brown & Knight, 1994). In this regard, the students utilised the spreadsheet tool when conducting their compulsory assignments and the final examination, and they eventually evolved into skilled spreadsheet users after completing the undergraduate finance course. This became the starting point for developing a digital examination procedure which concluded the second macro-cycle of development (*Paper 5*).

The third macro-cycle of design, development and implementation

After approximately four years of performing the educational intervention activities, the design and development process changed and became integrated with research-based activities. As a result, it was not only significant to underpin the interventions by pedagogical theory, but it became just as important to produce a theoretical contribution of value for others outside the research/design setting. This change in approach evolved after Tromsø University College merged with the university in the city, which resulted in the establishment of a new university business school. Consequently, I became a permanent employee and I joined a community of research-oriented academics. Together with one of my new colleagues, Espen Sirnes, I shared the responsibility for the finance course. More specifically, we established a distinct division of labour in which I was responsible for classic corporate finance (2/3 of the course), while Espen concentrated on modern corporate finance (1/3 of the course).

Through this experience, I quickly realised that at the university, new opportunities had emerged to help develop the course design as well as further develop myself as a research-oriented professional practitioner. Finally, during this cycle, I began submitting articles to scientific journals (see p. viii). The feedback which I received from the referees had a significant impact on both the scientific and practical outcomes of this dissertation.

The remainder of this chapter builds on Labro & Tuomela's (2003) model for conducting interventionist action research in management accounting (p. 415). For each educational intervention reported, the following features are discussed: 1) find a practical relevant problem with a research potential; 2) obtain a comprehensive understanding of the problem; 3) construct a innovative solution to the problem; 4) implement the solution and test whether it works in practice; 5) examine the solutions applicability. The theoretical connections and the research contribution of the interventions will be discussed in chapters 4 and 5.

3.2 The course design intervention

3.2.1 A practical relevant problem with a research potential

In general, many students have already mastered information and computer technology (ICT) skills by the time they arrive at their respective universities. In Norway, both primary and secondary school students currently employ computers for learning

and assessment (Utdanningsdirektoratet, n. d.) and the younger generation expects that their digital literacy will be elaborated upon in higher education. The improvement of ICT skills lays the foundation for subsequent development of students' digital literacy, which will be applied in their future studies as well as their careers. Moreover, approximately 80% of managers and academic staff in higher education in Norway consider that students should develop digital skills which correspond to industry expectations (Ørnes et al., 2011). Politicians have also stated that students should develop digital literacy in higher education. According to a report by the Norwegian Parliament titled, *An Information Society for All* (Report No. 17, 2006-2007, p. 57), 'In higher education, the government wants students to be trained in using ICT as an integral part of their learning'. Moreover, research indicates that the ICT revolution has, to a certain extent, gradually replaced the traditional pen and paper with the screen and keyboard in higher education (Aure & Abelsen, 2011).

Despite the aforementioned statements and findings, students' motivation to engage in spreadsheet-based learning and assessment activities may be a challenge. Generally in business-related coursework, the workloads are heavy and emphasis is placed on the compulsory assignments and the final examination, both of which require students to perfect their spreadsheet skills in order to perform well. However, spreadsheet skills are not separately assessed during the entire learning process. Therefore, the students do not improve their spreadsheet skills directly. Instead, they 'indirectly' enhance such skills by attempting to work more efficiently on the assessments. This is a conceivable source of student demotivation since the time used to develop spreadsheet skills could alternatively be applied toward the learning of finance theory.

Another challenge is students' perceived learning outcomes from engaging in the spreadsheet-based activities. Using a spreadsheet requires the learners to be both cognitive and motoric active. When attention is split between several sources, an additional burden is placed on working memory, which can sometimes obstruct learning (Tarmizi & Sweller, 1988). It is conceivable that using a spreadsheet can prove to be so distracting that students may fail to learn the presented financial information.

The pedagogical goals with this course design were twofold: 1) To have the students learn as much finance theory as they would in a traditional curriculum; and 2) To provide the opportunity for the students to develop their spreadsheet skills, which can be useful in their future studies and employment. The approach was to

make spreadsheet usage a cultural extension of the learning environment (Somekh, 2007). After having taught the 10 ECTS finance course in two cycles at Harstad University College in 2005 and 2006, respectively, I was asked to arrange the same course at Tromsø University College. However, before teaching the course at the latter college, I discussed my ideas with the management on how to improve the course design. We agreed upon the following pedagogical goals: 1) To engage the students on extensive practising and problem-solving activities; 2) To emphasise student collaboration; and 3) To integrate spreadsheet technology into every practical part of the curriculum including the summative assessments. At the outset, the research potential of integrating ICT into subject matter learning and teaching was not considered, but as the development of the intervention progressed, several research opportunities materialised.

3.2.2 A comprehensive understanding of the topic

Ideas drawn from sociocultural theory underline the social nature of learning and the crucial role that language and other semiotic systems play in classroom interactions. In particular, the notion of 'cultural tools' is central, given their propensity to act as both material and symbolic mediators of learning (Wertsch, 1997). Broadly conceived, such 'tools' represent any artefact belonging to a given culture (Cole & Engestrom, 1993). The practices of disciplinary knowledge have been changing to incorporate ICT tools, which provide new types of affordances which can extend the mind (Somekh, 2007).

Technological tools are developed within a particular sociocultural setting and carry the origins of these cultures (Sutherland et al., 2004). Spreadsheets, for instance, were developed for use within a business context (Baker & Sugden, 2007) and provide an elegant and time-efficient tool for solving mathematical problems which would otherwise involve extensive, time-consuming calculations. The number-crunching facilities of spreadsheets have changed the nature of business peoples' calculation needs.

Humans are experts at creating tools to transform practices and knowledge, and ICT is part of this creative production. However, a computer installed with spreadsheets is not a learning aid alone, and knowing how to use the tool to transform learning in a classroom is not straightforward (Somekh, 2007). The reason being that new ICT tools often challenge existing practices of teaching and learning,

and they can threaten a well-established knowledge domain (Sutherland et al., 2004). In sociocultural theory, the term 'affordance' indicates a tool's latent possibilities for mediating human activity (Pea, 1993). New technologies do not of themselves lead to innovative use. Instead, they are dependent on creative perceptions of their possibilities and on human agents exploring them and developing skills through their use.

The development of new social practices deploying tools will be transformative to varying degrees, depending on the affordances of the tool, the skill with which human agents learn to use them and their ability to imagine new possible uses (Somekh, 2007). It is not spreadsheet technology itself that has changed the culture of business calculation and simulation, but rather the creativity and skill of users who explore these affordances.

A significant issue is related to the distinction between teaching about and teaching via ICT. Using ICT for one hour a week in a specialist suite makes it impossible to embed ICT in subject teaching (McCormick's, 2004; also see 1.1.1). Programs which emphasise the development of knowledge and skills in an isolated manner have difficulty in succeeding (Koehler et al., 2014). It is not surprising to find that many teachers may have been persuaded by the hype attached to the use of ICT in schools; that is, ICT itself 'causes' learning. However, it is what one does with it that counts and not the tool itself (ibid.). The cultural significance of technology as an effective learning tool must be highly visible. At the same time, its role as a mediating technology which supports subject learning must be highly invisible in the form of unproblematic interpretation and integration into activity (Lave & Wenger, 1991).

Where subject communities resist the integration of ICT, the role of transparency is reversed. Computers are then highly visible as mediating technologies which obstruct the process of learning and highly invisible in terms of their cultural significance as learning tools within subject-specific pedagogy (Selwyn, 1999). Latour (1990) argued that technology requires an educational justification for promoting learning, e.g. by integrating ICT usage in learning and assessment activities. Moreover, Somekh (2007) considered ICT as a cultural extension of the learning environment and stated that the technology does not create such an extension of itself. It requires a subject culture ready to adopt technology as well as an interaction between learners and artefacts (e.g. spreadsheets), which is central to this user culture. In addition, when the artefact is fully mastered by a student, it can 'stand back' so that academic learning comes to the foreground (Latour, 1990).

3.2.3 An innovative solution

As a teacher, I was not free to design the course exactly as I had wanted since the institution placed certain restraints on available lecture theatres, manpower resources invested in arranging the course, the number of students attending the course, etc. (*Paper 3*). Furthermore, since this was a compulsory course in the Bachelor's Degree in Business Administration in Norway, its overall curriculum content was determined by a national entity; that is, The National Council for Economic and Administrative Studies (NRØA, 2011). Nevertheless, within these given constraints, I still had room to influence the course design (*Paper 1*).

This study was nourished by literature and my personal experience of identifying existing opportunities for students to practice their spreadsheet skills while learning the subject matter. Any event in which students could apply a spreadsheet to complete their work was regarded a potential focal point for spreadsheet intervention. My previous experience with a digital course design (Bertheussen et al., 1986) also taught me some important intervention lessons, one of which was that the students should not be supplied with ready-to-use spreadsheet templates. Instead, I wanted them to develop financial models from basic principles and demonstrate that they were able to define and analyse a problem, remember and understand subject matter procedures as well as apply procedures to solve the presented problem (*Paper 4*, *Paper 6*).

During the course, the quality of the students' spreadsheet skills was not separately assessed since the ability to use spreadsheets was considered an implicit criterion of the learning objectives (*Paper 1*). Therefore, spreadsheet skills were indirectly assessed on two mid-term compulsory assignments as well as on the final examination (*Figure 3.1*, *Paper 5*). In other words, in the same manner as their ability to use a financial calculator would have been alternatively.

Cycles of design, development and implementation

The course design discussed in this dissertation has been ongoing for approximately 10 years. It entailed three main cycles: baseline, intervention and retrospective analysis. First, a two-year baseline phase was conducted to obtain a thorough understanding of the context. At the end of the baseline phase, I reflected upon what I had learned and, based on the discussions with the students, decided on which intervention would be appropriate to improve the learning environment. In the

intervention phase, which occurred of the next years, I designed, developed and implemented a textbook rich with spreadsheet-based practice exercises, interactive problem-solving tasks, a flipped plenary lecture format where students bring their own PCs, spreadsheet usage in learning communities and finally, a digital examination procedure. All of the aforementioned interventions were significant parts of the course design (see Figure 3.1). The design and development of the interventions were intertwined and seamless since I used the classroom as a naturalistic testbed.

3.2.4 A solution implemented and tested to work in practice

The course design has been through classroom iterations for several years at this author's business school. Each repetition has provided me with new opportunities to make improvements. Thus, over time, the course has evolved into a well-developed practice. Based on my best professional judgement and the feedback from the students' evaluations, the course fulfils its two pedagogical goals: 1) the students learn as much finance theory as they would with a technology-poor learning environment; and 2) the students become skilled spreadsheet users during the course work.

3.2.5 The scope of the solutions applicability

As will be discussed in section 3.3, digital summative assessments were considered a critical requirement for successfully implementing ICT tools within a course design. Digital skills will not receive the attention they are due unless they contribute to students' performance when being assessed (Locke & Latham, 2002; Looney, 2009; Somekh, 2007). In fact, the students initiated the examination practice discussed in this study by asking why it was so important to acquire spreadsheet skills while learning the finance subject matter when they could not actually apply such expertise in their respective final examinations. Moreover, in order to successfully implement this type of course in finance/business economics (with integrated spreadsheet usage) at other business schools, it is essential that the teacher is also a skilled spreadsheet user. That is, he/she does not have to be skilled in VBA-programming, creating graphs or formatting a spreadsheet, but he/she must, first and foremost, be skilled in creating and revising spreadsheet models which use spreadsheet formulas.

Being able to establish formulas on a spreadsheet and construct models are essential skills for a teacher when performing the following: lecturing using a spreadsheet (see Section 3.5); supporting students when solving problems on a spreadsheet

(see Sections 3.4 and 3.6); creating tailor-made interactive problem-solving tasks (see Section 3.4); and constructing semi-individual examination tasks (see Section 3.3). To date, the course design presented in this study has been implemented at some other business schools in Norway. Furthermore, the spreadsheet artefacts resulting from this study (see p. ix) have been distributed to business professors on request. In order to establish a large-scale digital subject practice, as outlined in this study, it will require deliberate cooperation among relevant stakeholders, such as the college which must permit the practice, the teachers who must develop semi-individual examination tasks and validate the examination practice, and the students who must bring their own devices to the lecture theatres, seminars and examination halls.

3.3 The digital examination intervention

3.3.1 A practical relevant problem with a research potential

Computer-based testing can have several advantages over traditional assessment formats including paperless test distribution and data collection, efficiency gains, rapid feedback and machine-scorable responses (Bridgeman, 2009). Moreover, automated scoring can dramatically reduce the time and costs regarding the assessment of complex skills (Ljungdahl & Prescott, 2009). Finally, computer-based tests generally have a positive effect on students' motivation, concentration and performance (Garrett et al., 2009). Nevertheless, research indicates that the ICT revolution has only to a certain extent replaced paper-based technology in higher education in Norway (Aure & Abelsen, 2011).

However, when knowledge is assessed on a final written examination, the students must take a technological step back in which a pen, paper and a calculator still apply even when the use of such traditional tools is becoming increasingly outdated. Reasonably, students have asked why it is so important to develop digital skills when they cannot actually use such expertise in their respective exams. This was seen, inter alia, in the *We Want PCs on our Exam* student campaign in Norway, which occurred during autumn 2011. Realising that employers generally search for digitally competent candidates reinforced the idea that students should be allowed to use computers for their examinations.

One major reason why students are generally denied the opportunity to use computers is the lack of facilities (computers and premises) which can simultan-

eously handle hundreds of students taking their final examinations digitally. Johnson et al. (2011) reported that individual organisational constraints are likely to be the most important factors in decisions to adopt new technologies in education. Another reason is the fear that students may be tempted to cheat when using their own computers, which are connected to the Internet (King, Guyette & Piotrowski, 2009).

However, due to the insistence of the students, the majority of the universities in Norway have been experimenting with digital examinations under various models. In addition, certain initiatives have been taken to coordinate the work in the *eCampus* national project. The assessment practice implemented in any course should be validated irrespective of its delivering format or system deployed. However, validation may be even more important to a digital examination practice which will challenge existing well-established analogue practices (Somekh, 2007). To assure the quality of the intervention and to legitimate it, I wanted to validate the intervention by means of scientific principles. At the end of the intervention cyclus, it turned out that there was a potential of publishing a validation study based on the digital examination intervention (*Paper 5*).

3.3.2 A comprehensive understanding of the topic

According to Knight (2002), assessment is 'the Achilles' heel of quality'. Summative assessments are an essential component of learning and teaching, since it often influences practices and affects learning (Ellis & Barrs, 2008). It has also been shown that changes in curriculums and learning objectives are ineffective if assessment practices remain the same, since learning and teaching tend to be modelled against tests (Cachia et al., 2010). In professional training, an important learning outcome for a student is the ability to use knowledge and skill to solve problems, rather than simply answering questions about doing (Ferrari, Cachia, & Punie, 2009; Nitko & Brookhart, 2014).

Many learning objectives simply cannot be measured using standard paper-and-pencil assessments such as building a financial simulation model on a spreadsheet from basic principles. Examination tasks are a powerful way to communicate what is really valued in students' learning (Nitko & Brookhart, 2014). For example, teachers may inform their business students how important it is for them to develop spreadsheet skills to prepare for their future careers. However, if the assessments consist of questions which only require a paper and pencil to solve them, then the

students will know differently (Rowntree, 1987; Brookhart, 2011). Conversely, if assessments require the students to integrate financial knowledge and spreadsheet skills to solve 'real-life' problems, then they learn what level of expertise is expected. Therefore, summative assessments play an important role in developing digital skills, since such skills will not receive sufficient attention unless they contribute to the students' performance when being assessed (Locke & Latham, 2002; Looney, 2009).

Assessments can also effectively guide instruction and learning (Knight, 2002). Teachers may be reluctant to devote class time to a certain topic (i.e. development of students' digital skills) if it is not going to be tested or graded. Consequently, they may be less likely to provide sufficient feedback and meaningful opportunities for skill development (Mueller, 2009). In other words, assessments may be a critical part of developing digital skills. According to Popham (2001), locally created assessments integrated in classroom instruction will provide the best tools for promoting effective teaching and learning of certain skills. In addition, since skills involve performance, the assessment of skills should be performance-oriented (ibid.). To be assured that digital skills can be competently applied beyond the classroom, the students should be given the opportunity to perform them in more or less authentic real-world contexts (Mueller, 2009).

However, assessment frameworks can constrain teachers in using technology in the classroom since there is a perceived tension between using ICT and needing to conform to traditional examination requirements (Hennessy et al., 2005; Redecker & Johannessen, 2013). The obligation to use technology to enhance learning without recognition through assessment is problematic. Selwyn (1999) asserted that for many teachers, subject pedagogy is dictated by the nature of the qualifications being taught and the final examinations. As a result, ICT must take 'second place' behind guiding students to pass traditional examinations. Existing inflexible patterns and means of assessment (i.e. paper-and-pencil written tests) have placed a 'stranglehold' on the curriculum and have acted as a 'brake' on innovative uses of ICT (ibid). Thus, new assessment systems allowing for the use of digital artefacts need to address new types of skills and knowledge which ICT can help develop (Hennessy et al., 2005; Redecker & Johannessen, 2013).

Furthermore, assessments have the potential to undermine educational innovations (Phelp, 2014). However, there is strong evidence that innovations in

pedagogy can be rapidly introduced if they are tied to changes in assessment practice (Somehk, 2007). High-stakes assessments are intended to provide incentives for learners, teachers and schools in order to focus on measured aspects. Changes in what is being assessed represent risk-taking for all stakeholders, which can discourage innovation (Looney, 2009). Without fundamental changes to the aims, purposes and practices of assessments, pedagogical innovations are likely to become seriously constrained (Somekh, 2007; Redecker & Johannessen, 2013). According to Somekh (2007), 'Students should be assessed on what they can achieve when working in new ways they have developed to make use of the affordances of these tools which have the potential to transform learning'. If spreadsheet usage is an integral part of learners' practices, then how can it make sense to assess their performance without allowing them access to these tools?

Finally, evaluation and assessment can be a lever to drive innovation in education by signalling the types of learning which are valued (Phelp, 2014). This is likely to be facilitated by some discretion at the local and school level in order to develop curriculum innovations and approaches to evaluations and assessments. For example, educational policymaking in higher education in Norway is characterised by a high level of respect for local ownership, and this is evident in the development of the national evaluation and assessment framework (ibid.). Moreover, school owners and schools have a high degree of autonomy regarding school policies, curriculum development and evaluations and assessments. Authentic evaluations, which lead to the improvement of educational practices, are central to establishing a high-performing education system (ibid.). For ICT technology to support and foster pedagogical innovations, ICT-enabled assessment practices need to be developed (Istance & Kools, 2013).

3.3.3 An innovative solution

The intervention 'built on students' ideas' is a pragmatic intervention principle derived from the conjectures and empirical findings from several intervention studies (Linn et al., 2004). The problem regarding the limited capacity of data laboratories was resolved by allowing the students to bring their own PCs to the examination halls. There, the examinations were distributed and electronically collected by email. In addition, the more than one hundred examination papers were marked and graded automatically (as well as the two compulsory assignments), which saved us a

significant amount of time compared to the previous approach of manually marking and grading.

Since the students also have access to the Internet and their own hard disks during the examination, this can provide opportunities for communicating with others and cheating. However, in order to hinder cheating on examinations and assignments, several methods were employed. First, the students were given the same problem-solving tasks for the summative assessments, but with different numbers. Thus, no solutions were similar. Second, the data used in the formulas are located in different cells on the spreadsheets (*Artefact 2, Paper 6*). Therefore, for a student, information from another student has little value. Finally, the workload on the examination was so heavy that the students had a strong incentive to focus on their own examinations.

3.3.4 A solution implemented and tested to work in practice

This digital assessment practice has been implemented and used by cohorts of more than one hundred students at this author's business school each year from 2008 to the present. To date, approximately 20 iterations, including the compulsory assignments, have been conducted. Consequently, digital tests performed on students' PCs have become an established assessment practice in the course.

3.3.5 The scope of the solutions applicability

In higher education in Norway, there is a big pressure on implementing digital examinations due to students demand. Besides, the institutions may reap administrative efficiency gains by digitizing administrative examination procedures. However, the scope of the digital examination intervention discussed in this paper, is restricted to smaller problem-solving tasks suitable for spreadsheet analysis. With one exception, it has not been tested on other than business economics topics even though the marking algorithm is generic. The exception is that the multiple-choice module of the system has been utilized as part of a corporate strategy examination for almost 200 students.

Table 3.2 reviews papers and artefacts supporting business teachers who want to tailor-make digital examination procedures in their management accounting subjects.

Table 3.2. Papers and artefacts supporting practitioners in developing tailor-made digital examination practices

○ Paper 5	Bertheussen, B. A. (2016b). *Validating a digital assessment practice implemented in a finance course*. Article accepted by the Journal of Financial Education.
○ Artefact 2	Bertheussen, B. A. (2014e). *Automatic summative grading of problem-solving tasks in a spreadsheet.xls*. Open source system available from the author: bernt.bertheussen@uit.no.
○ Artefact 3	Bertheussen, B. A. (2014). *Implementation guide–Power to business professors: Automatic grading of problem-solving tasks in a spreadsheet*. Supplement to article published in Journal of Accounting Education 32 (1), 76–87. Open source document available from the author: bernt.bertheussen@uit.no.

A teacher wanting to create a tailor-made digital test must, of course, spend time designing and developing test tasks using the principles described and the system template presented as his/her starting point. In *Paper 6*, interested readers were encouraged to obtain the reviewed workbooks and a detailed implementation guide by sending an email to bernt.bertheussen@uit.no. Hopefully, this marks the beginning of a more extensive diffusion phase of the digital examination intervention.

3.4 The digital formative feedback intervention

3.4.1 A practical relevant problem with a research potential

One of the most obvious findings of educational research is that feedback has a significant effect on learning (Black & Wiliam, 2009; Evans, 2013; Hattie & Timperley, 2007; Nicol & Macfarlane-Dick, 2006; Shute, 2008). However, in a large group of students which only meets once a week for lectures (plus every other week for workshops), feedback and individual guidance can be sparse. It was not difficult to find resonance for this experience in the Norwegian Quality Reform (Report No. 27, 2000-2001), which aimed to increase the quality of higher education in Norway. In this document, the institutions were encouraged to provide more feedback for students and offer more varied learning activities.

Before starting the design and development process leading up to this dissertation, I had been working for several years on developing a learning system (doIT), which provided automatic feedback to students striving to acquire basic skills in Microsoft Office applications, including Excel spreadsheets. As long as Microsoft offered the Microsoft Office User Certificate (MOUS), the doIT-system was a success both pedagogically and commercially. After I began teaching finance at Harstad University College, I wanted to explore if I could extend the scope of the system into business economics subjects. I found support in the literature which confirmed how innovative uses of ICT can replace oral and paper-based feedback to some extent (Marriott & Lau, 2008; Evans, 2013) by providing learners and teachers with detailed reports which describe its strengths and weaknesses, thus supporting formative assessments (Ripley, 2009).

Research also indicated that the closer the feedback is to actual performance, the more powerful its impact on subsequent performance and learner motivation (Evans, 2013). Moreover, as I had also experienced, computer-provided feedback can significantly ease the teacher's marking and grading workload (Gikandi et al., 2011). In sum, the objective of designing and developing interactive problem-solving tasks was twofold: 1) To automatically provide individual formative feedback to students working on problem-solving tasks on a spreadsheet in order to support and improve their engagement and learning; and 2) To present an innovative approach which enables teachers in business economics to develop user-created content; that is, individualised problem-solving tasks for their own practices.

3.4.2 A comprehensive understanding of the topic

The purpose of feedback can be formative as well as summative (Sadler, 1998; also see previous section). Formative feedback (or professional feedback) is a more or less continuous process which is often described as feedback *for* learning (Price et al., 2010). In addition, feedback is formative when the intention is to change students' thinking or behaviour and help improve their learning outcomes (Shute, 2008). In contrast, summative feedback is feedback or assessment *of* learning (Knight, 2002; Marriott & Lau, 2008). The purpose of summative feedback is to measure the extent to which an intended learning outcome is achieved. An examination is an example of summative feedback (ibid.).

According to previous studies, both formative and summative feedback should be integrated into a course design (Biggs, 1996; Knight, 2002; Nicols & Macfarlane-Dick, 2006). Feedback, motivation and learning are interrelated. Educational research is evident that formative feedback is significant for learning (Black & Wiliam, 2009; Evans, 2013; Shute, 2008; Hattie & Timperley, 2007). In addition to enhancing learning outcomes, formative feedback can provide greater motivation for learning (i.e. Narciss & Huth, 2004). Learning motivation may also increase when a student experiences a certain level of mastery. In an academic context, the aim is often to master problem-solving and in this regard, prompt and constructive feedback on students' performance can stimulate interest in this area (Wigfield & Eccles, 2000). However, the distance learning format makes it difficult for teachers to provide individual professional feedback to their students (Simonson & al., 2000). If there are many students in a course with limited teaching resources, then professional feedback can also be provided digitally (e-feedback) in the form of multiple-choice tests or as feedback on problem-solving in a digital environment (Denton et al., 2008).

Moreover, software programs can effectively deliver detailed personalised formative feedback (Gibbs 2006; Pachler & al., 2010). It has been shown that students appreciate receiving immediate feedback on their efforts (Denton et al., 2008). ICT technology may have contributed to a greater emphasis on multiple-choice questions since they are easy to automatically correct (see, for example, Drier, 2001; Lehman & Herring, 2003). Multiple-choice questions primarily test a student's ability to remember facts and understand concepts. However, they do not provide formative feedback which students can use to resolve misunderstandings or weaknesses in order to improve their solutions in the future (Scouller, 1998).

The abilities of memory and understanding are lower-order cognitive processes (Andersen & Krathwohl, 2001). Nevertheless, in higher education, one goal is to have students learn more than simply memorising facts and drilling procedures. Another aim is to challenge students on higher-order cognitive thinking processes (NRØA, 2011; Pettersen, 2005; Ramsden, 1992), which implies that students should also be trained to analyse, evaluate and create something new (Andersen & Krathwohl, 2001). According to an evaluation of the Norwegian Quality Reform (Aamodt, Hovdhaugen and Opheim, 2006), the institutions were encouraged to develop their curriculums with emphasis on providing more formative feedback to the students

and offering more varied learning activities. In addition, the National Council for Economic and Administrative Studies in Norway (NRØA, 2011) emphasised diverse teaching and assessment methods in the curriculum for the Bachelor of Business Administration degree.

3.4.3 An innovative solution

The remedy for the feedback problem experienced in the class was to develop interactive problem-solving tasks in Excel. Through this approach, I could automatically provide individual professional feedback to the students as necessary. Working on problem-solving tasks in a finance course is about applying economic theory to practical problems. According to Wagner (1995), solving practice problems stimulates the reasoning and development of various hypotheses regarding how a problem can be solved. This calls for an understanding of the underpinning theory.

The problem-solving tasks in the present study were designed to promote thinking and understanding by requiring the students to build financial models from basic principles (*Paper 4*, *Paper 6*). In addition, these tasks were practice-oriented so that the students could recognise and experience them as relevant. Biggs (1999) argued that tasks with an authentic touch may increase engagement and overall motivation as well as help students adopt more advanced learning strategies and higher-order cognitive thinking. Finally, one of the important goals of the interactive problem-solving tasks was that specific tips and comments were provided in order to enhance student engagement and learning (*Paper 7*). In this regard, immediate and constructive feedback on their work can stimulate students' interests in problem-solving (Denton et al., 2008, Wigfield and Eccles, 2000).

First cycle of development (2000-2005)

The design and development of the interactive problem-solving tasks has been a lengthy process. The first cycle of development (2000-2005) began when I developed doIT–an interactive approach for learning practical ICT-skills, i.e. how to master Microsoft's Office applications like Word, Excel, PowerPoint, Access and Outlook. In the early stage of this development process, Leif Krane (employed at DataKvalitet) came up with a creative idea on how to solve the consecutive error problem. In this regard, managing consecutive errors is fundamental for students to gain confidence in automatic feedback provided by a learning system.

Automatic feedback is complicated by the risk of consecutive errors in calculations. A consecutive error is not an error caused by the user (student), but the result of an earlier error which the user made in the calculation procedure, thus causing errors in subsequent calculations. To handle this situation, a feedback algorithm must detect and correct consecutive errors so that students are not successively penalised for the same error. Moreover, in the first cycle of development, a supporting management system was developed by Svein Halvorsen (employed at DataKvalitet) for distributing, collecting and maintaining records of the students' scores. In this cycle, the management system was Windows-based and accordingly, it did not support users of Mac operating systems. In addition to contributing to the design of the overall system, my role in the first cycle was to design, develop and code the learning content provided by the system. At that point in time, every practise exercise entered into the system had to be individually hand coded in VBA, the programming language integrated into the Microsoft Office system. This was a quite labour intensive and time-consuming task.

Second cycle of development (2006-2011)

In the second cycle of development, the scope of the practice exercises was broadened to include business economic subjects. I developed and implemented practice exercises for business subjects such as finance and budgeting (implemented at Tromso University College), financial accounting (implemented at Tromsdalen College) and cost accounting (implemented at Tromso University Business School). The more extensive exercise tasks required even more labour-intensive coding. At that time, I could, for example, spend a week coding a single integrated budgeting model specified by Bjarne Fossheim at Tromso University College.

Third cycle of development (2012)

In the third cycle of development, the system was completely recoded so that a teacher without coding (programming) skills was capable to develop his/her own interactive problem-solving tasks in Excel. This was accomplished by developing a generic 'plug and play' VBA algorithm which was able to mark and provide automatic feedback to 'any' problem-solving task modelled in Excel. The scores and feedback provided were tailored to each student and they not only addressed the problem-solving outcome, but also the problem-solving process.

Using the generic marking and feedback algorithm, a teacher with proficient spreadsheet skills no longer has to use the 'out-of-the-box' problem-solving tasks that I had constructed for the undergraduate finance course. Instead, he/she could now create individualised problem-solving tasks for exercises, assignments and examinations within any subject, provided that the Excel spreadsheet software was a suitable tool for solving subject matter problems. At that time of the development cycle, in addition to those who brought their Windows-based PCs, a substantial number of students also brought their Macs. Therefore, it was necessary to redesign the management system to make it independent of the Windows operating system.

Fourth cycle of development (2013-)

At the beginning of this cycle, I felt that the time was ready to 'inform the world' about the innovation. I wrote an article on the substantive principles underpinning the system, which was published in an international journal (*Paper 6*). The scope of the system was substantially extended after each of the two resubmissions to the journal based on the reviewers' feedback. In addition to managing general problem-solving tasks in the field of business economics, the system could be applied for developing more advanced practising problems such as goalseeking, optimisation and regression problems. Moreover, the system was made more 'user-friendly' as a result of the reviewers' feedback. Finally, I was strongly advised to write a user-manual in order to support teachers who want to implement the system when designing their own interactive problem-solving tasks.

3.4.4 A solution implemented and tested to work in practice

The interactive problem-solving tasks have been implemented and used by cohorts of more than one hundred students at this author's business school each year from 2008 to the present. In doing so, these tasks have become an established practice in the course. The innovative feedback system is able to provide instant and valid feedback as well as advice to learners and teachers concerning future learning strategies, based on the learners' individual needs (*Paper 6*). More recently, the feedback tool has been enriched to include tasks which are more authentic and allow for business constructs which have been difficult to assess such as regression analysis and optimisation problems (ibid.).

3.4.5 The scope of the solutions applicability

The increasing numbers of student attending Norwegian business schools, challenge the capacity of the teachers at the institutions to provide sufficient quality formative feedback to the learners. My hope is that, the digital formative feedback intervention presented in this study, may contribute to solve a part of the feedback capacity problem in business economics related subjects. Nevertheless, it is important to bear in mind that the digital feedback intervention discussed, is restricted to smaller problem-solving tasks suitable for spreadsheet analysis. A teacher wanting to tailor-make his/her interactive problem-solving tasks must, of course, spend time in designing and developing tasks using the principles described in *Paper 6* and the system presented in *Arteface 1* as his/her starting point. Table 3.3 outlines papers and artefacts supporting a practitioner who wants to tailor-make problems-solving tasks which are implemented in a spreadsheet and provide automatic formative feedback to a student.

Table 3.3. Papers and artefacts supporting practitioner in developing tailor-made problem-solving tasks in a spreadsheet that provide automatic formative feedback

o Paper 6	Bertheussen, B. A. (2014a). Power to business professors: Automatic grading of problem-solving tasks in a spreadsheet. *Journal of Accounting Education; 32* (1), 76–87.
o Paper 7	Bertheussen, B. A. (2014b). Automatisk formativ feedback kan gi god læring og motivasjon. *Uniped*; *37* (4), 58–72.
o Artefact 1	Bertheussen, B. A. (2014d). *Automatic formative grading of problem-solving tasks in a spreadsheet.xls.* Open source system available from the author: bernt.bertheussen@uit.no.
o Artefact 3	Bertheussen, B. A. (2014c). *Implementation guide–Power to business professors: Automatic grading of problem-solving tasks in a spreadsheet*. Supplement to article published in the Journal of Accounting Education; 32 (1), 76–87.

3.5 The flipped plenary finance lecture intervention

3.5.1 A practical relevant problem with a research potential

Norwegian business schools must mass produce teaching in order to deal with the large number of students (*Paper 3*). Basic business economic courses (NRØA-courses) at this author's school (the smallest of the three 'all-inclusive' universities in Norway) often include approximately 200 students. In this regard, the plenary lecture (as a teaching method) is an efficient tool for the mass production of education. However, the major emphasis of volume production can be a disadvantage for the quality of education since the primary teaching method used only promotes surface learning and not in-depth learning (Biggs, 1999).

Large lectures, perhaps implemented with numerous and densely packed PowerPoint slides to cover the entire curriculum, may be perceived as monotonous monologues by the students. Such a learning environment does not characterise quality learning, but it invites inactivity (Freeman et al., 2014; Østerud, 2004). As stated earlier, one of the most obvious findings of educational research is that feedback has a significant effect on learning (Black & Wiliam, 2009; Hounsell & Entwistle, 2005; Raaheim, 2006).

However, in a large auditorium with many students, feedback is usually scarce. Across the field of education, the notion that knowledge is uniquely constructed by the individual, rather than transmitted, has gained a strong foothold among researchers as well as practitioners. This viewpoint has been referred to as 'constructivist' (Piaget, 1977; Rorty, 1991). As the flipped plenary lecture intervention matured, it grew into a format which turned out to have a research potential.

3.5.2 A comprehensive understanding of the topic

Säljö (2001) described an education based on large lectures in his transmission metaphor. According to this metaphor, knowledge is transferred by breaking up the information into appropriate pieces and distributing them to the students when lecturing. In this case, students are passive, listening receivers and in a large auditorium with many students, feedback is usually absent. Implicit in the transmission metaphor is a simplified mechanistic view of learning (Østerud, 2009). Dewey's (1938) call for active learning is based on a pragmatic view of knowledge, which implies that learners construct knowledge by engaging in practical activities; that is, 'practice makes

perfect'. Moreover, sociocultural theory emphasises that students should actively construct knowledge by drawing upon what they already know and believe (Dysthe, 2001). In terms of the affordances offered by ICT, the tool has the potential to enable active learning and engagement (John & La Velle, 2004).

In a recent comprehensive meta-analysis of undergraduate students, Freeman et al. (2014) reported that active learning leads to increases in examination performance which can raise average grades by a half letter grade. This study also showed that failure rates under traditional lecturing increased by 55% over the rates observed under active learning. Moreover, a teacher at a Norwegian business school 'flipped the classroom' in a large introductory economics course in order to create more satisfied freshmen, reduce the failure rate and achieve better mean grades (Heimly & Bertheussen, 2016a). In broad terms, the classroom was 'flipped' by compressing the traditional oral lectures into articulated videos and distributing them to the students via the Internet so that they could 'attend the lectures' at their convenience. The teaching resources released were then applied to problem-solving in the auditorium. The results indicated that the students were more satisfied with the 'flipped' course design than the traditional approach. Moreover, the failure rate decreased by 35.2% ($p < 0.05$) while the average grades increased by approximately 1/3 letter grade ($p < 0.05$).

3.5.3 An innovative solution

When working on revitalising the lecture format to improve the learning environment, the design decisions were informed by the desire to facilitate students' practicing or more specifically, practising by using a more industry-authenticated tool, i.e. the spreadsheet. The plenary lecture format has not been regarded as suitable for collaborative practice. In order to overcome the lack of opportunities to learn through social interaction in plenary lectures, I attempted to balance this by designing workshops and utilising pedagogical pairs as collaborative formats (see Section 3.6). When exploring the opportunities to change the lecturing format, the available options were severely constrained by the following resource boundaries at the business school as the teacher was allocated 38 teaching hours for the course, more than 100 students were expected to attend the lectures, there was only one PC suite available including roughly 20 PCs, and finally a large theatre was available for lecturing (for a maximum 500 students).

Based on the theoretical underpinnings of the course, the resource boundaries listed above, a literature review on how to activate students on plenary lectures and my own creativity, I constructed a solution in which the students brought their own PCs to the lecture theatre. In the new lecture design, I chose to activate technical infrastructure already possessed by the students, which was a laptop with spreadsheet software installed and a WIFI adapter. When lecturing, the lecturer (this author) and the students solved worked examples together (*Paper 8*). I developed the 'skeletons' of the worked examples, which served as the starting points for their work, and distributed them to the students through the business school's learning management system.

In this case, a worked example involved a problem and the procedure for solving it. Then, the students and I developed the examples simultaneously on individual PCs. While I demonstrated the examples on a spreadsheet presented on a large screen, the students modelled the examples on separate spreadsheets in their own laptops. In addition, I introduced new theoretical concepts and principles as the examples required. Once the example was complete, the students and I encoded the general principles behind the problem solution through various dialogues.

In the first cycle of this social constructivist-inspired and technology-enhanced lecture format, I presented more comprehensive business-related examples. However, since many students felt that these examples were too complicated, I redesigned the lecture content by developing worked examples. For each lecture, I took printouts of the worked examples and distributed them to the students who did not want to use a PC when attending the lectures. In spring 2015, I developed interactive micro-lectures to support the worked example lecture format, and by this approach, the classroom was 'flipped' (Heimly & Bertheussen, 2016a; Lage et al., 2000).

One purpose for the interactive micro-lectures was to scaffold the students who thought that the progress in the class was too fast. As a result, these students could watch the calculation procedures on a PC, laptop, tablet or mobile device (either before the live lecture or after) and even review the material according to their needs. Another purpose for the micro-lectures was to support the students who could not attend the live lectures for one reason or another. Through this constructed solution, I did not interfere with any of the course's resource constraints. I continued to use the large auditorium for teaching, which enabled me to teach more than 100

students at a time. Moreover, I was not restricted by the small PC laboratories and I was able to perform all of the teaching within the 38 hours allocated for the course.

3.5.4 A solution implemented and tested to work in practice

The cost-benefit ratio for the institution when implementing the aforementioned lecture format is positive since more satisfied students are produced at no extra cost, i.e. the students bring (and finance) the added infrastructure necessary. The lecture notes on the worked examples are distributed for free (freeware) for this specific course. Thus, a finance lecturer wanting to create more activity in his/her finance lectures (based on the constructivist pedagogical principles outlined here) can implement the innovation right 'out-of-the-box'.

3.5.5 The scope of the solutions applicability

The concept of worked examples is not restricted to an undergraduate finance course, but it can have a wider area of application, i.e. other business topics such as budgeting, cost accounting, tax accounting, etc. However, it will require an extra effort by the teacher to design and develop subject specific worked examples. In Heimly & Bertheussen (2016a), another variant of the flipped plenary lectures format is discussed and evaluated. In Table 3.4, resources resulting from the present study are listed in order to support a teacher in flipping his/her plenary lectures.

Table 3.4. Papers and artefacts that can inspire a practitioners to flip plenary lectures in business-related topics

○ Paper 8	Bertheussen, B. A. (2013a). Revitalizing Plenary Finance Lectures. *Beta, 27* (1), 78–92.
○ Artefact 5	Interactive micro-lectures in basic finance. Open source documents available from the author: bernt.bertheussen@uit.no
○ Artefact 6	Bertheussen, B. A. (2012b). Slik kan regnearkmodellering revitalisere læring av klassisk bedriftsøkonomi. *Dybde 1*/2012, Publication at School of Business and Economics, UiT–The Arctic University of Norway.

3.6 The learning community interventions

3.6.1 A practical relevant problem

The learning activities discussed thus far in this study (i.e. textbook reading, plenary lectures and individual problem-solving) do not exploit the learning possibilities embedded within dialogue and collaboration. However, it was essential in the present study to make the spreadsheet an enculturated artefact of the learning community. Thus, two specific formats of learning communities were designed and integrated into the learning environment of the course.

3.6.2 A comprehensive understanding of the topic

Students learn, not only by direct instructions, but also by participating in the discourses and engaging in the practices within a learning community (Putnam & Borko, 2000). This is in line with the sociocultural perspective on learning (Wenger, 1998). Learning is fundamentally a social phenomenon (Lave & Wenger, 1991) and at the outset, integrating spreadsheet usage into learning communities is a concept which is rooted in sociocultural learning theory (Warschauer, 1997). In learning communities, fellow students can help, encourage and challenge one another in order to achieve greater results (Daniels, 2001). More specifically, those in such communities can utilise one another for scaffolding (Wood et al., 1976) when considering difficult problem-solving tasks which challenge their zones of proximal development (Vygotsky, 1978). In a learning community, participants learn by discussing subject matter and they can collaborate to solve difficult problems.

3.6.3 An innovative solution

In the course design (see Figure 3.1), I added learning activities which could enrich dialogue and collaboration. In addition to the workshops using spreadsheets, an attempt was made to integrate a learning community format in which students worked in pedagogical pairs in order to produce better learning outcomes. Peer instruction (Mazur, 1997; Crouch & Mazur, 2001; Lasry, Mazur & Watkins, 2008) involves classroom activities '…that require each student to apply the core concepts being presented and to explain those concepts to their fellow students' (Crouch & Mazur, 2001). Moreover, collaborating in pairs promotes professional dialogues and

a supportive learning environment as well as improves understanding and analytical skills (Williams & Upchurch, 2001).

The concept of 'pedagogical-pairs', as applied in this study, was inspired by the computer industry where it proved to be productive, especially in the design and development of software (Williams & Upchurch, 2001). In the context of this study, the pairs worked on the same PCs, but one person was in control while the other served as an observer whose job was to ask questions, suggest alternative solutions, seek information and detect errors. In addition, each person could switch between being the operator and the observer, and vice versa. The concept of 'pedagogical pairs' is rooted in sociocultural learning theory in which knowledge is constructed through the social practice of people working towards a common goal or through dialogues with different perspectives (Salomon, 1993). In the present study, the students could also attend the workshops (held after every second lecture) where they could jointly solve difficult problem-solving tasks. Moreover, professional subjects were discussed and scaffolded by the fellow students and the student assistants as well as the teacher.

3.6.4 A solution implemented and tested, but not sustainable

The formats of the learning communities in which students learned subject matter theory supported by spreadsheet usage and scaffolded by student assistants and/or the teacher was an ongoing practice for only two years at this author's university business school. However, because of low attendance by the students both interventions were eventually removed from the curricula. In section 4.4.2, this issue will be discussed in more detail.

3.6.5 The scope of the solutions applicability

The workshop where students collaborated on problem-solving using spreadsheets and supported by tutors can be viewed as a miniaturized version of the plenary finance lecture format. One difference is the smaller format as maximum 30 students were allowed to attend. Another difference is the sharpened focus on academic problem solving. There is, however, not much innovative in supporting learning through the use of workshops in higher (business) education. The novelty of the presented workshop format was the conscious use of spreadsheets in mediating subject matter problem solving, an attribute supported by the students who brought

their own laptops to the seminar rooms. Also, working in pedagogical pairs required no additional financial investments from any of the stakeholders, i.e. the students, the teachers or the institution. It was simply a matter of organising the learning activity. Nevertheless, these two interventions turned out not to be sustainable in the present study (see section 4.4.3 for a reflection on this issue).

3.7 The textbook intervention

A new textbook was one of several interventions in the course design presented in section 3.2 (see Figure 3.1).

3.7.1 A practical relevant problem

A textbook of corporate finance at the bachelor's level can summarily be described as a basic book in mathematics, statistics and microeconomic theory applied for financial problems. In order to design a course aiming to foster a spreadsheet user-culture, I began by developing worksheet based problem-solving tasks and assembling them within an exercise workbook. Although the tasks were well-received, the students suggested certain improvements, which I applied afterward. For example, the link between the 'old fashioned' syllabus textbook, which had been used for many years, and my financial spreadsheet-based, problem-solving tasks were too vague. According to the students, 'You must write a textbook that reflects that we are always using spreadsheets when practicing'.

3.7.2 A comprehensive understanding of the topic

The evaluation of the Norwegian Quality Reform (Aamodt et al., 2006) reveals that students' approach to the subjects is characterised by reading to remember, and they are significantly less likely to read critically and evaluative. In other words, basic ways to acquire knowledge are the priority. The evaluation also shows that there are small differences in studying between Norwegian institutions and between disciplines (ibid.). An important goal of the Norwegian Quality Reform (Report No. 27, 2000–2001) was to increase the quality of higher education in Norway. The reform was based on the fact that the Norwegian student population is heterogeneous and that students have different needs.

In a basic professional course, it is important to have a practical approach. Since the students will eventually become professionals, the present study emphasises their capacity to implement disciplinary procedures in spreadsheets. Nevertheless, an academic course must also accommodate subject theories to provide the learners with tools which enable them to solve practical problems in the subject. However, theories which degenerate into an abstract incomprehensible flow of words for the learners have limited transfer value (Salemi & Siegfried, 1999).

Finally, if theories are not connected to applications in economic reality, then it may be difficult for learners to apprehend the value of such theories. Working with theory and problem-solving tasks which do not make sense rarely increases the motivation to engage with the curriculum (Pintrinch, 1999). Moreover, new meanings, values and attitudes become enculturated within schools only when they have become embodied and are sustained within real-life contexts (Dewey, 1938).

3.7.3 An innovative solution

In the textbook, I only included theory that was relevant for the spreadsheet-based exercises and the problem-solving tasks. The theory was purified through informal 'chit-chat'. However, I was careful to keep myself within the curriculum requirements of the National Council for Economic and Administrative Studies (NRØA) since the course is compulsory for the Bachelor's Degree in Business Administration. When I developed the manuscript, I began by first creating the practice problems, not the theory, since most of us learn best when we are active (Freeman et. al, 2014) and practising stimulates activity. This was a backward writing process. In addition, it has been shown that it is more engaging for students to work with problems that are perceived as meaningful (Fels & Buckles, 1984; Herrington & al., 2009). Therefore, some of the practising problems were related to the students' everyday lives, i.e. is it profitable to invest time, money and effort into the Bachelor's Degree in Business Administration?

I gradually extended the scope of the problems in order to challenge the learners' proximate zones of development. By taking this approach, I hoped that practising problem-solving would create a sense of empowerment and motivation for learning. Some practising exercises were designed to drill fundamental concepts and understanding, whereas other problem-solving tasks were more open and constructed to prepare the students for the final examination. The theory, which

enabled the students to solve the problems, was written after I had completed the practice problems. In this manner, I intended to establish a direct link between theory and practice, thus making it easier for the students to appreciate the purpose of reading theory. The students also solved the practice problems on spreadsheets. In this regard, they developed digital skills in parallel with applying financial theory. The textbook intervention went through three macro-cycles of design, development and revision. In the first cycle (2005), I developed an exercise workbook without any texts attached. Next, I 'wrapped' the text around the practising exercises (2007), thus making it a textbook (the second cycle). In the final cycle (2010), a colleague (Espen Sirnes), extended the scope of the book by adding more advanced finance topics.

3.7.4 Implementation and scope of the solutions applicability

The textbook is subject specific anchored in the Norwegian NRØA-requirements (NRØA, 2011). It is available at most academic bookstores in Norway, since it is distributed by a national publisher. Consequently, it has been implemented within several introductory finance classes.

3.8 Conclusion

This conclusive section aims to integrate and synthesise the various issues raised in this chapter, while reflecting on research question 1 as presented in Chapter 1. When I returned to a university college after having worked for more than twenty years in the business field, I was assigned to teach an undergraduate finance course characterised by a high failure rate and dissatisfied students. In the subject, the students used handheld calculators and paper-based interest tables for their calculations just as I myself had used as a student thirty years earlier. It seemed like the rapid technological development in society had passed academia unnoticed since information and communication technology (ICT) was underutilised in the learning and assessment activities.

Against this backdrop, I decided to design, develop and implement digital learning and assessment activities within a finance course in higher education, which could contribute to student engagement, motivation and learning outcomes. In the learning culture of the subject, I placed special emphasis on facilitating students' development of spreadsheet skills in parallel with learning finance theory.

Accordingly, the interventions described in this chapter is concerned about the promises and challenges of establishing a spreadsheet user-culture within a finance subject, as seen through the eyes of an individual teacher. Drawing on notions from cognitive and sociocultural learning perspectives, the focus has been on facilitating active learning supported through the spreadsheet artefact, which was regarded a 'cultural tool' of the subject's learning community (Somekh, 2007). Therefore, in the research project, I integrated spreadsheet usage into the learning and assessment activities in a naturalistic classroom setting.

The philosophical and methodological 'middle ground' offered by pragmatism empowered this study to draw upon both quantitative and qualitative methods to address certain research questions. The methodology applied has clear similarities with IR, which is a practical research methodology which can help bridging the gap between theory and practice (i.e. Jönsson & Lukka, 2007; Baard, 2010). In addition, IR focuses on real-world problems and the overall goal of change and achieving improvements at the host organisation, as was the case in this study.

In the first phase of the research process, the problems were analysed in-depth in consultation with students and colleagues where I (the author of this dissertation) served as the teacher, designer and researcher. Underpinned by sound cognitive and sociocultural pedagogical principles, I designed and implemented solutions in several iterations with improvements made between them. The emphasis was on presenting the subject so that the students implicitly expanded their spreadsheet skills as they applied the artefact while learning of subject matter theory in a motivating and engaging way. Now, I will synthesise the empirical findings discussed in this chapter.

3.8.1 The textbook intervention

The integration of spreadsheet-based exercises within a finance textbook was motivated by a call for active learning, which is situated in both cognitive and sociocultural learning perspectives (Dysthe, 2001) and currently supported empirically by Freeman et al. (2014). The textbook encouraged the students to construct financial models into their respective spreadsheets, which implicitly developed their spreadsheet skills, and utilise the completed models for subsequent simulations and reflections. Moreover, such spreadsheet usage has the potential to expand the learning of subject matter theory (*Paper 4*). I wrote the textbook through a backward design and writing process by first creating the practice problems and then 'wrapping' the theory around

them. In this manner, my goal was to make it easier for the learners to link theory and practice when working with the textbook and the exercises. According to an evaluation survey, the students reported good learning outcomes from applying spreadsheets when working with the textbook (*Paper 1*).

3.8.2 The flipped plenary finance lecture intervention

The plenary lecture, as a teaching method, is an efficient tool for the mass production of education if an institution includes a large influx of students, few available teaching hours and previous investments in large lecture theatres (*Paper 3*). However, such a learning environment does not invite activity which characterises high-quality learning (Freeman et al., 2014). In order to invite the students to take a more active approach in the plenary lectures, I designed a lecture format in which the students brought their own PCs. When lecturing, the learners and the lecturer simultaneously developed worked examples on their spreadsheets. In addition, the lecturer introduced new theoretical concepts and principles as the examples required. Once the example was completed, the students and the lecturer encoded the general principles behind its solution through various dialogues (*Paper 8*). In this case, the students could prepare for the plenary lectures by reading the textbook or watching the interactive micro-lectures at home.

In the aforementioned lecture format, a student gained spreadsheet skills implicitly when developing a worked example in his or her spreadsheet. Moreover, when applying the spreadsheets, it supported learning of subject matter theory. For examples, the learners used the spreadsheets to construct worked examples and they utilised the completed worked examples for simulations and reflections in the lecture theatre. According to an evaluation survey, the students reported good learning outcomes from participating in the flipped plenary finance lecture format (ibid.).

3.8.3 The learning community interventions

Learning communities provide an arena for collaborative practice and they stimulate learning through discussions of subject matter theory (Dysthe, 2001). In the present study, learning communities were integrated into two formats. One of which students worked in pedagogical pairs and another in which students worked in tutor-led workshops. In the pedagogical-pairs format, two students worked on the same PC, whereas one was in control while the other served as an observer whose job was to

ask questions, suggest alternative solutions, seek information and detect errors. In addition, each person could switch between being the operator and the observer and vice versa. The primary purpose of both formats was to engage students in solving difficult problem-solving tasks on their spreadsheets. Spreadsheet usage supported an active learning approach and through their participation, the students implicitly developed spreadsheet skills as they actively learned subject matter theory (*Artefact 6*). It turned out after a couple of years, however, that the learning community interventions were not sustainable. It will be reflected upon this issue in more detail in section 4.4.2.

3.8.4 The digital formative feedback intervention

In a large group of students which only meets once a week for lectures (plus every other week for workshops), feedback and individual guidance will be insufficient. To solve this problem of feedback shortage, I decided to design, develop and implement interactive problem-solving tasks within the curriculum. The spreadsheet-based tasks provided individual formative feedback to the learners on both the problem-solving outcomes as well as on the problem-solving processes (*Paper 7*). By means of VBA, the programming language embedded within the Excel spreadsheet software, I was able to build 'artificial intelligence' into the spreadsheet-based problem-solving tasks and make them interactive. In this regard, an interactive problem-solving task is basically an inactive traditional spreadsheet-based task with a marking and feedback algorithm attached (*Paper 6*). The interactive tasks, which are digital learning resources in micro format, are considered an educational innovation in this study.

The information provided by the interactive problem-solving tasks was built on Nicol and Macfarlane-Dick's (2006) principles of good formative feedback practice, which aimed to support and develop learners' self-regulation (ibid.). One of the principles underlines that good formative feedback can scaffold a student when attempting to improve his/her solution, while another principle highlights the importance of encouraging positive motivation and self-esteem (*Paper 7*). In the digital formative feedback practice, the students worked with interactive problem-solving tasks at home, on the compulsory assignments and on the final examination. Based on the taxonomic analysis of the tasks, the intention was to test the learners on their cognitive thinking processes (beyond memorising and drilling) as they were

required to model and solve business problems from basic principles in a spreadsheet environment (*Paper 4*).

When predicting academic performance, based on the students' engagement in the digital learning activities of the presented finance course, we found (*Paper 2*), after controlling for prior achievement (e.g. mathematics grades), that academic performance (e.g. examination scores) was significantly associated with deliberate problem-solving activities using interactive problem-solving tasks. Furthermore, according to an evaluation survey, the students were satisfied with utilising the interactive problem solving-tasks, and they claimed that the feedback received created a sense of achievement and motivation for problem-solving (*Paper 7*). In addition, the learning outcomes from engaging in interactive practice were positively perceived (ibid.). In the third cycle of development, the system was further developed so that a teacher with no programming skills can tailor-make problem-solving tasks to his/her subject context and develop an individual digital formative assessment practice (*Paper 6*).

3.8.5 The digital summative assessment intervention

Students have questioned why it is so important to develop digital skills when they cannot actually use such expertise in their respective examinations. This was seen, inter alia, in the *We Want PCs on our Exam* student campaign in Norway, which occurred during autumn 2011. One reason why institutions deny students the use of computers is the lack of facilities (e.g. computers and premises) which can simultaneously handle hundreds of students undertaking their final examinations digitally. To establish a large-scale digital examination practice, as outlined in the present study, required deliberate cooperation among relevant stakeholders such as the faculty (which permitted the practice), the teachers (who developed the semi-individual exam tasks and validated the examination practice) and the students (who brought their own electronic devices). According to a evaluation survey, the students stated that being able to use spreadsheets on the assignments and on the final examination motivated them to use this tool in their daily learning activities (*Paper 1*).

3.8.6 The course design intervention

This study shares the notion that the development of digital knowledge and skills in an isolated manner has little hope to succeed (Koehler et al., 2014). Consequently, by taking a holistic approach to technology integration within subject teaching and learning, I consider implementing a digital examination practice to be a critical prerequisite for a technology-rich course to yield the intended learning outcomes. This is a significant lesson learned from the present research and development project. It was crucial to give priority to implementing a digital examination practice when developing a spreadsheet user-culture in the finance subject.

This finding is not surprising since it is in line with extensive research in the area (i.e. Cachia et al., 2010; Ellis & Barrs, 2008; Looney, 2009; Phelp, 2014; Redecker & Johannessen, 2013; Somehk, 2007). If the faculty implements digital examination practices within subject cultures, then it is logical that the practical learning interventions also need to include the use of the same tool(s) in order to prepare the students for the summative assessments. In this study, the digital examination practice acted as an 'ice breaker' for successfully developing the other digital learning interventions into the course design. This is also in line with previous research, i.e. Somekh (2007); Redecker & Johannessen (2013); Phelp (2014).

However, a teacher can tailor-make spreadsheet-mediated textbooks, flipped plenary lectures and ICT-supported learning communities as well as a digital formative feedback practice in a finance course as high-quality, stand-alone interventions. Each intervention is special in its own right, but when combined, the result is an extraordinary finance course in which students implicitly develop their spreadsheet skills at the same time as they apply the artefact while learning subject matter theory. As a designer and practitioner of the course, I believe that the total learning outcome for students by implementing the entire innovative 'package' is more than the sum of its parts. Finally, subject matter theory was the focal point of the learning interventions in the presented finance course, not the development of spreadsheet skills. However, the students implicitly developed their spreadsheet skills as they applied the artefact when learning subject matter theory. The learners accomplished this through the construction of spreadsheet-based financial models and by using the completed models for simulations and engaging subject matter reflection within all of the presented learning interventions.

Chapter 4: Retrospective reflective analysis

4.1 Introduction

The present study was a longitudinal interventionist (IR) case study where I, as a practitioner researcher, introduced several ICT-based interventions into an undergraduate finance course in order to engage students' when learning subject theory at the same time as the students developed spreadsheet skills. The pedagogical intention was to narrow the gap between the learning of subject theories and the application of these theories through solving financial problems using a business-relevant ICT tool, i.e. a spreadsheet. An important educational goal was to make the students' knowledge and skills more relevant for later occupation and further studies.

However, high-quality IR aims at producing contributions that are not only practically relevant but also theoretically significant (e.g. Baard, 2010; Labro & Tuomela, 2003; Jönsson & Lukka, 2007; Suomala et al., 2014). This implies that a good interventionist researcher has to be effective in both the practical (emic) and theoretical (etic) domains. Three streams were actually ongoing at the same time during the study as seen from the perspective of the practitioner-researcher. First, there was a production stream, i.e. ordinary teaching and learning activities. Second, there was an intervention stream concerning the design and development of interventions into the production stream. Finally, there was a research stream aiming to develop theoretical understanding based on the production and intervention streams. As an interventionist researcher I had to straddle between the emic (insider) world that was followed during the empirical phase in particular, and the etic (outsider) world that was required in reflection and for deriving broader theoretical implications based on the empirical evidence (Suomala & Lyly-Yrjänäinen, 2012).

The objective with this chapter is to answer research question 2 of this study, which was presented in the introduction chapter of this study as follows:

> *How were tensions and problems between and within the etic and emic domains managed and exploited in this study?*

In the discussion that follows, I will distinguish between three kinds of tensions inherent in any IR project (Suomala et al., 2014). These are tensions within the emic domain, within the etic domain and between the two domains.

4.2 Tensions within the emic domain

4.2.1 An emic point of departure: a sense of educational relevance lost

Before any of the interventions in this study were designed and developed, two pilot semesters of the undergraduate finance course were conducted at the university college near my home village during the 2005 and 2006 spring semesters. This provided me with the opportunity to observe features of the traditional educational environment in operation and form an elementary awareness of how it functioned (*Paper 3*).

The observations and awareness of the technology-poor, non-collaborative and disengaged students gave me a feeling of 'educational relevance was lost' (Barab & Squire, 2004). Accordingly, I was inspired to design a new course aiming to solve the aforementioned problems. This was the emic point of departure of this long-lasting research and development adventure.

Included in my backpack of business experiences, I brought about a lot of practical examples that I could connect to theory to make it more relevant. Also from my business experience, I brought a culture in which we attempted to solve difficult problems together by benefitting from each other's strengths. In business, as I had experienced myself, we worked in teams. Moreover, we took advantage of ICT technology whenever it could cost-effectively contribute to more effective problem solving. Accordingly, the initial cycle of development began in the spring semester of 2005 as a response to a tension of educational relevance lost.

It did, however, not take long before I decided to use a spreadsheet as the practical calculation tool. The first action taken was to develop worksheet-based, financial exercises and problem-solving tasks. At this stage of the development process, the spreadsheets were not interactive, i.e. they could not automatically provide feedback on the students' solution attempts. Moreover, the capacity of the data lab was adequate to seat all students in the cohort so we could solve the spreadsheet-based financial tasks there. In this way, ICT was introduced into the classroom in isolation (McCormick, 2004; Somekh, 2007) at the very early stage of development.

4.2.2 A holistic approach to teaching and learning

A classroom is a complex and dynamic organisation (Chai et al., 2014; Pine, 2009). As educational researchers, we typically deal with this complexity by breaking initially, simple integrative ideas into more and more fine-grained concepts (van den Akker et al., 2006). As a consequence, we tend to complicate and fragment our theories. I believed the opposite was needed to unite rigour and relevance when this research and development project started (*Paper 3*).

At this time, I found no good examples of integrating ICT into subject learning and teaching, either among business schools or among publishers. As a practitioner, having already completed in 1986 an attempt to embed ICT within business economic subjects at NKS Bedriftslederskolen, I had experienced some of the complexity of integrating ICT within classroom learning and teaching (Bertheussen & al., 1986). During the research and development process, I realised the limitations of studying a classroom culture without considering external conditions (Wang & Hannafin, 2005). In the prevalent teaching paradigm, plenary lectures and individual examinations were considered suitable tools for cost-efficient mass education despite the fact that the major emphasis of volume production can compromise the quality of the education (*Paper 3*) by promoting surface learning not in-depth learning (*Paper 4*).

The practical course design model (*Paper 1; also see Figure 3.1*) focused on creating alignment between the learning targets, the learning activities and the assessment activities (Biggs, 1996), while integrating ICT usage whenever practically appropriate. In its conceptual simplicity the model took a holistic approach (Somekh, 2007) and embraced all the complexities involved in an integrated effort to scaffold the learning of theory at the same time as the students implicitly developed ICT skills.

In my experience, a teacher need simple but comprehensive frameworks in order to be able to comprehend and set directions in a complex and dynamic reality (*Paper 1*). If we continue to equate higher levels of conceptual disaggregation with more profound knowledge, our research efforts risk being of ongoing irrelevance to the practitioner (Gutiérrez & Penuel, 2014, Reeves, 2011).

4.2.3 Emic reasoning in an etic world: developing low-cost/low-technology interventions

To compensate for the lack of guidance when the project was initiated, as an interventionist researcher I had to turn to diverse resources for inspiration such as my

craft knowledge and experience, feedback from students and the like. Actually, I took ideas from whatever sources to construct the educational interventions discussed in Chapter 3. In this respect, the way of working resembled the manner of working of what is called a 'bicolour' (Gravemeijer & Cobb, 2006).

A bicolour is a handy person, who uses as much as possible of those materials that happen to be available. Consequently, the interventions in this study (see *Chapter 3*, *Paper 1*, *Paper 5*, *Paper 6*) are examples of low-cost/low-technology interventions. Most resulted from practical reasoning, as I the practitioner researcher ensured that the interventions have been congruent with the capacity of the participant system, i.e. with available time resources, competence and material resources at the host organisation (Baard, 2010).

Consequently, the project may be described as a low-cost/low-technology project organised as voluntary communal work where the stakeholders that have been most directly affected (students, business school, practitioner-researcher) have contributed without much other compensation than the learning outcomes from participating. During the research and development process, I did not apply for or was provided with any funding support from any institutions, except for the business school who paid my wage.

For any stakeholder wanting to adapt the interventions, there is actually no financial threshold preventing interactive problem-solving tasks (*3.4*) or the automated examination procedure (*3.3*) from being adopted. First, the systems are distributed for free. Second, the only infrastructure required for students and teachers is the Excel spreadsheet software that most students and teachers already have access to (*Paper 6*). Third, the institution will require a system to distribute the problem-solving tasks to their students.

However, this can be accomplished either through a learning management system (LMS) or by e-mail or a digital system for managing exams like Wiseflow, and such basic infrastructure is so common at higher educational institutions that there is no need for additional investments. If students bring their own electronic devices, then a digital feedback and assessment practice may only occupy physical resources already present at a college, such as a wireless network, an e-mail server and sufficient electrical outlets in the examination halls.

As a benefit, the students are automatically provided with formative feedback during the coursework, while the assessment load on teachers is significantly reduced

because the examination papers are automatically scored and marked. In this regard, the automated feedback and assessment practices addressed in this study is cost-effective, practical and efficient (*3.8.4, 3.8.5*).

4.2.4 Was the finance course released from its historical pedagogical path dependency through the educational interventions?

Paper 3 argues that Norwegian business schools may be locked in to historical pedagogical path dependency, characterised by plenary lecturing as a teaching method and utilising individual examinations as an assessment procedure in order to produce low-cost mass education at the expense of learning quality. The question raised at this point is whether the finance course has been unlocked from this simplistic production model through the educational interventions discussed in Chapter 3?

I think the answer is 'no', although with a certain reservation. The most important reason is that interventions do not represent a paradigm shift; that is they do not cause a systemic change in the teaching and learning environment. As I see it, they first and foremost represent efforts on improving existing business processes. The 'business model' is still instructor-designed and more or less unchanged, however, except that it now is materialised in a digital disguise (*Paper 1*).

The most important change is that I have strained to streamline the teaching and learning processes by digitising them. Still, the students are gathered in a large lecture theatre although bringing their own devices, thus supporting a low-cost model of learning production (*Paper 8*). Moreover, there still is a 'sage' on the 'stage' although the message is shared through worked examples the students examine in their own spreadsheets. Also as before, the students mainly work with individual assignments, except that now they automatically receive formative feedback on their solution attempts (*Paper 7)*. The individual-based examination model is also unchanged except from being digitised (*Paper 5*).

One lesson learned from this study is that the introduction of new technology into existing production processes does not lead to systemic change itself (Somekh, 2007). On the contrary, digital technologies may contribute to continued confinement into the old teacher-centred paradigm. This is especially true if new technology can help with simplifying the working day of teachers, for example through automatically correcting assignments and exam questions. If this is the case, new technology

may work counterproductively when it comes to accelerating a long-awaited paradigm shift (systemic change) in higher business education (*Paper 3*).

However, the solution chosen in the present study of improving learning and teaching processes can be interpreted as a compromise between the interventions and the institution's need for stability (Suomala et al., 2014). The production methods in the present study were streamlined through ICT primarily by students having access to a practical digital tool that made it more effective to build financial models, enabling them to simulate with the models' underlying assumptions and through this open up productive professional reflections (*Artefact 6*, *Paper 4*).

If the students were activated and engaged to a greater extent in the digital learning processes than in the corresponding analogue, this study may be interpreted as a (very) small step toward a more student-centred paradigm (*Paper 3*).

4.2.5 Were students engaged within deep learning processes?

In higher education, we seek to encourage deep or quality learning. In contrast, surface learning is the opposite of deep learning (*Paper 4*). When students can only achieve high marks through memorisation and drills, then the course design promotes surface learning. Surface learning is restricted to remembering processes such as the memorisation of facts and concepts as well as learning by drilling (Anderson & Krathwohl, 2001).

At the undergraduate level, learning is about understanding, applying and analysing facts, concepts and procedures (NRØA, 2011). However, it is also necessary to remember pertinent information to acquire in-depth knowledge. An original conjecture in the present study was that high exam scores only could be achieved by students being deeply engaged in spreadsheet-based learning activities. In this regard, a significant portion of our examination practice was to craft examination questions and problems that could challenge students to undertake a deeper learning approach (*Paper 4, Paper 5*).

A regression model was developed to analyse the effect of student engagement in digital learning activities on academic performance (*Paper 2*). The main finding was that 'interactive practising makes perfect', but only to a certain extent. The results showed that if such practice degenerated into mechanical drilling without professional reflection, the overall documented learning outcome decreased.

Consequently, we do know that some students in this study undertook a surface approach to learning. In these instances, applying the spreadsheet artefact did not expand subject matter learning. Whether or not all students that achieved high exam scores undertook a deep learning approach we cannot conclude because there may be alternative explanations for high performers, e.g. by students cheating.

4.2.6 Was cheating hindered on digital examinations?

Cheating on exams has been a considerable problem in the education sector for more than a century (Anderson, 1998) and the research literature with regard to cheating on traditional exams is extensive. However, the literature is considerably sparse in relation to online cheating (Watson & Sottile, 2010). In fact, the results of studies on online cheating have been contradictory (Stuber-McEwen et al., 2009). Nevertheless, students taking a surface approach to learning are more likely to cheat compared to intrinsically motivated students (Carroll & Appleton, 2001). Therefore, it is important to develop digital exam practices that foster deep learning approaches.

In the present study, the final exam was proctored; it was not an open-book examination as the students were not allowed to open or copy materials from files since this was regarded as cheating. We also considered any communication with fellow students as cheating. To reduce the potential for cheating, students were given common problems to address, but they included individual data sets. In other words, the examination papers were semi-individual as the problems were similar but the data sets were personal. This implied that the students should solve the problems by applying the same procedures, but they had to implement the procedures in their own way. In the data sets, the values of the variables differed, which resulted in various solutions (*3.3*).

Moreover, the variables used in calculation procedures (formulas) were inserted in randomised cells on the spreadsheet and, as a result, the formulas created by the students were different. Therefore, information concerning another student's solution, or formulas leading to the solution, was of no value. The fact that students developed different solutions, as well as different formulas leading up to the solutions, made it more difficult and time-consuming to cheat (*Paper 6*). Nevertheless, this was not a guarantee against cheating. Prior to the exam, the students may have worked with financial issues solved in a specified way and they may have saved many of the solutions on their computers. As we had limited opportunities to enforce the

ban on cheating, students could still open these spreadsheets and compare them with the exam questions during the examination.

Furthermore, by analysing the structure of an exercise that was previously stored on the computer, a student could find helpful guidelines that may aid in working out the solution. However, as the individual data sets were different, they could not simply copy and paste elements from the previous exercises into their examination paper. Comparing and discovering the underlying structure of the two problems requires sophisticated abstract thinking. According to Anderson (2001), evaluating is, along with analysing and creating, a higher-order cognitive process. Students who were capable of this type of thinking process are more likely to resolve the original exam questions and problems.

However, we cannot rule out that students are searching for solutions to exam questions and problems by opening, analysing and evaluating material stored on their computers. In addition to being knowledge-intensive, this operation requires students to have completed the exercises in the course and saved the solutions. Indeed, this will be a time-consuming method for solving an exam question or problem. During a digital examination such as ours, time was a limited resource and the students receive approximately half of what they would have received on a similar manual examination.

Nevertheless, the approach taken to deter cheating in the present study builds on a conjecture that was not tested. Accordingly, the study cannot conclude whether the measures led to less cheating than if they were not implemented. For the same reason, the study cannot either conclude whether the propensity to cheat was smaller or larger in this blended course than in a similar traditional finance course. Nor can the study conclude whether semi-individual examination papers were able to deter cheating versus the alternative, which would have been common and not semi-individual examination questions.

4.2.7 Managing institutional resource constraints

The management and administration of the business school have been positive toward students using digital tools when learning and being assessed. However, I was of course not free to design the interventions exactly as I wanted because the institution placed certain restrictions on available lecture theatres, manpower resources available to arrange the course, number of students that could attend the course,

access to ICT infrastructure (e.g. PC labs), etc. If students are to take advantage of engagement opportunities then institutions are required to provide them (Coates, 2005).

Some of the tensions related to resource issues were more explicit than others. Computer rooms with very limited capacity (approximately 25 PC's) were, for example, an explicit issue. However, this challenge was resolved through a compromise negotiated between the practitioner researcher, the institution and the students in which the students were allowed to bring their own laptops to the lecture theatre and examination hall.

When this project started about ten years ago, procedures for submitting and collecting digital examination papers did not exist. Accordingly, I initiated upon students' requests (*3.3.1*) the development of digital administrative procedures (*Artefact 2*) as this was regarded a critical component to get the educational programme going. This intervention was, however, an unintended spin-off of the study. Ten years later the introduction of digital examinations is about to be introduced on a large scale throughout higher education in Norway. From autumn 2016, the custom-made digital administrative system will be replaced by a general system (Wiseflow) recently introduced at the business school. However, the generation of semi-individual examination papers and automatic marking will continue as before.

4.2.8 Intervention processes initiated by students

Throughout the practical development process of the interventions, there have been several tensions between the students and the practitioner-researcher, which have either initiated new intervention processes or refinement of ongoing processes. In order to design a course aiming to also foster spreadsheet skills, I began by developing worksheet-based problem-solving tasks and assembling them into an exercise workbook (*3.1.3*).

However, the students complained and proposed certain improvements. For example, the link between the 'old fashioned' syllabus textbook, which had been used for years, and my financial spreadsheet-based exercises were too vague. Accordingly, the students requested me to 'write a textbook that reflected that we are using a spreadsheet when practising'. As a compromise, I wrote a textbook that was the precursor to *Artefact 4*, which contributed to *Paper 1*.

It was also a student who came up with the idea that I should stop using the traditional blackboard and chalk approach in the auditorium and replace it with employing Excel when teaching (*3.5*). After having discussed the matter in plenum, we agreed that all of students should bring their own laptops with spreadsheet software installed, thus enabling us to develop worked finance examples as a group in the lecture theatre. By bringing their own devices, the students made a compromise with the institution regarding the shortage of ICT infrastructure and the development project achieved flexibility. The resulting practical artefacts I developed were lecture notes in a spreadsheet format (*Paper 8*).

It was also student tension that initiated the development of the digital school examination intervention (*3.3*). When introducing the spreadsheet-supported course design to the students at Tromsø University College in 2007, it was an absolute requirement for them to be allowed to utilise the spreadsheet artefact when conducting their compulsory assignments and the final examination, so that they eventually could evolve into skilled spreadsheet users after completing the undergraduate finance course. This tension became the starting point for the intervention process, ending up with a digital examination procedure *(Artefact 2, Paper 5)*.

4.2.9 Opportunity costs for students' learning of the blended course

Blending ICT into learning and assessment activities requires learners to be both actively cognitive and motoric when working on subject matter theory (*Paper 8*). They can learn finance while using a spreadsheet. However, when attention is split into several sources, an additional burden is put on working memory. This can obstruct learning (Tarmizi & Sweller 1988).

For students with poor spreadsheet skills, it is conceivable that using a spreadsheet will be so distracting that they could fail to learn financial theory (*3.2.1*). If this is the case, the students will experience an efficiency loss. Conversely, for ICT-skilled students, solving financial problems in a spreadsheet will be more efficient than on paper. These students will therefore experience an efficiency gain and free up time to other learning activities by utilising a spreadsheet.

In brief, there may be trade-offs (negative for some students, positive for others) in establishing a course that puts great emphasis on applying ICT tools, because with more time spent on using ICT, less or more time may be available for learning traditional subject matter topics. The opportunity cost for students' learning

of the blended course design presented in this study is not explored. However, students reported that using a spreadsheet in plenary lectures did not obstruct them from learning financial theory (*Paper 8*).

4.2.10 Implicit development of spreadsheet skills

In the presented course design, students acquired spreadsheet skills implicitly, since applying a spreadsheet was embedded within the learning and assessment activities (*3.2.1, Paper 1*). This was a thoughtful apriori choice based on the conjecture that if learning of ICT skills is made explicit then this may shift the students focus away from learning of subject matter theory.

Nevertheless, at the beginning of the term, the students were offered a 'crash course' in Excel, which was attended by about one-third of the cohort. The educational and research approach chosen does, however, not allow this study to conclude whether students actually gained more spreadsheet skills during the course work or not (*4.4.1*). If a pretest of students' spreadsheet skills was undertaken at the beginning of the term, and a similar test was completed along with the final examination, the development of spreadsheet skills during the course work could have been gauged.

4.2.11 Intervention processes initiated by colleagues

When Tromsø University College merged with the local university in 2009, I and a university colleague were allocated shared responsibility for the undergraduate finance subject. At this stage, a tension arose because the textbook was not considered adequate for the university curriculum by my new colleague Espen Sirnes. However, this tension was resolved through his engagement in extending the scope and depth of the book by adding more advanced finance topics.

Accordingly, a compromise was reached and a new textbook produced (*Artefact 4*). Furthermore, in order to improve his teaching, another colleague, Finn-Steinar Heimly, flipped his classroom in an introductory management accounting course (Heimly & Bertheussen, 2016a). A typical attribute with a flipped classroom design is that the plenary lectures are taped on video and distributed electronically to the students so that they can attend the lectures whenever they want to and wherever they are (Bishop & Verleger, 2013). In the autumn 2015, I was inspired by Heimly's

effort and implemented flipped plenary micro lectures (duration of about 3–10 minutes each) into the flipped finance classroom (*Artefact 5*, *Paper 8*).

In 2008, I was challenged by a fellow teacher (Bjarne Fossheim) at Tromsø University College to justify the use of spreadsheets activities as we were developing budgeting tasks the students should built from ground up in a spreadsheet. During the process, Bjarne queried my use of spreadsheets as he feared that the students would only become skilled budgeting operators ('budsjettoperatører') without being able to understand the logic behind the integrated budgeting concept that consisted of three linked parts–an operating budget, a balance sheet budget and a cash budget.

I argued that applying a spreadsheet would motivate students to thoroughly examine the details in the system in order to link information by formulas from the different budgets. Without dynamic spreadsheet formulas, it would not be possible for a student to use the integrated budgeting system for simulations and reflections. Nevertheless, Bjarne did not let slip his worry that the students may only learn on the surface without gaining deep understanding, which he meant would result from applying pen, paper and a calculator. As a response to this tension, I started doing a literature review on the topic, and finally in 2012, I wrote *Paper 5*, which compares the cognitive challenges by solving financial problems on paper and PC.

4.2.12 Working interdisciplinary to improve teaching and learning of management accounting subjects in higher business education

In this research and development project, I have worked interdisciplinarily and crossed the boundaries between subjects such as business economics, pedagogy and ICT. I have also taken actions to develop interventions with elements from all these subjects. Finally, I have written scientific papers on the basis of the interventions. I have experienced the interdisciplinary work as challenging and thus informative and exciting. As a business economics graduate ('Siviløkonom') with more than 20 years of experience in businesses, I have been familiar with working interdisciplinarily. Moreover, I have been accustomed to take action to make 'things happen'.

The academic 'Siviløkonom' programme is itself interdisciplinary. It is a hybrid education that mixes 'soft' behavioural subjects (such as marketing and organisational theory) with 'hard' (economy) subjects (such as business economics and statistics). A 'Siviløkonom' is often employed in a management position in order to create

change within an organisation by improving processes and/or structures. Such change requires action. A practising 'Siviløkonom' can therefore be viewed as an interdisciplinary 'action researcher' who develops new knowledge by reflecting on whether interventions work in practice or not. This is not far from the role I have had as a designer and developer of the educational interventions in this study.

4.2.13 A reflection on engagement

This IR study would hardly been completed without a considerable engagement from various stakeholders, many of which were triggered through tensions that have arisen in the process (*see 4.1, 4.2, 4.3*). When I started to develop the interventions, I had a strong emotional wish to develop my own teaching to the benefit of my students. I wanted to become an active and engaged teacher in a learning community that could contribute to developing active and engaged students (*Chapter 3*). In this process, the administration at the business school also engaged in implementing digital assignments and digital exams which was regard educational innovations within higher business education at the time (*Paper 1*).

As the interventions were found to work more or less as intended, I engaged cognitively in communicating the results to the business teacher profession. This engagement was expressed behavioural through interventions which resulted in flexible and reusable digital artefacts that other teachers can customise and apply in their own teaching within management accounting subjects (*Artefact 1, Artefact 2, Artefact 3*). I also engaged cognitively by writing papers that were published in scientific journals, hoping that the interventions could have a value beyond their specific context.

However, the research activity was also emotionally motivated–now I felt a need to engage in order to become a part of the research community at the business school. Nevertheless, the research engagement were also extrinsic motivated as I saw an opportunity to rise through the ranks, achieving a higher wage and better working conditions, i.e. more time for research and development.

Despite the fact that I as a practitioner researcher have been active and engaged in teaching and R & D activities for many years through this IR project, from the very beginning and throughout the project the main aim has been to facilitate students' learning processes by creating an active and engaging learning environment. To this end, the use of spreadsheets has proven to be a very good activity and

engagement driver in this study. The spreadsheet has catalysed students' behavioural engagement as they have deployed their own laptop in every practical learning and assessment activities during the course (*Figure 4.1*, *Paper 1*).

However, the spreadsheet usage may also have helped challenge the students cognitively at a higher abstraction level than alternative analogue tools like a financial calculator would have accomplished (*Paper 4*). If the spreadsheet usage also has contributed to give students a better sense of professional mastery (e.g. *Paper 7*), then this digital artefact may have engaged students more emotionally than they otherwise would have done. Finally, the engagement of students in learning design can lead to students perceiving improvements in curricular relevance (Trowler, 2010*)*.

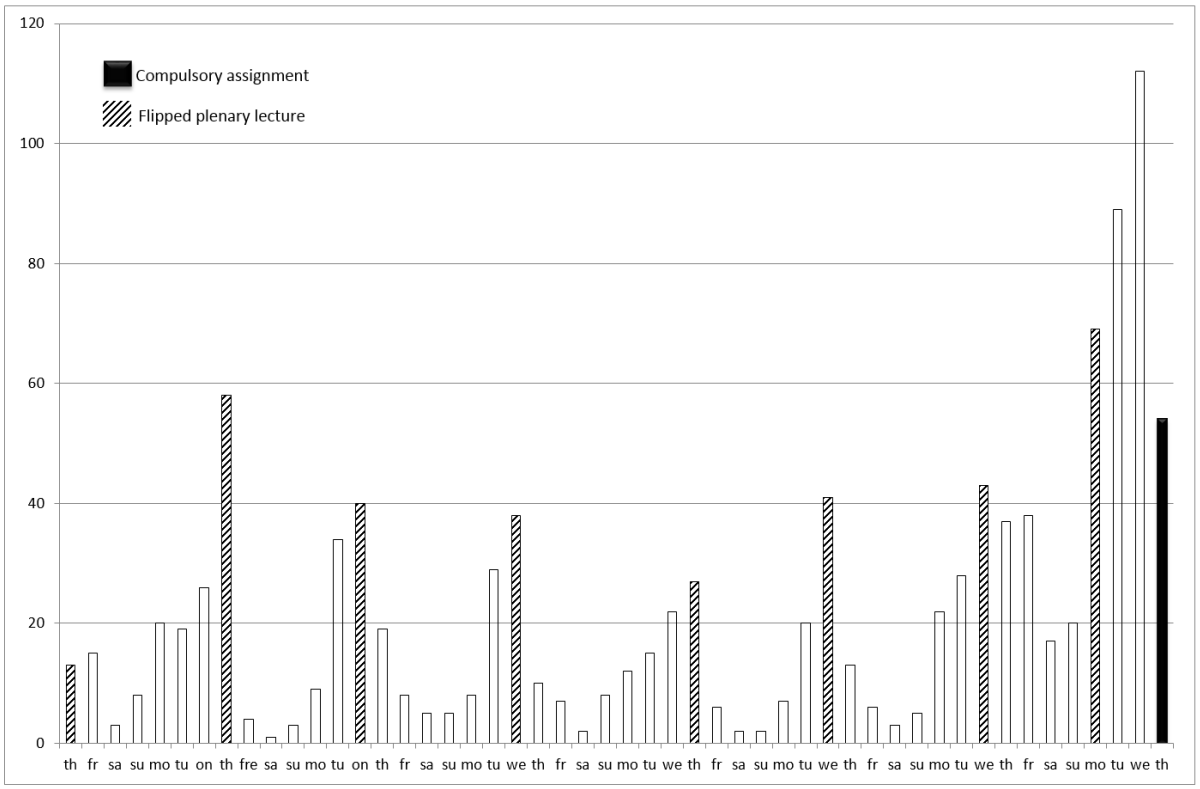

Figure 4.1. Daily exercising activity for 120 students during a period of 50 days.

4.3 Tensions within the etic domain

4.3.1 A unique long-lasting access to a host organisation

The idea of intervening research can be utilised in getting at true (emic) access and acceptance within a host organisation (Sumola & Lyly-Yrjänäinen, 2012). The case chosen in this study is not randomly picked, and for a good reason: it is special in the sense that it allowed the practitioner researcher long-term access to a host organisation in order to gain insights through integrating ICT into subject teaching, learning and assessment activities, taking an emic holistic approach.

A most significant obstacle as experienced in this study when it comes to integrating the use of digital tools in subject learning, was the fact that the students must be allowed to use digital tools on their compulsory assignments and their school examinations. This study was granted access to a host organisation who were willing to participate in a field experiment in 2007/8 at HiT, which continued on HHT in 2009 after having first been denied such access on HiH in 2006.

Consequently, this case study is an example of how longitudinal research is needed to provide the details of how interventions processes actually play out before, during and after implementation. Interventions work may be one of rare available research weapons for studying issues 'bubbling under' or that have not been extensively adopted by real-life organisations (Sumola & Lyly-Yrjänäinen, 2012).

Maintaining dynamic engagement with the host organisation was important both for the practical and the scientific output of this research project. If I had engaged in the project only for a term or a year, I would probably not have witnessed the need for integrating ICT within all of the learning and assessment activities within the course design and much less been able to design and develop the interventions into ongoing educational processes.

Likewise, had I not observed and analysed the interventions over several years, I would not have been able to produce the scientific articles as the vast majority came at the very end of the process. Fruitful interaction between research and practice requires a long-lasting relationship to experience first-hand the shifts and ongoing dynamics embedded in practical constructs (Schultz & Hatch, 2005).

The act of intervention can be used for validating the results during the process of research (*Paper 1, Paper 2, Paper 5, Paper 7, Paper 8*) in order to support both the

relevance and efficiency of theory production (Sumola & Lyly-Yrjänäinen, 2012). Referring to the existing literature on learning of management accounting subjects, it is unusual to follow a real-life classroom development based on such longitudinal data, as in this study. Finally, the study is positioned in retrospect as a rare educational study that applies the traditional management accounting IR methodology in an educational setting.

4.3.2 On adding a research approach to a thesis summary in retrospective

Various research methods are used in the published articles resulting from this study depending on the issues discussed. Paper 6 is conceptual, while the other papers are empirical. Most of these are based on primary data, and Paper 1, Paper 7 and Paper 8 are based on surveys. A significant part of the data for Paper 2 was collected automatically while the students worked with Artefact 1, whereas Paper 5 uses examination data that was automatically generated by Artefact 2. Paper 4 is using Bloom's taxonomy as a method to analyse a typical digital financial task drawn from this study. Finally, secondary data is applied in Paper 3.

The above mentioned articles and artefacts are, however, the result of a long-term educational development project where the focus was on developing, and evaluating educational interventions in an authentic setting. The interventions were carried on to the next cohort when working. The study is, however, conducted by me as a teacher, and it was initiated as I saw a need to change my own practice (Chapter 3). To bring about change, I had to take action; thus I became an action teacher. Eventually, research-based issues emerged that I found exciting to pursue. Consequently, I gradually developed into a teacher who researched interventions that I developed and implemented in my own teaching practice; i.e. I became an intervening action researcher.

However, I did not reflect much upon the overarching research approach that I utilised in the process. This issue was not highlighted until the end of the process, when I decided to compile an article-based thesis of the papers which were eventually published. I started to search for literature in order to find an intervening action research variant that resembled my process, which gradually evolved to become more than a development process– a research process. In recent years, I have indeed been working as an intervening action researcher.

However, there are many variants of this overarching approach, and in retrospect, I strain to find one that matched my process. As a result, I have actually developed two versions of the thesis summary, one based on an educational intervening action research variant (Educational Design Research; EDR) (McKenney & Reeves, 2012), and another variant that is more common in the field of management accounting (Interventionists Action Research; IR) (e.g. Baard, 2010; Jönsson & Lukka, 2007).

When I compare the two versions of the thesis summary, I can see clearly that the choice of AR variant has important consequences for how this study is positioned. The EDR version that I started with is quite practice-oriented, thus this version emphasised primarily the practical features of the study. Here the effort in developing theory was formulated as design principles, which are not decontextualised, or general theories which equally function in all contexts. Instead, design principles reflect the conditions in which they operate (McKenney & Reeves, 2012).

However, at the end of the process, the EDR variant was discarded and replaced with an IR variant as the theoretical ambitions may be greater within this tradition (Baard, 2010). This change to IR is mirrored in how the study is motivated, which research questions that are being addressed, the theoretical basis for the study, the findings being emphasised, how these are interpreted and how they are being used to develop a more overarching and general theoretical contribution.

In a scientific thesis it is obviously important to choose an AR variant that highlights the theoretical yield from the study. If beforehand I had sufficient knowledge about AR in general and about the various AR variants specifically, this could have saved me months of work. On the other hand, I would then have missed the learning outcome from preparing two versions of the thesis summary: an unofficial EDR variant and an official IR variant.

4.4 Tensions between the etic and emic domains

4.4.1 Measuring the effectiveness of the interventions

A key part of intervention research focuses on 'what works in practice' (e.g. Baard, 2010; Kasanen et al., 1993). To pass the 'strong market test' (which interventions rarely do) as specified by Labro and Tuomela (2003), will require the implementation to produce systematically better results than any alternative intervention. In traditional empirical research there is in general a reliance on the use of randomised controlled trials (RCTs) for evaluating the effectiveness of new interventions (Goldstein & Blatchford, 1998; Pine, 2009).

When publishing *Paper 2*, a reviewer requested us (the authors) to conduct the interventions discussed both with and without spreadsheet usage in order to evaluate the specific learning effects in relation to relevant alternative interventions, which could be using a financial calculator (widely used in businesses and working life during the period 1970–1990) or using paper-based interest tables (widely used before 1970).

The reviewer asked us, in other words, to conduct a quasi experiment encompassing at least two groups; one applying a spreadsheet and another utilising a financial calculator, interest rate tables, etc. Moreover, for the quasi experiment to be effective, the students enrolled in the course should have been assigned to two different groups randomly, with about 60 individuals in each group. To control for the teacher effect, the same teachers should complete the teaching for all groups in two separate sequences where only tool usage should be allowed to differ. At the final exam, which must have been organised simultaneously for the two groups, the students should receive the same tasks and the same amount of time to resolve them, however with access to different practical tools (i.e. a spreadsheet versus a financial calculator).

In order to make a conclusion about the effectiveness of different tool usage, every other attribute related to the interventions should match. However, this would require the practitioner researcher to develop a new set of intervention artefacts to the best extent possible. I would have to develop a different tool usage culture in each classroom (with the same enthusiasm): a calculator usage culture in addition to the existing spreadsheet usage culture. Moreover, I and the co-author of the textbook would have to write a new version of the textbook; one that replaces spreadsheet

usage with the use of, for example, a financial calculator. Likewise, the teachers would have to make new sets of lecture notes and video-based micro lectures in finance adapted to different tool usage.

To make the quasi experiments comparable, we would also have to create a new set of the finance exercises, problem-solving tasks and past exam papers, but now without interactivity, as implementing this is not possible without a programming language (i.e. Visual Basic for Applications). Furthermore, to make the marking of the examination papers comparable (and fair), we would have to drop automatic marking and mark all the exam papers manually.

In brief, conducting a quasi experiment in a naturalistic setting in the present study would first require the development of one more textbooks variant; second, a new learning community format; third, a new plenary finance lecture format; fourth, an new analogue format for exercises and problem-solving tasks; and fifth, a new format for compulsory assignments and the final exam. Furthermore, the experiment would require two parallel instruction sequences during a whole term, one accomplished for each group with the same teachers. Based on emic reasoning, such a field experiment was not practical feasible within the resources that I possessed.

4.4.2 Triangulation of the intervention process

To assure that the intervention processes have been on a 'healthy course', diverse data sources were utilised for triangulation. After several years of use and revisions, the students made few claims about the textbook (*Paper 1*). Nevertheless, in order to assure the quality of the book by outsiders, the manuscript was, after about six years of development, submitted to a Norwegian national publisher and reviewed by external subject matter specialists.

Through their review report we were assured that the quality of the textbook was considered satisfactory, and the manuscript was published accordingly. The flipped classroom intervention (minus the videos) has been an ongoing practice for years at my business school and is accepted by the students as a sustainable working intervention. Moreover, through the publication of *Paper 8*, the theoretical concept which underpins the intervention has been reviewed by peers. Finally, several of the principles developed has been successfully implemented in another management accounting course by a colleague (Heimly & Bertheussen, 2016a).

The automatic feedback intervention process has been in use for years at my business school and it is accepted by the students as a sustainable working intervention. The students have been involved in debugging the interactive problem-solving tasks, and they have suggested improvements along the road. Moreover, through the publication of *Paper 6*, the conceptual model that underpins the intervention has been reviewed by peers. Finally, I wrote *Paper 7* to discuss the feedback principles underpinning the application along with a student evaluation based on a survey.

Again, I was inspired by the reviewers to refine the practical artefact based on their feedback. Also, the digital exam procedure has been through classroom iterations for many years at my business school. About 1000 students have passed the exam in this financial course by using their own computers to solve semi-individual exam questions and problems. Each repetition has provided us with new opportunities to make improvements, so over time we think the procedure has evolved into a well-developed practice.

For a student, it is important to be treated as credible and fair when taking the exam. The practice would probably have been stopped years ago if this was not the case. On one occasion a member of our administrative staff conducted the exam in order to validate it; he discovered a flaw in the examination procedure, which has been corrected since. Through the publication of *Paper 5*, the validation principles that underpin the examination process were reviewed by peers, along with validation evidence based on empirical data collected from one cohort.

4.4.3 The learning community interventions turned out to be unsustainable–why?

The learning community (pedagogical pairs and seminars; see *3.6*) as implemented in this study, turned out not to be sustainable as the student attendance rate was relatively low on these activities, i.e. about 50% of the lecture attendance. To reap the full benefits from working in pedagogical pairs, I believe that the concept should also have been integrated into the summative assessment format. As it currently stands, there is a lack of consistency between the individual summative assessment practice and the community-based learning activities. To align these constructively would be more in agreement with both constructivist (Biggs, 1996) and sociocultural learning and assessment perspectives (Dysthe, 2001).

However, there are issues by implementing pedagogical pairs into a digital assessment format. In the course described in this study, the students met in large lecture theatres and brought their own electronic devices for both the compulsory assignments as well as the final examination. However, all of the digital assessment formats utilised the same infrastructure. For example, in the theatres, the students worked individually and silently in a proctored examination environment. In this case, if the same theatres should be utilised for pair-wise working, then the students should be allowed to talk as dialogue is a key component of working in pairs (*3.6.2*).

Yet, dialogues create a certain amount of noise which may disturb other students working on their examinations. Large auditoriums are not suitable for arranging large paired digital examinations. In other words, the physical building constraints at the institution may prevent the implementation of such a large-scale, innovative examination format. This author's institution definitely cannot provide 60 small rooms to handle as many examination pairs. Finally, an complementary explanation on why the designed learning communities in the learning environment turned out not to be sustainable after 2013, is that the gardener failed (I as the teacher) in fertilising the activities, both as a consequence of low student engagement and my increased engagement in producing scientific articles from this study.

4.4.4 Intervention refinement processes initiated by reviewers

It was reviewers who initiated the refinement of *Artefact 1* and *Artefact 2* of this study. After the automatic feedback system had been used by several cohorts of more than 100, each refined incrementally and thoroughly debugged, I wrote a conceptual article on the system, which was submitted, reviewed and published (*Paper 6*). During the review process I was, however, advised to broaden the scope of the system.

In addition to managing general problem-solving tasks in the field of business economics, the system was now further developed so it could now be applied for handling more advanced practising problems such as goal-seeking, optimisation and regression problems. Moreover, the system was made more 'user-friendly', also as a result of reviewers' feedback. I was advised to write a user-manual with procedural principles in order to support teachers who want to implement the system when designing their own interactive problem-solving tasks (*Artefact 3*). Also in this intervention process, the pattern of *emic–etic–emic* interaction was significant.

Moreover, during the literature review in *Paper 8*, I came across research on worked examples, which I utilised to refine and improve the lecture notes. In this way, knowledge from the etic domain contributed to improving artefacts utilised in the emic domain, and a pattern of *emic–etic–emic* interaction emerged in the intervention process.

4.4.5 Is it worthwhile for a practitioner researcher to do a solo research and development project on this scale?

When Tromsø University College merged with the university in the city in 2009, a new university business school was established. Consequently, I became a permanent employee and I joined a community of research-oriented academics. Together with a fellow teacher, Espen Sirnes, I shared the responsibility for the finance course. More specifically, we established a distinct division of labour in which I was responsible for classic corporate finance (two-thirds of the course), while Espen concentrated on modern corporate finance (one-third of the course).

Through this experience, I quickly realised that, at the university, new prospects emerged to help develop the course design as well as opportunities to develop myself as a research-oriented professional practitioner. Finally, during this cycle I began submitting articles to scientific journals. The feedback I received from the referees has had a significant impact on both the scientific and practical outcomes of this dissertation. Furthermore, the feedback that I received from the dissertation committee has been influential on the topics covered as well as the structure of the thesis summary.

Conducting good interventions research calls for many qualities and abilities (Baard, 2010). In the present study, it was not difficult to get true 'emic' access as I was faculty at the business school during the lengthiest period of the research project. The school director and the administrative staff were both supportive and forgave my 'emphatic' failures along the long research and development road. At the same time, deriving academically acceptable output from the process was a professional challenge. However, during the process I hopefully developed good analytical (scientific writing/argumentation) skills, a versatile and multi-disciplinary knowledge-base and research methodological capabilities that facilitated handling both quantitative and qualitative data.

Nevertheless, I think it is hard to find the best combination of the required abilities in interventionist research in a single individual practitioner researcher. The diversity of skills and competence required provides a strong argument for team-based interventionist research and development. It is much more realistic for a team to be able to combine and include all the necessary virtues than it is for an individual (Suomala & Lyly-Yrjänäinen, 2012).

One of the distinctive characteristics of a field experiment methodology is that the researcher deepens their understanding of the phenomenon under investigation while the experiment is in progress (Cobb et al., 2003). For this reason, it is methodologically advantageous to cultivate diverse points of view from members of a research team, as this can be an important resource for developing alternative interpretations and ask different team members to assume primary responsibility for representing particular perspectives during the analysis (ibid.).

This opportunity to acquire different views through discussions and sparring with co-researchers, I have by-and-large foregone, as this mainly has been a solo project. In retrospect, I will not initiate another such an extensive research and development project without being part of a research team.

4.4.6 Risks when conducting interventionist research

Intervention research has a potential to both produce emic (practical solutions) and etic (scientific) knowledge but this comes at a risk. The main risks, as experienced in the present study, I will now reflect upon. As an interventionist researcher, you should expect to spend a long time on an IR project. The extensive length of the research and development process, without any certainty of a practical output (interventions that work in context) or an academic output (scientific publications), is a clear risk.

In the present study, the development of interventions was ongoing for several years before the first paper was published (*Paper 4*), and the vast majority of the articles were published during the later phases of the venture (2014–2016). Moreover, this project was about to be terminated when the management at my first university college did not accept to implement a digital school examination. This was in 2007, and as a consequence, I lost access to the host organisation. At that time I felt that without a digital school examination I would have to teach ICT in isolation within the finance course, which was not an appealing option.

However, by a coincidence I met the person (Ulf Mack Groven) who taught the same subject at Tromsø University College on the express boat on my way home from Harstad, after having completed a teaching session there. He asked me to run the digital inspired finance course at the college in Tromsø, including a digital examination practice. Now I was back on track again due to pure luck. Later on in the project, there were other incidents that might have terminated the project, i.e. when the University College in Tromsø merged with the university (UiT). However, at this point the system (included digital examinations) gained credibility with the students and my new academic colleague at UiT (Espen Sirnes) also valued the technology rich course design.

A lesson learned through this description is that interventions must work and satisfy the needs of major stakeholders (students, faculty, school management) in order to survive, as it is a risk for an interventionist research project to reach a dead end before any practical or scientific output materialises. As the empirical material emerged throughout the project, it was not easy to identify its theoretical value and, consequently, it is probable that some interventions do not result in theoretical contributions but are restricted to practical insights (Suomala & Lyly-Yrjänäinen, 2012).

This was the case with the textbook intervention (*3.7*) and the learning community intervention in this study (*3.6*), which led to scientific dead ends. Interventionist research always involves more than one group of stakeholders: those who intervene (practitioner researcher in the current study), and those who are being intervened with (first and foremost students, but also administrative faculty in this study). Strong expectations of the teacher on producing credits and satisfied students, combined with time-consuming practical development work and also time-consuming research efforts, are vulnerable.

I, as the practitioner researcher, also had to recognise my own scientific objectives and work toward them in parallel with keeping the other stakeholders satisfied. This is a demanding challenge, which opens up rooms for tensions (Suomala et al., 2014). If I had not coped with the balancing act around the interventions, the outcome may have been an uneven emphasis on practically relevant issues at the expense of academically interesting results (Suomala & Lyly-Yrjänäinen, 2012).

Interventionist research is about creating a real-life laboratory within which something interesting can be tested, and it can be seen as an experiment in the field

(Jönsson & Lukka, 2007). This raises not only ethical but also ontological and epistemological issues (Suomala & Lyly-Yrjänäinen, 2012). In the case of strong interventions, as was the case in the present study, there is a risk of creating artificial or unrealistic settings, which would not have been implemented without interventions. An example could be the implementation of irrelevant technology into subject matter learning from a practical business point of view.

There is a risk that a strong individual interventionist researcher might develop interventions that could be seen as counterproductive anywhere other than that in their particular educational setting. If this is the case, the interventionist researcher is not facilitating changes for improvements, but rather manipulating their practical context. As a result, the suggested implications would only contain anecdotal value (ibid.).

4.4.7 Personal development

This project has been a long-lasting learning experience for me, both as a practitioner and researcher. My learning perspective has gradually developed in the direction of a sociocultural view on learning (*3.1.1*) that emphasises authenticity (of which tool usage is a significant part) when creating learning environments aimed at activating and engaging business students (*Paper 1*, Heimly & Bertheussen, 2016b). Moreover, my software coding skills have developed gradually in line with the development of the product interventions resulting from this study (*Artefact 1, Artefact 2*).

Furthermore, I have gradually gained an increased understanding of the craft on doing research through publishing papers in scientific journals. My professional understanding has also developed both through theoretical studies and through the development of practical tools. Finally, I have gradually developed an identity as a researcher as well as a teacher and professional during this study.

4.5 Conclusion

The relationship between theory and practice is demanding in education in general (Gutiérrez & Penuel, 2014; Plomp, 2009; Reeves, 2011) and in educational research in particular (Barab & Squire, 2004; Van den Akker, 1999). For that very reason, this relationship should be subject to thorough reflection as the contributions from an interventionist study tend to emerge around these dynamic tension-based processes (Suomala & Lyly-Yrjänäinen, 2012).

The retrospective analysis provided has disclosed numerous tensions and problems experienced during the intervention processes within the emic domain, within the etic domain and between the emic and etic domains. In this chapter, I have discussed the balancing of tensions that I had to act upon both in the theoretical and empirical domains. The analysis demonstrates that the tensions were managed carefully through trust building, flexible acting and a willingness to compromise to keep the streams of production, intervention and research ongoing. Moreover, I experienced that moving within and between the etic and emic domains provided new opportunities, as I strived to develop solutions that worked in the field and at the same time return with findings and conclusions of theoretical significance.

Most of the interventions in this study originated from tensions that were articulated by students (*4.2.8*), colleagues (*4.2.11*) or the institution (*4.2.7*). As a response, I (the practitioner researcher) developed and documented a practical artefact (e.g. *Artefact 1*), which was implemented in the classroom. Finally, I reflected upon the intervention's theoretical opportunities and wrote a scientific article on the topic (*e.g. Paper 6, Paper 7*). Thus, as the practitioner researcher, I moved from the emic to the etic domain and quite often back and forth (*Chapter 4.1, 4.2, 4.3,* Jönsson & Lukka, 2007). In other words, the practical as well as the research opportunities materialised in this tension based field.

This interventionist research project has also shed light on emerging issues, such as the demand for a digital examination intervention (*3.3*) when cultivating spreadsheet usage within a subject. This dispute resulted in the development of a practical artefact (*Artefact 2*), which in the next phase contributed to a theoretical argument on examination validation (*Paper 5*). Moreover, tensions during the intervention processes also initiated 'reality-checks' in the sense of quantitative studies during the later stages of the project (e.g. *Paper 2, Paper 7*). Hence, interventionist research can pose a good test of relevance, as application is central for gaining understanding concerning the functioning of an idea (Labro & Tuomela, 2003).

Stakeholder tension sometimes occurred due to limited access to physical resources (*4.2.3*). As the students valued the outcome from engaging in the digital learning and assessment interventions (e.g. *Paper 1*), they had a flexible attitude and deployed their private infrastructure (laptops) within the interventions. Consequently, a vital part of the institutions infrastructure was transformed from a fixed asset (number of PCs available in a data lab) to a flexible asset in the theatres. This

compromise that was negotiated between the institution, the practitioner researcher and the students was essential for the digital-shaped educational interventions to work and progress (*4.5*) and consequently also for the theoretical output of the study.

Intervention is typically about implementing something, i.e. a process model (*Paper 8*), a measure (*Paper 4*), a measurement system (*Paper 2*) or perhaps a novel ICT solution (*Paper 6*). As it is a precondition during the process of implementation to question the fundamental premises related to the construct being implemented, the findings and contributions from this study were at least tested and thus applicable in this local context (Suomala & Lyly-Yrjänäinen, 2012).

Furthermore, this retrospective analysis has disclosed that there still are tensions in the form of untested conjectures that can open up for more research opportunities in the future. Important conjectures underpinning the course design are based on practical reasoning, i.e. implementing tools that can support student learning with the limited development resources available and within other constraints at the host organisation (*4.2.3, 4.2.4*). However, several of the conjectures, some of them implicit, were not tested empirically during the study. For example, the conjecture that applying a spreadsheet is more effective when it comes to student learning of management accounting subjects than utilising an alternative tool like a financial calculator is untested (*4.4.1*). Neither is the conjecture tested empirically that spreadsheet usage engages students in deeper cognitive processes than the alternative paper and pen approach (*4.2.5, Paper 4*). Nor is the conjecture tested empirically that providing students with semi-individual exam papers hinders cheating on compulsory assignments and digital exams (*4.2.7, Paper 5*). To support the above conjectures with empirical evidence a better theoretical foundation and another research design would be required. This issue will be discussed in the next chapter (*5.2*).

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Chapter 5: Research output

To be able to further elaborate theoretically the practical matters discussed in this thesis, a reliable translation between practice and theory is needed (Hastrup, 2005). In this chapter, such a translation is conducted as seen through the lenses of the practitioner researcher who conducted the study.

The chapter starts by reporting on the scientific outcomes from the study in terms of extended abstracts of the eight reviewed papers which are a part of the dissertation (p. viii). Next, an overarching tentative framework will be developed in order to summarize the theoretical lessons learned from the study.

5.1 Extented paper abstracts

Paper 1: Cultivating spreadsheet usage in a finance course through learning and assessment innovations

This study rejects the view that ICT should be studied in isolation and argues for a holistic approach of embedding ICT into subject matter. In other words, the integration of ICT must be grounded within the broader context wherein it is situated. In this study, a combination of e-learning and face-to-face teaching was used in an undergraduate corporate finance course. In the course design, innovative spreadsheet usage was embedded into all of the practical learning activities.

To determine the transference of the applied spreadsheet emphasis to the summative assessments, an innovative digital examination practice was developed. In this learning culture, special emphasis was placed on facilitating students' development of spreadsheet skills in parallel with learning finance theory, although the latter was the focal point. However, the students implicitly developed their spreadsheet skills by constructing financial models in spreadsheets and using the completed models for simulations and subject matter reflection.

This study also evaluates whether the innovations contributed to student motivation and the achievement of the learning outcomes. According to the 83 participants in the survey, this study demonstrated that a spreadsheet culture embedded into a course design can be both motivating and engaging. The students reported the greatest learning outcome and motivation from being allowed to use spreadsheets during the lectures, for the mandatory assignments and for the final

examination. As assessments are designed to represent the types of learning which are valued, an implication of this study is that new digital assessment practices are important drivers for ICT-based learning innovations. Another implication is that it can be productive to establish spreadsheet cultures in other business economic subjects such as accounting and financial management. Finally, it can fulfil both students' and industries' expectations of candidates possessing such digital skills after graduation.

Paper 2: Relation between academic performance and students' engagement in digital learning activities

The background of this study is that current research has been rather limited in regard to the impact of digital technologies on students' academic performance, despite the substantial investments in digitising education in recent years. The context was a finance course which not only aimed to empower students to master the theory of finance but also sought to apply this theory in solving financial problems by using spreadsheets in practice also on a digital examination. The measurement of spreadsheet skills was not included as a part of the examination but was considered an implicit criterion within the learning objectives.

A regression model, based upon prior literature, was developed to analyse the effect of student engagement in digital learning activities on academic performance. Through several proxy variables, the goal was to measure the extent to which students applied spreadsheets in their learning activities and whether such efforts were reflected in the examination scores. Data collection began immediately and every time a student engaged in a digital learning or assessment activity. It was automatically logged into a database and occurred on a daily basis until the midterm examination, which was held 50 days after the start of the class. The main finding was that practising interactive exercises and exam problems matters, and 'interactive practising makes perfect'. However, this mantra was only true to a certain extent since the findings also showed that if such practising activities degenerate into mechanical drilling (without professional reflection), then the overall learning outcome decreases.

Moreover, this study supports research indicating that previous achievement is a strong predictor of future academic performance. It was also found that a more experienced student was expected to outperform a freshman, which is also in line with previous research. Finally, no significant relationship was found between academic

performance and lecture attendance, textbook usage, all-out effort, gender or age. For teachers, an implication of this study is to develop practising exercises and exam-related, problem-solving tasks in order to scaffold the students for the 'real thing', i.e. the final examination. Furthermore, for institutions, it is vital to provide infrastructure necessary to support extensive practising. In this regard, a point of departure may be to offer seminar rooms suitable for digital learning activities.

Paper 3: Er handelshøyskolene innelåst i historiske pedagogiske spor? (English translation: Are business schools locked-in into historical pedagogical path dependency?)

According to this paper, lecturing (as a teaching method) and utilising individual examinations (as an assessment procedure) may be suitable tools for mass education. However, the major emphasis of volume production can compromise the quality of the education since the teaching and assessment methods used may only promote surface learning and not in-depth learning. One of the clearest findings from educational research is that feedback has a significant impact on learning. In a large auditorium with many students, however, feedback is usually absent. Such a learning environment invites inaction and does not promote quality learning. In addition, it is the student's ability to remember and reproduce subject matter which is assessed at the final examination. Alone and without any other aid than a paper and pencil, the students work in an examination environment which is not authentic with what they will later encounter in the workplace.

An evaluation of the Norwegian Quality Reform showed that students' approach to subjects was characterised by reading to remember. In addition, they were significantly less likely to read critically and evaluatively. The evaluation also showed that the basal approach to acquire knowledge was given high priority, and that there were small differences in the way students studied between learning institutions and between subjects. If the claim is true that business schools are strategically 'locked in' in historical pedagogical paths, such as plenary lectures and individual exams, then the results may be that business students will achieve inadequate learning outcomes compared to those who participate in alternative learning and assessment activities. There is also a risk that dropout rates can be influenced by educational programs which are not engaging.

This study further argues that a paradigm shift may be occurring in higher education. The emergences of the constructivist view of learning (which emphasises student activities) and the sociocultural view on learning (which emphasises learning communities) have contributed to a greater interest in student-centred learning as opposed to teacher-centred learning. Student-centred learning constitutes the core of the learning paradigm and it is a more 'innovation friendly' paradigm, which may lay a better foundation for the integration of technology into subject matter learning.

Paper 4: Ruteark eller regneark? Kognitive utfordringer ved å løse finansoppgaver på papir og PC. (English translation: Squared paper or spreadsheets? Cognitive challenges by solving financial problems on paper and PC.)

This study examines whether it is less academically demanding to solve (examination) problems on a spreadsheet than on paper. On a spreadsheet, one can easily create sophisticated calculations (using built-in financial functions) and develop a solution rather quickly by copying formulas instead of creating them manually (as one is required to do on paper). The purpose of this study is to answer this question by analysing a typical examination problem-solving task in finance using Bloom's revised taxonomy (BRT) for the cognitive domain as a method.

The analysis demonstrates, on the contrary, that it is cognitively more challenging to develop dynamic spreadsheet models than static solutions on paper. This is because one must adopt a new type of categorisation knowledge (relative, absolute and mixed cell addresses) in order to create dynamic formulas on a spreadsheet. Creating dynamic formulas in this manner also pulls the implementation of the models' calculation procedures up to a higher level of abstraction. This extra cognitive effort may provide a good 'pay-off' in that students can save time by not having to repeatedly perform manual procedures since the formulas can simply be copied onto spreadsheets.

It is more important, however, that dynamic financial models can be used for simulations and employed as learning resources by stimulating subject matter discussions and reflections among the participants in a learning community. If this materialises, then the spreadsheet artefact can contribute to greater learning outcomes than alternatives such as calculators and tables of interest rates. As an implicit 'add-on', the students can develop digital skills which are in demand in future studies and in the workplace.

Paper 5: Validating a Digital Assessment Practice

In Norway, students have questioned the importance of acquiring digital skills since they cannot actually apply such expertise on their final examinations. In order to address this problem, a digital assessment practice was designed and implemented at a business school in which students were allowed to bring their own PCs to the final examination. The purpose of this study was to evaluate the effectiveness of the innovative digital assessment practice and present evidence of its validity.

An outside expert reviewed the test to validate if the test contents were representative and relevant. To validate if the test takers were engaged in the thinking processes and skills represented in the learning targets, constructed-response tasks were designed, which enabled the examinees to demonstrate that they not only mastered the theory of finance, but they were also able to apply this theory to solve practical financial problems on spreadsheets. Moreover, by using Bloom's revised taxonomy for the cognitive domain, this study ensured that the test takers were engaged in the thinking processes represented in the learning targets.

To validate if the test results were reliable, test score statistics were calculated based on a dataset for the 2012 cohort. A coefficient alpha of .92 indicated that the examination tasks actually measured the students' knowledge and skills in a single content domain. Moreover, item analysis of the examination tasks indicated that both the level of difficulty and the discrimination level of the tasks were acceptable. Finally, the design principles, spreadsheet files and a detailed implementation guide were made available as freeware so that other teachers could effectively implement a rela-ted approach in their own digital assessment practices.

Paper 6: Power to business professors: Automatic grading of problem-solving tasks in a spreadsheet

Whether on campus or online, teaching undergraduate accounting and business economics subjects often involves a large group of students. For such courses, it is challenging for a teacher to provide timely feedback which is tailored and targeted toward improving both the process and the outcome of the students' problem-solving activities. Educational research, however, emphasises that formative feedback can engage and motivate students as well as help them identify their weaknesses, reflect on their performances and improve their study skills. Moreover, the assessment load

on teachers can be substantial if it includes manual marking and grading of written assignments and examinations.

This study describes an approach which can enable teachers with proficient spreadsheet skills to create problem-solving tasks in basic accounting/business subjects which are automatically marked. In order to model regression and optimisation problem-solving tasks, teachers should be familiar with array formulas in Excel.

The problem-solving application architecture, which is the teacher's point of departure, includes a generic 'plug and play' marking and feedback algorithm developed in VBA (the programming language integrated into Excel). The generic model-tracing algorithm which evaluates the student's work provides feedback, not only on the problem-solving result, but also on the student's problem-solving process. This feedback is delivered via a feedback report, which indicates the steps which can improve the student's solution.

However, automatic marking is complicated by the risk of consecutive errors in calculations. A consecutive error is one which occurs early and is propagated through subsequent steps, thus causing errors in subsequent calculations. For this situation, the marking algorithm detects and corrects consecutive errors so that students are not successively penalised for the same error. The concept discussed in this paper has been applied at a university business school in Norway for several years and utilised for approximately 1,000 students. In addition, this concept was not only used for summative tasks (i.e. mandatory assignments and the final examination) but also as a vital component for providing the students with formative feedback on their homework. In this case, since homework, assignments and examinations were automatically marked, the assessment load on the teachers was substantially reduced.

Paper 7: Automatisk formativ feedback kan gi god motivasjon og læring (English translation: Automatic formative feedback can provide good motivation and learning)

Educational research strongly emphasises that formative feedback is significant for students' engagement and learning motivation. High-quality feedback can help students succeed as well as nurture professional reflections about their work. This paper discusses how a high-quality feedback practice (based on the theoretical framework of Nicol and Macfarlane-Dick (2006)) was implemented into interactive spreadsheet

tasks for an undergraduate finance course at the School of Business and Economics at the University of Tromsø. In this regard, interactivity implies that a student can automatically obtain formative feedback on demand. The purpose of such feedback was to help the students improve their problem-solving skills through the use of spreadsheets.

Unlike multiple-choice questions and exercises that can be solved through drills, students are also challenged on higher-order cognitive levels by requiring that financial models are developed from basic principles. The innovative algorithm which assesses the students' work provides feedback not only on the final solution result, but also on the subtasks (process) which lead to the result. The students are also provided with individual tips and comments which they can use in future efforts to improve their solutions.

Finally, an evaluation indicated that formative feedback which is automatically provided can contribute to a sense of empowerment and motivation in students. Students also reported that they constructively used the feedback to develop their own solutions, and they experienced good learning outcomes from solving interactive financial tasks on spreadsheets.

Paper 8: Revitalising Plenary Finance Lectures

The purpose of this paper was to discuss how to approach the challenges of generating student activity in plenary finance lectures at a business school. In the basic finance course, students actively worked on finance examples on their own PCs while the teacher explained and demonstrated the subject matter on a spreadsheet, which was displayed on a large screen. The teacher also introduced new concepts and principles along with the related examples. The general principles were encoded behind the problems' solutions once the examples were complete. In order for learners to be able to use abstract concepts and theories to solve complex problems, they should first be trained in using them with specific examples. Then, in cognitive skill acquisition, learners should solve problems on their own in order to achieve proficiency.

An evaluation of the digital lecture format was performed through a survey which focused on three research questions concerning the perceived effectiveness of spreadsheet use in lectures versus more traditional methods. First, the students reported that they achieved good learning outcomes by developing worked examples on their own worksheets during the lectures. Indeed, the students were so satisfied

with using the spreadsheets that they also recommended using them for other business economics subjects. Second, according to the survey, the students were asked if learning finance theory was obstructed by the use of spreadsheets during the lectures, especially since this also required them to be active in terms of motor skills. In this regard, when attention is divided between several sources, it can add an extra burden to working memory, which can hinder learning. However, one must also split his/her attention when taking lecture notes by hand. The results showed that the students did not experience such split attention and a significant majority did not want to replace the use of spreadsheets with traditional paper notes.

In the third and final research question, the students were asked whether they preferred lecturers to use a blackboard or slides instead of spreadsheets in basic finance lectures. The results revealed that the learners did not perceive the use of slides as an attractive alternative to using spreadsheets in finance lectures. However, replacing spreadsheets with a traditional blackboard was even less appealing to the students. A theoretical implication of this study is that it is possible to create student activity in plenary lectures by the innovative application of technology. Finance lectures which include worked examples which students can develop on their own PCs is a clear indication of this possibility.

5.2 A tentative theoretical framework

The tentative theoretical framework presented in Figure 5.1 is an abstraction of the practical findings from this study. The objective with the framework is to answer research question 3 of this study, which was presented in the introduction chapter of this study as follows:

> *How can the interventions, the retrospective analysis and the papers resulting from this study be translated into a tentative theory on student engagement and learning?*

The theoretical framework is being nourished through the thick description of the interventions (Chapter 3), the retrospective analysis of the intervention process (Chapter 4), the published articles and literature. The framework depicts the complex array of factors influencing students' learning outcomes (*Paper 2*) when engaging in

learning and assessment interventions (*Paper 1*) using relevant tools (*Paper 4*) that are embedded within a wider sociocultural perspective on learning (*Paper 3*).

As shown in Figure 5.1, there are three elements in the tentative framework with relations in between them: interventions, student engagement and learning outcomes (i.e. learning and achievement and student satisfaction). The tentative framework conceptualises student engagement as an important construct and theorises that engagement is related to learning outcomes and is influenced by students' participation in interventions (e.g. see Figure 3.1).

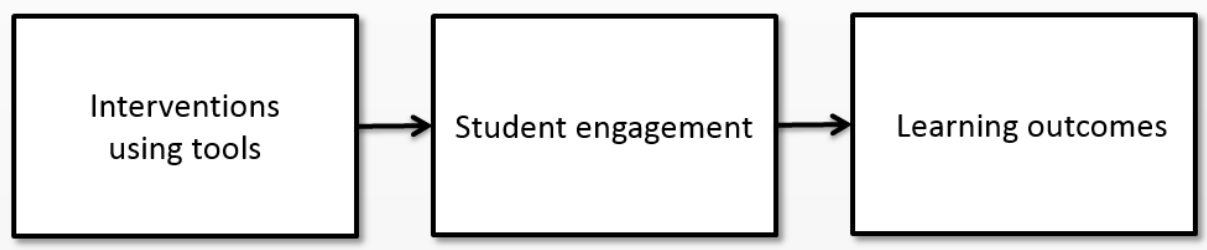

Figure 5.1. A tentative theoretical framework.

5.2.1 A sociocultural perspective on learning

The entire process of student learning is embedded within the wider social, political and cultural discourses (Kahu, 2013). It is not just student learning that is influenced by this broad context, but every element of the student experience (*Paper 3*). Mann (2001) highlights how alienating the sociocultural conditions can be for students' engagement and consequently learning. In fact, it was a sense of educational relevance lost due to the technology poor, non-collaborative and disengaged learning environment experienced at a university college that initiated the present study (*3.1.3, 3.2.1, 4.2.1*).

A noteworthy weakness of the traditional teacher-centred learning approach is that the primary focus for learning is instructor focused and that the learner plays a passive role as the receiver of information (*Paper 3*). Another shortcoming is that it does not give enough consideration to the potential contribution of engagement theory for understanding learner motivation, learner satisfaction and learning outcomes (Noe et al., 2010). Recent learning agendas emphasise a more active role for the learner as it is acknowledged that the learner is at least as important as the

instructor and the interventions in determining whether learning occurs (*Paper 2*, *Paper 3*).

Kraiger (2008) underscores the importance of considering learning from an engagement perspective in his discussion of 'third-generation' instructional design models. There is an implicit assumption in these models that knowledge is socially constructed with shared meaning based on learner–learner interactions (*3.6, 4.4.2*) and instructor–learner interactions (*Paper 8, 3.5,)*, a view which is in line with a sociocultural perspective on learning (Dysthe, 2001). In this context, the role of instructional design is to define content areas and create instructional strategies to facilitate active and collaborative learning (Noe et al., 2010). Learner engagement may be even more relevant given the need for students to take a more active role in their knowledge production. I do, however in this thesis, not propose a complete rejection of the traditional model (*3.2.1, 4.2.4*), partly due to resource constraints at the institutions (*4.2.3*). Rather, the model needs to be adapted to a more learner-centric rather than teacher-centric approach (*Paper 3*).

5.2.2 Interventions using tools

With an intervention shown in Figure 5.1, I mean an activity (learning or assessment) that is implemented within an academic context to obtain a result. This definition is in line with Kasanen et al. (1993) who refer to a construction as an entity which produces a solution to an explicit problem. An important attribute with an intervention is that its usability can only be demonstrated through the implementation of the solution (Baard, 2010).

In the course design presented in Figure 3.1, different interventions were presented all of them using the same digital tool, i.e. a spreadsheet. An important objective with selecting a spreadsheet was to exploit the extra learning affordances offered by this ICT tool when it comes to teaching and learning of management accounting subjects (*Paper 4, Artefact 6*). However, the type of tool chosen could have been otherwise. There are, for example, alternative tools to a spreadsheet readily available and widely used in higher business education (*4.4.1*). In the period before 1970, paper-based interest rate tables were used by practitioners and educators to undertake complex financial calculations. In the period 1970–1985, financial calculators replaced interest tables. Thereafter, the spreadsheet replaced the financial calculator as the business people's new financial 'hammer' (Baker & Sugden, 2007).

This study argues that the combination of interventions along with the selected ICT tool strengthened the effect of students participating in learning interventions on student engagement. One reason is that in the spreadsheet-based interventions, students could quickly and efficiently build financial models that they used for simulations and subject reflections (*Paper 6, Artefact 6*). If a financial calculator was chosen as the tool used in the interventions, the students would have spent more time on task and missed the rich opportunities to simulate and reflect on the simulation results, which could in turn have reduced their engagement (*Paper 4*).

Moreover, the type of tool chosen opened up the development of the spreadsheet-based formative feedback tool, which was implemented into all problem-solving tasks, thus making them interactive (*Paper 6, Artefact 1, 3.4*). In this way the students were provided with immediate customised digital feedback both on their solution result and on their solution process when practising (*Paper 7, 3.4*). Finally, it is conjectured that the digital examination intervention (*Artefact 2*) strengthened the effect of the other digital-shaped learning interventions in this study (*3.3*), which is an interaction effect. This intervention was also enabled through using a spreadsheet tool with an integrated programming language (*Paper 5, Paper 6*).

One important objective with integrating a spreadsheet into the interventions (*Figure 3.1*) was to implicitly develop students' skills in using this specific tool. However, it is conceivable that poor skills in tool usage can have a negative effect on engagement (*4.2.9*). Students with poor skills may not master a complete spreadsheet model or spend more time on it compared to using alternative tools, e.g. a financial calculator. Furthermore, if a spreadsheet model is not constructed properly, it is unsuitable for simulations or it may provide wrong simulation results, which in turn will affect the quality of the student's subject reflections (*Paper 4*).

In the present study, skills in tool usage was implicit developed during the following interventions (*Figure 3.1*): 1) when students read the textbook through the integration of spreadsheet exercises (*3.7*); 2) when students attended plenary lectures through the development of worked-examples (*3.5*); 3) when students participated in learning communities through using spreadsheets within pedagogical pairs and workshops (*3.6*); 4) when students deliberately did their homework through interactive problem-solving tasks (*3.4*) and 5) when students attended the compulsory assignments and the final examination through solving problems using a spreadsheet (*3.3*).

5.2.3 Student engagement

Student engagement is a complex and multifaceted construct that aims to bridge diverse threads of research that contribute to explain student success Fredricks et al., 2004). While researchers agree it is important, there is debate over the exact nature of the construct. According to Kahu (2013), four different approaches to understanding engagement can be identified in the literature: the behavioural perspective, which focuses on effective teaching practices (i.e. *Paper 8*); the psychological perspective, which views engagement as an internal individual process (i.e. *Paper 7*); the sociocultural perspective, which considers the critical role of the sociocultural context in which student engagement takes place (i.e. *Paper 3*) and finally a *holistic* perspective, which strives to draw the strands together and recognise the need to consider the student's own motivations and expectations (i.e. *4.2.2*, *Paper 1*).

When focusing on student engagement, Fredricks, Blumenfeld & Paris (2004), identified three dimensions–behaviour (e.g. attending lectures), affect (e.g. student satisfaction) and cognition (e.g. problem solving). Consequently, engagement is more than participation as it requires feelings and sense-making as well as activity (Harper & Quaye, 2009). Acting without feeling engaged is just participation or involvement (Trowler, 2010).

Students who are behaviourally engaged will comply with behavioural norms, such as attendance and demonstrate absence of negative behaviour (ibid.). Students who engage emotionally experience affective reactions such as interest, enjoyment or a sense of belonging (ibid.). Cognitively engaged students will invest in their learning, seek to go beyond the requirements and take on academic challenges (ibid.).

A student who is engaged to a less degree may take a surface approach to learning (*Paper 4*) as this is a response to alienation from the content and process of study (Trowler, 2010). Krause (2008) lists inertia, apathy or engagement in other pursuits as alternatives to engagement for the student. Mann (2001) contrasted engagement with alienation, whereas Maslach (2001) characterised engagement as the opposite of burnout.

The design and delivery of interventions may promote as well as demote learner engagement (Kahn, 1990). Due to a variety of constraints, interventions are not always designed to embrace individuals in the learning process but rather to maximise efficiency and reduce the cost of instruction (*4.2.3, 4.2.4*, *Paper 3*). For example, traditional instruction through lectures that merely present content with

PowerPoint slides may lead to learner disengagement (Noe et al., 2010). Such intervention designs provide limited opportunities for learners to discuss subject matter content or to practice skills and it provides few opportunities for social interaction with peers or the instructor (ibid., *Paper 8*).

Interventions can be engaging because they provide students with an intrinsically enjoyable experience of learning something new (intrinsic motivation) (*Paper 7*). Experiences are not necessarily exclusive and some learning content can engender high levels of multiple experiences. Feeling part of a learning community is positively related to student engagement (Zhao & Kuh, 2003; *3.6; 4.4.2*). Moreover, numerous studies have demonstrated the importance of teachers and teaching practice on student engagement (Pascarella & Terenzini, 2005; *Paper 8*; *4.2.6*). Relationship with staff is also considered to be at the core of the learning experience (Smith & Gillespie, 2007, *4.2.8*).

Engagement comes from experiencing an intervention in a certain way (Rodriguez & Armellini, 2013). Students' engagement with a course is a collection of experiences with the interventions in the course design (*i.e. 3.1.2*). For example, an intervention can be engaging because students have a utilitarian experience with it (extrinsic motivation) as they believe that the intervention can prepare for an assignment or the exam (*Paper 1*, *Paper 5,* Rodriguez & Armellini, 2013).

Interventions can shape the student experience and encourage engagement (Trowler, 2010, *3.3.2*), for example by providing formative feedback and continuous assessment on tasks early and often (*Paper 7, 3.4*). Moreover, assessment can bring peers together in creative ways both in and out of the classroom (*3.6, 4.4.2*). Furthermore, to focus on student's own responsibility for becoming and remaining engaged in the learning process, they can engage in self-assessment and peer assessment (Trowler, 2010). Curriculum (*3.2*) and assessment (*3.3*) have a recognised impact on student engagement (Barnett & Coate, 2004). For example, there is a risk that students are alienated when failing on summative assessments (Mann, 2001).

A learner-centric approach (*Paper 3*)–students' involvement in the design, delivery and assessment of their learning–can enhance engagement (Trowler, 2010). Through their participation (*4.2.8*), learners can be recognised as knowledgeable individuals who also are able to contribute to others in the learning community, which is engaging in itself (Dysthe, 2001.). In the present study, the designs of several

interventions were initiated by students (*4.2.9*). Furthermore, students were engaged in the delivery of the interventions through bringing their own devices to lecture theatres, seminar rooms and examination halls (*3.2.5*, *4.2.4*). Students also used their own devices when practising on interactive problem-solving tasks (*3.4.3*, *4.2.6*).

The influences can be bi-directional between engagement and its consequences as it is widely recognised that engagement breeds engagement (Kahu, 2013). For example, engagement that leads to better grades, can in turn motivate students to be even more engaged (ibid.). Likewise, there can be a feedback loop that relates student engagement to the interventions. For example, learners who believe they have sufficient resources (e.g. access to a spreadsheet when doing course work and sufficient spreadsheet skills) may lead to increases in self-efficacy, which causes increased engagement, which next spirals up to even greater self belief (Llorens et al., 2007).

However, engagement is not an outcome of any one of the influences discussed above, but rather the complex interplay between them (Kahu, 2013). As Nystrand & Gamoran (1991) point out, engagement depends on what students, teachers and staff do, think and feel together–neither can make it alone. Consequently, it is necessary to realise that there is more than one path to engagement and that the different paths are realised by different experiences (Rodriguez & Armellini, 2013).

5.2.4 Learning outcomes

In the tentative theoretical framework shown in Figure 5.1, the consequences for students of being engaged in the interventions are learning outcomes (Kahu, 2013), i.e. achievement and student satisfaction. Student learning and development are the ultimate results of engagement in an academic context (Pascarella et al., 2010). Accordingly, students are the obvious beneficiaries of engagement (Coates, 2005; Kuh, 2009).

Engagement may lead to greater learning through knowledge and skill acquisition as an engaged learner may benefit more from the interventions (Kahn, 1990). Also, an engaged learner may to a greater extent appreciate the learning process that may lead to more favourable learner outcomes (Trowler, 2010). Robust relationships have been established over time between students' investment of time, effort and interest in a range of educationally orientated interventions and outcomes. Studies have consistently shown correlations between engagement and improvements in

grades (Astin, 1993), persistence (Pascarella & Terenzini 2005) and drop-out rates (Tinto, 1975). Furthermore, student engagement increases student satisfaction (Kuh, 2009).

A key finding of the present study is that practising using interactive exercises (*Paper 6, Paper 7*) matters when it comes to students' academic performance (*Paper 2*). However, according to the results, this mantra was true only to a certain point (*4.2.5*). If the undertaking of more practice activities degenerated into mechanical drilling without professional reflection, the learning outcome diminished and quickly flatlined (*Paper 2*).

This study also demonstrated that students found it motivating and engaging to participate in interventions using a digital tool (*Paper 1, Paper 7*). Students reported the greatest learning outcomes and motivation from participating actively during plenary lectures (*Paper 8*) and from being allowed to use an ICT tool when conducting compulsory assignments and the final exam (*Paper 1*). Indeed, the students were so satisfied with using an ICT tool in the interventions that they also recommended using it for other business economics subjects (*Paper 8*).

5.3 Conclusion

This chapter has discussed interventions and learning outcomes on the basis of engagement theory in an attempt to answer research question 3 of the study. Engagement theory offers a conceptual framework and empirical studies that can describe this encounter between interventions, engagement and outcomes (*Figure 5.1*).

This study argues that practical analogue and digital tools are able to engage students in varying degrees when participating in learning and assessment interventions. A student with good theoretical subject knowledge and excellent skills in using a tool, for example a spreadsheet, can solve financial problems quickly by implementing predefined financial functions and use the copying function when building models (*Paper 6*). Moreover, a model based on spreadsheet formulas is an effective simulation tool as opposed to a paper-based model (*Paper 4*). Simulations have the potential to lay the foundation for individual and collective reflections that, in the next phase, may create professional engagement and good learning outcomes. However, poor skills in tool usage may prevent student engagement, as there is a risk that

a student will spend so much time and effort on mastering the practical tool in itself if this happens at the expense of students' learning outcomes (*4.2.9*).

The tentative framework depicted in Figure 5.1, can be valuable for guiding future research on integrating tool usage into assessment and learning interventions and be useful in targeting interventions aimed at increasing student engagement and consequently learning. The framework does not claim to describe all the influences and relationships, but rather to disaggregate and organise the central phenomena and relationships between them as they emerged in the present study. Further research should strive at developing testable hypothesis about antecedents, consequences and potential mediators and moderators.

Chapter 6: Discussion and conclusion

This concluding chapter aims to integrate and synthesise the various issues raised in Chapter 3 (Interventions), Chapter 4 (Retrospective reflective analysis) and Chapter 5 (Research output). The chapter begins with an introduction, continues with a discussion of the findings and moves to contributions, implications and limitations of the study. The chapter ends by suggesting possible directions for future research and development.

6.1 Introduction

When I returned to a university college after having worked in business for more than twenty years , I was assigned to teach an undergraduate finance course characterised by a high failure rate and dissatisfied students. In the lessons, the students used hand-held calculators and paper-based interest tables for their calculations, just as I had done as a student thirty years earlier. It seemed like the rapid technological development in society had passed academia unnoticed as information and communication technology was underutilised in the learning and assessment activities, and I got a sense of educational relevance that was lost (*4.2.1, Paper 3*).

Against this backdrop, I decided to design and develop digital learning and assessment interventions within a finance course in higher education, which could contribute to student engagement and learning. In the learning culture of the subject, I placed special emphasis on facilitating students' development of spreadsheet skills in parallel with learning finance theory (*Paper 1*).

The philosophical and methodological 'middle ground' offered by pragmatism empowered this study to draw upon both quantitative and qualitative methods to address certain research questions. Furthermore, in retrospect, I found that the overarching methodology applied has clear similarities with IR, which is a practical research methodology that can help bridge the gap between research and practice in the field of management accounting (e.g. Baard, 2010; Jönsson & Lukka, 2007; Kasanen et al., 1993; Labro & Tuomela, 2003; Suomala et al., 2014). IR focuses on real-world problems and the overall goal of contributing to theory building. The purpose of the present study was to develop relevant ICT-shaped learning and assessment interventions to improve student engagement and learning outcomes in a finance subject.

6.2 Findings

The main findings of this study are chapter-specific and were summarised within the respective chapters. This chapter intends to synthesise all these findings.

6.2.1 Practical findings

In the practical layer of the intervention processes (Chapter 3), the problems were analysed in-depth in consultation with students and colleagues where I served as a practitioner researcher. Underpinned by sound cognitive and sociocultural pedagogical principles (*3.1.1*), I designed learning and assessment interventions in several iterations with improvements made between them (*3.1.3*), taking a holistic approach to teaching and learning (*4.2.2*). The emphasis was on presenting the subject so that the students implicitly expanded their spreadsheet skills as they applied the digital artefact when learning subject matter theory in a motivating and engaging way (*3.8*, *4.2.13*). Therefore, in this research and development project, spreadsheet usage was integrated into all the learning and assessment interventions in a naturalistic classroom setting (*Paper 1*). Thus, active learning was facilitated through the spreadsheet artefact, which was regarded a 'cultural tool' of the subject's learning community (Somekh, 2007).

An important practical finding from the present study is that the requirement of using technology to enhance learning without recognition through assessments is problematic (Hennessy et al., 2005, Redecker & Johannessen, 2013, Selwyn, 1999). Thus, the digital summative assessment intervention (*Artefact 2*, *Paper 5*) has been regarded as a requirement for establishing a spreadsheet user-culture in the subject (Somekh, 2007). Moreover, it worked as an 'icebreaker' for the other digital learning interventions integrated into the course design (*Paper 1*).

Some of the interventions have been developed into useful spreadsheet-based systems that can underpin a digital examination practice as well as a digital formative feedback practice. These systems are open source tools that allow teachers to create customised digital learning and assessment interventions by adapting them to fit their individual teaching styles as well as their learners' needs. By taking these systems as a point of departure, practitioners can experience a more rapid implementation of the presented systems with less effort.

6.2.2 Reflective findings

Interventionist research may be a valuable tool in bridging theoretical understanding and practical relevance in management accounting (Jönsson, 2010). As demonstrated from this study, it is important to understand that different questions call for different research strategies and designs. In this respect, interventionist research can be seen as a useful part of a researcher's toolbox (Westin & Roberts, 2010).

Suomala & Lyly-Yrjänäinen (2012) assert that reality may be understood in layers, and there is no such thing as an absolute insider or outsider position. Some phenomena may be visible to everybody, whereas some others may be observed only by insiders. In the present study, my role as an insider practitioner researcher gave me access to the data utilised in several papers (*4.4.3*). Thus, in the whole lifecycle of the study I have been an insider. Nevertheless, I have also attempted to be an outsider at times; especially when conducting traditional empirical research to evaluate the effectiveness of the interventions (e.g. *Paper 1*, *Paper 2*).

An intervening researcher can get true (emic) access and acceptance within a host organisation, and in the present study, the access has been long lasting. As a practitioner researcher, I immediately was 'one of them' (Jönsson & Lukka, 2007). This placed me in a good position for facilitating change in the subject learning and teaching culture in question (*Paper 1*), which was a substantial one given the culture and traditions at Norwegian business schools (*Paper 3*). From this perspective, one of the strengths of the practitioner research role is the ability to provide effective access to an organisation and to facilitate the creation of a research setting with novelty value (Campbell, 2013).

An intervention can be used for validating results immediately during the research process, which can support both the relevance and the efficiency of theory production (Suomala & Lyly-Yrjänäinen, 2012). The quality of the intervention processes in the present study was triangulated through discussions with students; the students' actual use of the interventions; student surveys (*Paper 1*, *Paper 2*, *Paper 8*); by automatically collecting data when students exercised, attended lectures and worked with the textbook (*Paper 2*) and by analysing examination results from a cohort (*Paper 5*). Finally, the textbook intervention was reviewed by a national publisher and thereafter published.

Over all, in the field of educational management accounting it is quite likely that situations will be identified where there is a need to develop more advanced

pedagogical interventions or subject cultural changes such as the integration of ICT within subject matter cultures (*Paper 1*). Only after that is it possible to assess the impact of these improved practices on the learning outcomes of the students. In this context, randomised controlled trials may be a possible new research agenda (*4.4.1*; Suomala & Lyly-Yrjänäinen, 2012).

6.2.3 Theoretical findings

Learning and assessment interventions have the potential to promote learner engagement, and engagement theory can provide new insights into how and why interventions are effective (Noe et al., 2010; *5.2*). In the present study, blended learning interventions were applied that combined face-to-face instruction (*Paper 1*) with online technology-based learning (*Paper 6*, *Paper 7*). Research indicates that blended learning can be more effective than classroom instruction for teaching both declarative knowledge and procedural knowledge (Sitzmann et al., 2006). The reason for this is that the online learning component allows the learner to better control the learning process and provides a safe environment in which they feel free to make errors (Noe et al., 2010, *Paper 7*).

When participating in learning and assessment interventions, students use practical tools that have the potential to influence their engagement (Kahu, 2013; Somekh, 2007). When using a tool (e.g. a spreadsheet), a learner is active (e.g. *Paper 4*). Accordingly, the students engaged behaviourally and cognitively, and maybe also affectively, whenever spreadsheet usage was integrated into the interventions (*5.2*). A learning intervention that promotes active learning is important in fostering student engagement (Noe et al., 2010). Katz-Navon et al. (2009, p. 1201) describe an active learning intervention as one that emphasises 'asking questions, seeking feedback, reflecting on potential results, exploring and experimenting'. In terms of the affordances offered by ICT, the tool has the potential to enable active learning and engagement (John & La Velle, 2004). A central conjecture in the present study is that the tool usage that is integrated into learning and assessment interventions can be influential on learning activity and engagement (*Figure 5.1, Paper 1, Artefact 6*).

Moreover, the relationship between tool usage and student engagement is conjectured to be weakened if a spreadsheet is replaced with, for example, a financial calculator or interest tables when students learn finance theory (*Paper 4*). It is further conjectured that students with poor skills in tool usage will not be as engaged as

those who are skilled (*5.2*). To balance this effect, tool usage was integrated into all academic practices in the present study (*Paper 1, Figure 3.1*).

The more students are engaged in subject matter learning and the more they practice and get feedback on their analysis and problem solving (*Paper 7*), the more proficient they become (Kuh, 2003, *Paper 2, 5.2*). Finally, students who are engaged in productive activities in college develop habits that increase their capacity for continuous learning and personal development that is essential to live a productive, satisfying life after college (Kuh, 2003).

6.3 Contributions, limitations and future research efforts

6.3.1 Contributions

When constructing theory from a case, a researcher must be prepared to justify why the research question is better addressed by building theory (see section *5.2*) than theory testing (Eisenhardt & Graebner, 2007). My response to this challenge was that when this study was initiated I found no existing theory that offered feasible answers (*4.4.2*). Moreover, Ross et al. (2010) claim that there is still a great need to obtain scientific knowledge regarding student learning with computers; moreover, even after three decades of technology initiatives, high levels of integration of technology with classroom learning remains much more the exception than the rule (Lowther et al., 2008). Furthermore, a survey revealed that high school graduates are entering today's workforce deficient in most of the 21st century knowledge and skills needed to achieve successful careers (Casner-Lotto & Barrington, 2006). Accordingly, this issue is also critical for the institutions because their legitimacy may be threatened if their candidates do not possess relevant knowledge and skills as graduates.

Management accounting and educational researchers argue for relevance to practice as a prominent dimension of theoretical contribution to a research study, stating that we need to focus more on including utility for practice in our assessment of theory (e.g. Baard, 2010; Jönsson & Lukka, 2007; Labro and Tuomela, 2003; McKenney & Reeves, 2012; Plomp & Nieveen, 2007). Hopefully, this study can add value to the urge for practical relevance when developing theories. A result of the present research process was the development of novel constructs (*Paper* 6, *Artefact 1*, *Artefact 2*) and practices (*Paper 1, Paper 5, Paper 7, Paper 8*).

According to Lukka (2000, 2003), if we consider a study where the intervention has taken the form of a new construction, two types of theoretical contributions are highlighted. First, the new construction in itself may be a contribution to the design knowledge in the area (e.g. *Paper 6, Artefact 1, Artefact 2*). This requires that the researcher is able to show how the new construction has contributed to a desirable result in a given situation (*Paper 1, Paper 2, Paper 5, Paper 7*). Such a contribution may assume the status of a design concept that is of interest to practitioners because it works and also to fellow researchers because it may constitute a starting point for further testing (*5.2*).

Both constructions resulting from this study (*Artefact 1, Artefact 2*) have been implemented and tested (*Paper 5, Paper 7*). Moreover, the learning outcome from students by engaging in the digital learning and assessment interventions in the blended course design has been empirically tested through surveys (*Paper 1, Paper 7, Paper 8*) and time series data analysis (*Paper 2*). In addition, the relationships that have been made visible in explaining why the constructions worked (*Paper 1, Paper 2, Paper 5, Paper 7*) or were used in designing the construction, may provide building blocks for further constructions. The main characteristics of these constructs are likely to be readily adaptable to accounting management teachers so that the knowledge is not lost to the profession. In the present study *Artefact 1, Artefact 2, Artefact 3* are all open source documents.

The important issue of integrating a digital examination intervention into an ICT-based course design has been thoroughly clarified (*Paper 1*, *Paper 5, Artefact 2*); an issue that turned out to bubble below the surface in the present study (*3.3, 4.2.9*). Furthermore, this study stresses that examination validity is always constructed into the measures used in a given subject matter context. Threats to validity may be faced at any step, from defining the examinations tasks to operationalising the definition to actual measurement (*Paper 5*).

Educational research strongly emphasises that formative feedback is significant for students' engagement and learning motivation (e.g. Evans, 2013). In this study, an innovative feedback intervention helped students improve their problem-solving skills (*Paper 6, Paper 7, Artefact 1*). Software algorithms can effectively provide detailed individual formative feedback both on learning outcomes and the learning processes (*Paper 7*). It has also been shown that learners appreciate receiving an immediate response on their work (Denton et al., 2008).

As the practice of educational management accounting is embedded within the operations and activities of a real-life business school, this IR project was first and foremost aimed at contributing to learning and teaching. However, the present study also demonstrated that interventions may relate to educational change processes in several ways. The target of an intervention can sometimes be directly related to a learning process (*Paper 7*), a teaching process (*Paper 8*) or an administrative process (*Paper 5*) that aim to support learning and/or teaching processes. The processes are, however, intertwined (*4.2.7*) and consequently an intervention intending to improve a learning process may also have some reflections on teaching and administrative processes. Many kinds of interventions may catalyst management and administrative considerations within the organisation and thus create opportunities of understanding the roles and meanings of different stakeholders in a real environment (Suomela & Lyly-Yrjänäinen, 2012).

Finally, knowledge sharing with the business teacher profession has been a significant aim of this study. In addition to the resulting artefacts and papers, knowledge from the present study has been shared with a colleague, and as a by-product, two papers that have not been included in this thesis have been published on educational interventions in introductory management accounting subjects in higher business education (Heimly & Bertheussen, 2016a; 2016b).

6.3.2 Implications

A fundamental premise of the tentative theoretical framework proposed in Figures 5.1 is that learner engagement is essential for producing good learning outcomes. Active learning through the use of technology-based and face-to-face learning interventions may enhance learner engagement through more student involvement, control and social interaction (Noe et al., 2010). Moreover, increased engagement can lead to better learner motivation and subsequent improved knowledge and skill acquisition (*Paper 2*). As emphasised in this study, I believe that learning research can benefit from changing its emphasis from being teacher-centric to becoming more learner-centric (*Paper 3*). Consequently, an important implication for future research on learning interventions and learning effectiveness is to include an engagement perspective.

A practical implication from the present study is the need for integrating ICT usage into the subject learning culture and not teaching and learning ICT in isolation

(Koehler et al., 2014). The present study also supports the notion of ICT as a cultural tool that provides a new type of affordance that can extend the mind (*Paper 4*, Somekh, 2007). In the finance subject, spreadsheet usage scaffolded subject learning by providing opportunities for the learners to construct financial models, to perform simulations using the completed models and to stimulate subject reflections based on the simulation results (*Paper 4; Artefact 6*). Another practical implication from this study is that the digital summative assessment practice reported (*Paper 5*) has been regarded as a requirement for establishing a spreadsheet user-culture in the subject (Somekh, 2007). It actually worked as a bottle opener for the other learning interventions integrated into the course design (*Paper 1*).

A wider policy implication of this study, which is in line with Hennessy et al. (2005), entails a shift from a technologically driven model of ICT integration towards one based on teacher involvement. This implies encouraging teachers to network and exchange good practices on ICT use in their subject teaching and learning. The involvement of teachers in discussions about viable ICT-enhanced learning and assessment interventions may also encourage them to develop and implement other innovative educational practices supported by ICT, as exemplified by this study. To establish and support good practices, it is necessary to support teachers engaging in educational development interventions involving ICT and encourage them to exchange their experiences (Redecker & Johannessen, 2013). The approach outlined in this study highlights the role of practitioners in affecting classroom changes through their development and implementation efforts, thus changing education through bottom-up innovations. Subject communities are expected to continue to change their practices to exploit the learning potential of ICT involvement more fully (ibid.).

6.3.3 Limitations

This study has been conducted in an authentic classroom setting with the purpose of developing theoretical insights and practical solutions in a particular context. As such, the study retains a high degree of ecological validity (Brewer, 2000). In an ecologically valid study, the methods, materials and settings are close to the real-life situation under investigation (Gutiérrez & Penuel, 2014). Nevertheless, the focus was on interventions within a specific context and I attempted to study these as integral and meaningful phenomena. The context-bound nature of the research explains why it does not strive towards context-free generalisations. Therefore, the findings cannot

be generalised to a larger universe (Plomp, 2009) because there is no statistical generalisation from sample to population in a case study, as in the case of survey research (Yin, 2014).

In interventionist action research, there are generalisation concerns both regarding the transfer of theoretical insights and regarding the transfer of practical interventions into other settings. Consequently, an effective intervention should be able to migrate from an experimental classroom to average classrooms operated by average teachers (Brown, 1992). However, there are so many factors at play when interventions 'go live' that replication differs from replication in the laboratory sense (Reinking & Bradley, 2008). Consequently, in the present study, I attempted to explicate the 'local conditions' as an integrated element of the research and development process (*Chapter 3, Chapter 4*).

Participant research involves active engagement of the researcher in the case being studied to the extent that it influences the activities and discourse that occur (Guba & Lincoln, 1994). The core criticism of the participant researcher is that the proximity of the investigator to the situation being researched can cause biased collection, interpretation and/or reporting (Burns, 2000). In the present study, I approached this issue by drawing my perspectives, motives and background for conducting the research into the analysis and by integrating it into existing theory (*Chapter 3, Chapter 4, Chapter 5*). From this perspective, the fact that the research was based upon real teaching in the field and was conducted by a teacher who has improved his practice through a methodological approach to research and development is a potentially valuable aspect of the study (Gutiérrez & Penuel, 2014).

The digital tools that have been developed and implemented in this case study are context-bound to educational management accounting subjects. However, the overarching tentative theoretical framework (5.2) is not as engagement theory and cultivating artefact usage into subject learning are general concepts. Nevertheless, to be relevant the tools used and how they are integrated into learning and assessment interventions must be context sensitive (*Paper 1*). This is obviously also true for the flipped classroom intervention (*Paper 8*) and the validation of assessment intervention (*Paper 5*). The automated formative (*Paper 6*) and summative (*Paper 5*) feedback interventions discussed in this study are, however, more limited in scope as they presuppose that a spreadsheet is a suitable practical tool for subject problem-solving.

6.3.4 Future research efforts

The formative feedback as well as the summative assessment interventions reported in this study were both underpinned by interactive problem-solving tasks, which can be tailor-made by a teacher based on their individual needs (*Paper 6*). However, the interactive concept requires that problem-solving tasks should have an undemanding structure and limited scope. Nevertheless, this is a distinctive characteristic with problem-solving tasks in basic and intermediate business economic subjects such as financial accounting and managerial accounting (*Paper 6*). I therefore believe that the concept may have appeal beyond the undergraduate finance course. In addition, by implementing the practices into other business economic subjects (and at a more advanced level) will allow for more replications and improve the generalisability of the interventions.

Baard et al. (2010) suggested that interventionist research that results in a validated and effective intervention, as a solution to the problem under study, can be followed by effect studies. Here the emphasis should be on upscaling the intervention to a wider context and, in doing so, testing the tentative theoretical framework (*5.2*) in a wider domain. Effect studies may range from small-scale learning experiments to large-scale comparative tests, e.g. via randomised controlled trials. Although several effect studies have been conducted as an integral part of the current research project (*Paper 1, Paper 2, Paper 5, Paper 7, Paper 8*), I did not utilise a control group. In addition, I did not attempt to differentiate the learning effect of applying spreadsheets to enhance subject learning from other pedagogical approaches in the course design (Mayes, 2009).

Therefore, there is a need for more research, i.e. to measure the success of the innovative approach presented in this study compared to a more traditional course design (*4.4.1*). This can be completed by randomly assigning students to either a treatment group (the current course design) or a control group (a traditional course design) and comparing the measures of effectiveness, such as the mean course grades (Fask et al., 2014). Future studies should address these methodological issues, even though there are obvious practical and ethical concerns of exposing students to different course designs as they attend the same course at the same university.

6.3.5 Further development efforts

Higher business education should strive to be relevant for working life (Haakstad & Kantardjiev, 2015). We can increase the quality of professional education by placing greater emphasis on integrating theoretical and practical knowledge (Mughan & Kyvik, 2010; Gjøsæter & Kyvik, 2015; Schjølberg, 2013). Accordingly, I want to further develop the course design presented in this dissertation (see Figure 3.1) in a more practical and collaborative direction in line with the educational principles discussed by Heimly and Bertheussen (2016b).

The goal is to conclude the course with a greater authentic and practice-related investment case (a narrative) that the students can work on as a group. The narrative will likely enhance learner engagement by providing a meaningful learning context in which students can practice their skills in a safe environment where all learners can be involved (Noe et al., 2010). The pedagogical goal of the case is to give students better insight into the complexities related to investment analysis that they will eventually encounter in the workplace. Through a more comprehensive case, it will be important for the students to do the following: 1) provide information that can be difficult to access; 2) sort out the essential information from less important information; 3) balance the interests of various interest groups that will be affected by the investment and 4) collaborate on solving major problems.

Both emphasising collaboration and linking learning activities to an authentic environment can enhance engagement and this has broad support in sociocultural learning theory (e.g. Lave & Wenger, 1991; Dysthe, 2001). In the future, theoretical finance may constitute approximately two-thirds of the course. In addition, the students will be assessed on an individual digital examination, as they are today, and the investment case can then balance the subject.

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Appendix: Expertise of practioner researcher

In Table A1 I will shortly describe my competence as a practioner researcher. When the project started in 2005, I had as a practioner researcher gained the following competencies through formal education and practical work.

Table A1. Expertise of the practitioner researcher when project started.

Type of competence	*Source of competence*
Business economics	Master of Administration and Business Economics (Siviløkonom), Norwegian School of Economics, 1980.
Pedagogy	Pedagogical seminar, University of Bergen, 1981.
Writing	Dozens of textbooks mostly within ICT-related topics.
Programming	By 2005 I had written several textbooks in programming and worked as a part time software developer at EDB Kunnskap AS.
Research	Research fellow at Norwegian School of Economics, 1980–82. Høyere avdelings siviløkonomeksamen (Siviløkonom HAE) Norwegian School of Economics, 1982.
Business	Business Consultant at the National Institute of Technology (STI), Oslo, 1982–85 Managing Director at Infosoft Management AS 1985–89, and EDB Kunnskap AS 1989–2009.
Entrepreneurship	I established the publishing company EDB Kunnskap AS in 1989. Before that, I co-established the software company Infosoft Management AS with Svein Arve Halvorsen and Ragnar Grønlund in 1985.
Educational development programs	In 1985, I developed in collaboration with my colleagues Bjørn Olav Kvaale and Svein Arve Halvorsen in Infosoft Management AS the program 'ICTsupported decision making for business managers' [in Norwegian: EDB for økonomer] on behalf of NKS – Norsk Korrespondanseskole.