Strømmen-Bakhtiar, Abbas [Hrsg.]; Helde, Roger [Hrsg.]; Suzen, Elisabeth [Hrsg.]

# Supplemental instruction I. Digital technologies

*Münster ; New York : Waxmann 2021, 106 S.*

Abbas Strømmen-Bakhtiar,
Roger Helde, Elisabeth Suzen (Eds.)

# Supplemental Instruction

**Volume 1:**
Digital Technologies

WAXMANN

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Volume 1:
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Waxmann 2021
Münster • New York

The publication has been sponsored by the Business School of Nord University (Norway).

**Bibliographic information published by the Deutsche Nationalbibliothek**
The Deutsche Nationalbibliothek lists this publication in the
Deutsche Nationalbibliografie; detailed bibliographic data
are available in the Internet at http://dnb.dnb.de

Print-ISBN 978-3-8309-4324-2
E-Book-ISBN 978-3-8309-9324-7
doi: https://doi.org/10.31244/9783830993247 (open access)

Waxmann Verlag GmbH, 2021
Münster, Germany

www.waxmann.com
info@waxmann.com

Cover Design: Anne Breitenbach, Münster, based on the corporate design of
Nord University Bodø, Norway
Typesetting: MTS. Satz & Layout, Münster

Abbas Strømmen-Bakhtiar
This book is dedicated with all my heart to my wife Bente

Roger Helde
I dedicate this book to my three lovely daughters Ina, Ingrid and Solveig

Elisabeth Suzen
I dedicate this book to my lovely husband Karsten

# Preface

This is the first book in the trilogy that explains different aspects of Supplemental Instruction (SI). The first book deals with SI and technology, and the second book looks at student learning processes and SI. And the third book examines different aspects of SI in organisations and leadership, including surveys of Supplemental Instruction programs in Europe, how SI sessions should be organized, the degree to which SI improves retention rates and exam results. This first book examines the different aspects of digital transformation and SI.

*Chapter one* contains a brief essay on the effects of digital transformation, primarily the internet, social media, and search engines on students. It discusses the adverse effects of these technologies on students' attention in the classroom and proposes the use of SI to reduce these adverse effects on academic performance.

*Chapter two* looks at the use of digital tools in SI. It also examines apps and programs that can be used in SI-sessions to help process course content and make the learning experience more exciting.

*Chapter three*. Despite extensive research on the use of digital tools in teaching, little is known about teachers' perceptions and use of technology in various subjects. It is also not clear why it is more likely or easier to integrate technology into some subjects than others. Based on a validated path model as a conceptual framework, this chapter presents an analysis of two subjects in education: Norwegian and mathematics.

*Chapter four*. Many institutions have considered recording lectures as a response to the call for increased digitalization in higher education. The literature review carried in this chapter shows mixed results regarding the effect of lecture capture on attendance and exam results; it also does not show how technology affects the learning situation. To build knowledge in this field, this study presents experiences from the introduction of lecture capture at a Norwegian university.

*Chapter five*. This chapter examines the origins and evolution of the peer-assisted student support (PASS) leadership program that was introduced to an Irish higher education institution over a decade ago. The functions and operations of the program are explored. In particular, it focuses on the introduction of various technologies modeled during training and transferred into practice.

*Chapter six*. This chapter looks at the use of technology in driving education. More specifically, the study presented in this chapter explores how simulator training in driver education could be beneficial by investigating authorized driver instructors as well as driving instructor students' perceptions after using testing the simulator.

*Chapter seven*. This chapter explores how knowledge co-creation in the learning process is affected and facilitated by digital technologies, in particular 3D printing and RFID reading. The study in this chapter reveals how digital technologies transform the learning process to help students to develop practical skills in the field of supply chain management (SCM) field.

We thank the Nord University, especially the Business school (Norway), and Lund University (Sweden) for their financial contribution to this project. Special thanks are also extended to Professor Terje Andreas Mathisen, the Vice Dean for research and others at Nord University's Business School for their support and encouragement.

*Abbas Strømmen-Bakhtiar, Roger Helde, and Elisabeth Suzen*

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# 1 A Brief Essay on Digital Transformation and Supplemental Instruction (SI)

*Abbas Strømmen-Bakhtiar & Roger Helde*

*Abstract:* Since the advent of the fourth industrial revolution, the digitalization and transformation of communication, work, and play have been taking place at an increasingly rapid pace. These changes have also been influencing students. It is changing and has changed their approach to learning, and the technologies are affecting their brain structure in ways that the consequences of which are yet to be determined. Meanwhile, the presence of digital gadgets and apps contribute to an increasing loss of focus and attention in the classroom. Also, the easy access to information through the ubiquitous search engine is reducing students' long-term memory capabilities. In this brief essay, some of these issues are discussed, and it is proposed the use of SI is a small step in solving some of these problems.

## Introduction

Birds do it, bees do it, even uneducated ants do it. In the animal kingdom, there are many examples of how insects and animals construct complicated structures, navigate long distances, or organize into cohesive communities without apparently any instruction from their elders or peers. They enjoy these abilities simply because they are born with a specific genetic memory, a memory that is present at birth. Bee workers instinctively know how to build a beehive, go about housekeeping, feed the queen, drones and larvae, collect pollen and nectar, and make wax. Humans, on the other hand, are different.

Humans are born with a work-in-progress brain (Shonkoff & Phillips, 2000), which, to a large extent, is a 'tabula rasa' or a clean slate. Although by age two, the human brain has developed to about 75% of its adult size (Huelke, 1998). The rational part of the brain takes approximately 25 years to fully develop ("Understanding the Teen Brain," n.d.). From infancy to adulthood, humans have to protect and teach their offspring about their environment so they can first survive and later become a functioning member of society. The learning process is done in both formal (schools) and informal settings. This chapter is concerned with is the learning process in the formal educational setting.

Education is defined as 'the act or process of imparting or acquiring particular knowledge or skills, as for a profession'(*The Definition of Education*, n.d.). Education is supposed to develop critical thinking, analysis, exploration and be a gateway to immense opportunities. Confucius (551–479 BCE) saw the purpose of education as more closely tied to social development than to individual development, emphasizing respect for one's elders, self-discipline, and correct behavior. He, like Plato, believed that educated people should govern the state. "Those who excel in office should learn:

those who excel in learning should take office" (Huang, 1997, p. 180). Later, Plato voiced similar ideas.

For Plato (427–347 BCE), the essential thing was morality. In his book *Republic* (Sayers, 380 BCE/1999 CE), he lays out a program for educating the leaders (philosopher-kings) of the utopian political system. He argued that leaders should study mathematics for ten years before starting their philosophical education. This is because abstract, disciplined thinking is essential to philosophical inquiry. This, of course, was wishful thinking, and Plato knew that this would never be accepted by the public.

Other philosophers also had problems with school. Saint Augustine of Hippo (354–430) hated his school because of the beatings that he had received there (Augustine & Pusey, 2013). Desiderius Erasmus (1466–1536) received his education from the clergy in monastic schools and from John Stuart Mill (1806–1873), one of the earliest proponents of compulsory universal education (Mill, 2015). And John Dewey (1859–1952), who "severely criticized public schools for silencing and ignoring student interests and experiences" (Cooper et al., 2002, p. 180); they all found their educational system lacking or wrong for their time. Each saw the shortcomings of their time's educational system and voiced concerns and, at times, even outrage at the ineffectual and sometimes harmful educational system (Strømmen-Bakhtiar, 2020). The same problems that previous thinkers, philosophers, and teachers faced are also being faced today. The present educational system may be suffering from the very technology that promises untold opportunities and riches. The educational system that was based on mass production is now being increasingly thought of as old fashioned and not fit for the purpose.

New technology and economic ideologies and policies emphasize the individual self-interest as the driving force in society. Consequently, developers are trying to take advantage of this phenomenon by developing applications and technologies that advance and facilitate this ideology. All the likes and selfies are an indication of this self-adoration and self-interest. But, there is also money to be made. Youtube, Instagram, and other platforms allow the people to enjoy temporary popularity and bask in the admiration of their followers, whom, by every click, add to the fortune of the admired. This has become the road to hell for some because it seems easy to do nothing and earn millions. So, technology is a double-edged sword that can be extremely useful when used right and extremely destructive when misused.

## Technology and Education

The very first technological innovation was the invention of writing. After thousands of years of oral history telling and informal instructions, writing made it possible for humanity to begin to accumulate and pass each generation's discoveries and technological progress to the next. Writing started an exponential increase in the advancement of new technologies, which led to new processes and economies. As such, writing was humanity's most significant discovery. As new technologies were created and

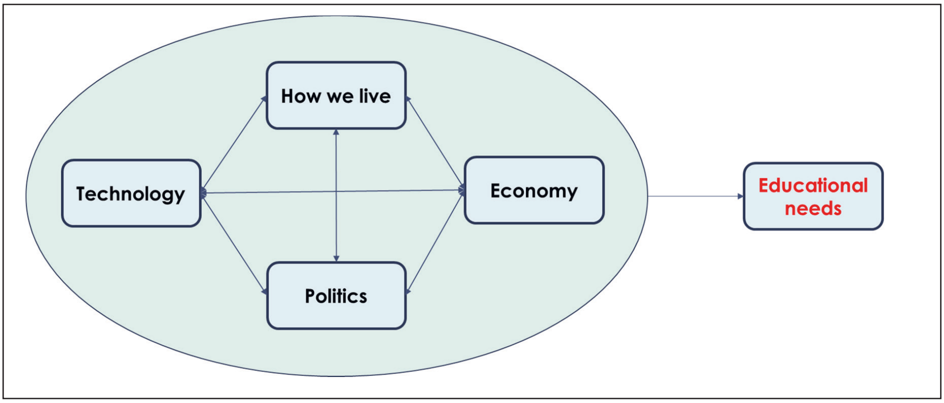


Fig. 1: A soft technological deterministic view.

societies expanded from villages to towns and large cities, the need for an educated class began to emerge. Administering a large number of people required a sophisticated administrative cadre that could collect taxes and pay civil servants and the army. As such, formal education then began to take shape but was always behind technological and economic advancement. This perhaps was one of the main reasons that during each era, philosophers and intellectuals criticized the educational system.

Today, there are similar problems with the educational system, but in a slightly different way. Technology is causing substantial problems because of the rapid social and technological changes that it brings and because of the effect it has on students' attention. The rapid accumulation of new technical information, which doubles every two years (Alexaqz, 2015), is creating problems for students and educators. For students starting a four-year technical or college degree, this means that half of what they learn in their first year of study will be outdated by their third year of study. Moreover, 90% of all data has been created in the last two years, and it is expected to grow exponentially in the future (Petrov, 2019). This means that if the problem will get worse if it is not dealt with now. Also, the deluge of social media applications is negatively affecting students.

Since the commercialization of the Internet in the early 1990s, there has been an explosion of peer-to-peer communication. The ease of communication with almost zero cost has created an environment of information overload. As of January 2019, there were 5.1 billion mobile users, 4.3 billion internet users, 3.484 billion social media users, and 3.2 billion mobile social media users in the world (Kemp, 2019). The ease of use and affordability has resulted in the rapid diffusion of social media. Social media platforms have, in turn, become rather addictive. This is because most of them create a space for displaying the socially acceptable self or stylized self-presentation (Figure 1.0). Furthermore, these constellations are shaped culturally and comparatively and are relatively autonomous from technical affordances (Boczkowski et al., 2018).

The negative effect of the very means of digital communication, such as the presence of mobile phones and laptops, affects the students' grades. Glass and Kang (2019) found that students who had mobile phones or laptops present while a lesson was being taught scored five percent, or half a letter grade, lower on exams than students who didn't use electronics. Another study by Demirbilek and Talan (2018) showed that engaging in social media while trying to follow instruction may reduce learners' capacity for cognitive processing causing poor academic performance. Yet, another study indicated that a large number of university students are using social media with more focus on Facebook, which in turn negatively affects their academic results (Habes et al., 2018). Similarly, another study found that social networking negatively affects academic performance. In addition, the study revealed that strategic study approaches did not mediate the negative effect of social networking on academic performance (Rostaminezhad et al., 2019).

The rise of electronic gadgets and social media has undoubtedly contributed to lower grades and a reduced attention span. This, in turn, has been reflected in the drop-out rates among students (Arce, Crespo, & Míguez-Álvarez, 2015; Bennett, 2003; Heublein, 2014; Ortiz-Lozano, Rua-Vieites, Bilbao-Calabuig, & Casadesús-Fa, 2018). According to the Organization for Economic Co-operation and Development (OECD), one-third of higher education students drop out of their studies before they complete their first degree (OECD, 2009). The transition from upper secondary school to studies at universities and university colleges where students are left to themselves is difficult for many new students. To help the student to succeed in their studies, it is essential that universities respond to students' needs for academic and social interaction. So, the question becomes, what can educators do to remedy the situation? The answer seems to lie in the use of Supplemental Instruction (SI).

## The Google Problem

According to Google, the number of searches per day has grown from 9,800 in 1998 to over 3.5 billion in 2019. It is the greatest tool for students. They regularly find answers to a myriad of questions, not all academic, of course. But, using the search engine regularly creates what is called the "Google Effect" or "digital amnesia," meaning the loss of a large block of interrelated memories. This means that Google becomes a personal memory bank (i.e., users cannot remember any information without looking it up). According to Steinhoff's (2016) study on college students' ability to recall information,

> students who knew that they would be able to access the information easily online in the future could recall the process and place where to find it more easily. Yet, in return, these students also remembered less of the information itself.

In 2019, Firth et al. explored how unique features of the online world may influence a variety of factors. First, it may influence attentional capacities, as the constantly evolving stream of online information encourages divided attention across multiple media sources at the expense of sustained concentration. Second, it may influence memory processes, as this vast and ubiquitous source of online information begins to shift the way knowledge is retrieved, stored, and even valued. Third, it may influence social cognition, as the ability for online social settings begins to resemble and evoke real-world social processes creates a new interplay between the Internet and social lives, including self-concepts and self-esteem. Overall, Firth et al. concluded that available evidence indicates that the Internet can produce both acute and sustained alterations in each of these areas of cognition, which may be reflected in changes in the brain. Also, neuroimaging of frequent Internet users shows twice as much activity in the short term memory as sporadic users during online tasks (Small et al., 2009). Basically, the brain is learning to disregard information found online, and this connection becomes stronger every time it is experienced. So the more Google is used, the less likely it is that information seen is retained.

As can be seen, technology is a double-edged sword that can aid students or hinder their studies. The problem of lack of focus and the effect of the Internet, especially Google or Wikipedia, has on long-term memory is a major problem that has to be solved. Meanwhile, teachers and academics have to assist students as best as possible. SI seems to be a good starting point.

## Supplemental Instruction (SI)

Supplemental instruction is perceived as a way of approaching these pressing educational challenges (Jacobs et al., 2008). It is a program developed to support students in their learning process and aims to improve students' performance and reduce the drop-out rate. SI is a voluntary offering of facilitation and guidance provided by the students. It is about learning in collaboration with others, where the importance of relationships, involvement, and reflection as a method and tool for learning are emphasized. SI does not focus on weak students but on traditionally difficult courses with a high percentage of fail marks and poor exam attendance. In this way, SI is a program for everyone and is offered regularly. Since its beginnings in 1973, more than 1,500 universities in more than 30 countries have implemented the program in their institutions. The method is well described in different handbooks developed for SI (Arendale, 1994).

SI complements regular teaching in that advanced students guide new students. The activity is organized in groups of 8 to 15 students that meet weekly throughout the semester and is led by an SI leader. SI leaders are advanced students (selected students with an A or B in the subject) who receive SI executive training and are guided and observed by an SI supervisor. The role of the SI leader is not to be a teacher but to facilitate learning through guidance and to organize the program. The students work in collaborative groups, where they take responsibility for their learning through what is known as self-regulated learning. The SI program can also be adapted for public and private organisations, where the rapid technological change necessitates reskilling or rapid retraining of staff in new technologies or processes. Here, SI can become a useful and relatively affordable retention tool.

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# 2 Digital Tools in Supplemental Instruction (SI)

*Joakim Malm & Johan Fredriksson*

*Abstract:* This chapter focuses on digital tools and software programs used in SI. It combines a case study for the SI program at Lund University with an international overview. The digital tools are divided into categories based on where they are used in SI. Digital tools for SI leaders are usually tools for communication with participants between sessions (e.g., Facebook, Messenger, WhatsApp). It also includes sharing good practices, learning activities, and problems that invite discussion using platforms like Google drive, apps for leaders with learning strategies, session planners, and Q & A help for challenges that may occur in sessions. There is a huge variety of software programs and apps that can be used to enhance the SI participants' learning experiences. These tools (e.g., jeopardy, Kahoot, memory) target retrieval and/or reflection practices course material to improve memorization and understanding. SI supervisors or coordinators also use digital tools to manage the SI program. Typical tasks can be to track attendance at SI sessions (e.g., Tutortrac, EAB Navigate, Google sheets), information exchange between supervisors (e.g., list-serves at regional SI centers), administer SI-programmes (e.g., Canvas, Microsoft Teams, Blackboard), create evaluation surveys (e.g., Surveymonkey, Qualtrics, Google forms), store leader training videos and promotions (e.g., Youtube playlists), and document observations (e.g., Notability, One Note).

Online SI, using video conferencing/teaching platforms like Zoom, Blackboard collaborate, and WebEx, is a relatively new form of SI created to address the needs of students in distance learning and students that have difficulties attending traditional SI sessions on campus. Online SI is still in its infancy, and its potential and efficiency are yet to be determined. Due to more education going online because of the Coronavirus, there are a huge amount of experiences and data being collected on online SI, which may provide answers about its usability.

## Introduction

Digital transformation in higher education can enhance students' learning experiences. However, there are several potential downsides with using digital technology and social network applications that may arise, such as a lack of focus on studies, negative effects on academic performance, and declining writing skills (e.g., Raja & Nagasubramani, 2018; Rostaminezhad, Porshafei, & Ahamdi, 2019; Selwyn, 2016). Furthermore, the use of social media may lead to a decline in students' people skills and the ability to communicate face-to-face (Raut & Patil, 2016). SI may, at least partly, be an antidote to these drawbacks and provide a safe haven for academic discussions and direct interaction between students. Digital tools can, however, be used to enrich learning in SI sessions and help optimize the SI program. By organizing learning opportunities online, students that otherwise would not be able to participate due to their commuters, parents, or job could participate.

The present study focuses on the use of digital tools in SI. The base is a case study for the SI program at Lund University, Sweden, where the authors are supervisors and coordinators, and nearby schools. The authors look at apps and programs that are used in SI sessions to help process course content and make the learning experience more exciting. Digital resources for the senior student that leads and facilitates the SI sessions are also highlighted. The authors also describe the use of online SI at the university since it is still in its infancy like many other online SI initiatives around the world. The case study is complemented with an overview of digital tools in SI based on information from the SI network and publications.

The authors address different types of tools based on supervision meetings, observations, and reflective reports from the SI program at Lund University and nearby schools. For an international outlook on digital tools used in SI, information from list-serves like SI net (provided by the International Center for SI at University of Missouri Kansas City), PASS-List (provided by the Australasian PASS Centre at the University of Wollongong, Australia), and Canadian SI List-serve (provided by the Canadian SI Center at University of Guelph, Canada) from the last five years along with relevant literature.

## Observations: Digital tools in SI at Lund University, Sweden

### Digital Technology in SI Session Planning

SI session planning can be a tedious task, and there are challenges surrounding the tendency of becoming uni-lateral in the selection of collaborative SI session exercises and resorting to a comfortable session disposition that the students expressed satisfaction with but might not benefit from in the long run. Hence, there is a need to promote variation and continuous learning among SI leaders.

One solution came in 2016 as an online cloud-based Idea Bank that was created by SI leaders for SI leaders. This tool is in Google Drive, and it is open for everyone who has a link to access it, and it is provided during SI leader training at Lund University. The bank contains tips and tricks, games, full session planning structures, exercises for general SI session activities, and specialized exercises in a wide array of topics. The Idea Bank is essentially a folder that contains more folders for SI tips related to different subjects. When clicking the link leading to the bank, SI leaders are greeted by a 'Read me' message that explains the why (purpose), how (rules and principles of the idea bank), and an accompanying, what-oriented, template for adding exercises and tips into the bank. Today, the Idea Bank consists of 13 subfolders ranging from Escape Room exercises to game-related exercises to English exercises, Math, History, and Chemistry. For instance, the math in secondary education subfolder contains 37 exercises. And, the bank is growing every week. One incentive that allows the Idea Bank to steadily grow is mentioning the Idea Bank in the SI leaders' weekly reflection reports (mandatory at most of Lund University). It asks them a yes or no question about whether they would like to make a contribution that week (with a link to the Idea Bank). There have also been elements of gamification linked to the process of catalyzing the Bank's growth. This means that every time a contribution is made, the SI leader gets a lottery ticket, which gives them a chance to win Cinema tickets at the end of the semester.

Another new and promising tool is the "SI Cards & Session Planner," which was developed by SI leaders and staff at Lund University. It contains a session planner function, a Q&A for SI leaders to address challenging situations that may occur during sessions, and an array of learning activities based on physical cards originally developed at Texas A&M University and revised by the International Centre for Supplemental Instruction at the University of Missouri Kansas City, University of Manchester and Lund University. The SI cards include categories for agenda-setting, the big picture, collaborative learning techniques, ice-breakers, Organisation, problem-solving, recall and review, SI-PASS leader tools and tips, and study skills. The session planning function is an interactive process between the SI leader and algorithms in the app that help the SI leader plan a holistic SI session, including an introduction and ice-breaker, agenda-setting, main activities, and closing activities. For each part, the SI leader chooses between strategy cards to use based on the algorithm's questions, such as "Is this your first SI session?" and "Have you used this strategy before?". After the session is planned, the SI leader will have the save the planned SI sessions on their phone.

Another important set of tools that can be used by SI leaders, but still outside the sessions, are tools to facilitate communication. The SI leader has the opportunity to gain important insight into what the students want and need to learn, which provides a relevant guide to plan the SI the session. Furthermore, a forum for communication and asking the students questions also contributes to building a safe-space around SI. There are several tools for this, for instance, Facebook, WhatsApp, or different learning platforms. On Facebook, the recommended format is either a Facebook group or a group chat in Messenger (Facebook's chat-function). One upside of a Facebook group is the ability to sort and search through posts; however, it might be more formal than just writing a message in a chat group, hence creating a higher threshold for communication. Therefore, a chat group in Messenger might be a more viable option. Another popular application is WhatsApp, which works similar to a chat group in Messenger, but it is separate from Facebook. Users might find it disturbing to be on Facebook while getting updated about the progress of the SI activities, which is a real risk. Therefore, WhatsApp is a different option. There are also numerous other communication applications, and they keep coming up with new ones. The recommended way to address the communication need is to ask the students what they prefer and to be aware of at least some of the basic tools out there. The benefits of social media applications such as Facebook, Messenger, and WhatsApp are that they are informal, which might enhance the relaxed atmosphere that characterizes SI. However, sometimes a bit more formal setting might be desirable (e.g., learning platforms at universities or schools, such as Canvas and It's Learning). Here, access to course content is also generally more accessible and integrable.

### Digital Application Tools for SI Sessions

The other application of digital tools for SI leaders is during SI sessions. Digital tools can be a powerful way to add variation and improve learning conditions. One in-session tool that has grown in popularity is Kahoot. Kahoot is a game-based learning platform. Its learning games, "Kahoots," are multiple-choice quizzes that allow user-generated content and can be accessed via a web browser or the Kahoot app. The Kahoots can have students compete individually, in groups, or as a whole class. Another in-session tool is Mentimeter, which allows interaction with the participants using real-time voting that shows up on the app's interface, which can be projected from a projector or viewed on any screen. This allows for the inclusion of student views and provides a real-time status-check of the group, which is helpful for discussions.

### Administrative Digital Tools for Running an SI Program

Presently, Lund has a university-wide trend of using Canvas in SI courses. This has also spilled over to SI; subspaces can be created for each faculty where common information and material used by SI Leaders are stored (e.g., time report sheets, links to weekly reflective reports and evaluations, scheduling documents, observation forms). For Lund University, Canvas appears to have more advantages from an SI perspective compared to earlier used administrative systems like Microsoft Teams and Office 365.

When recruiting new SI leaders, interviews are an important part of the selection process. When face-to-face interviews are not possible, video-conferencing tools like Zoom or Skype are used.

### Online SI

The use of online SI sessions is rare at Lund University, although there is a wide interest in making this SI option available in distance courses, to student groups (i.e., parents, commuters, students with part-time jobs that cannot attend face-to-face SI sessions), and to save room space for meetings.

The faculties that are pioneers in having online SI sessions are the humanities and theology, specifically with distance courses in some languages, as well as in a master's program in theology. Like other institutions, Zoom is used to run the SI sessions. The software is well equipped to handle the interactive nature of SI sessions based on the reflections from leaders and supervisors at Lund University. These groups also express that the online sessions capture the essence of SI. However, there is no data available on the effectiveness of online SI at Lund University.

The use of online SI increased considerably at Lund University during in spring 2020 due to the Coronavirus. Since all education went online, so did most of the supporting SI programs. Almost 100 SI leaders had to adjust their sessions to an online environment. Initially, this seems to have worked fine, but the attendance has dropped compared to face-to-face sessions. A more rigorous evaluation will be made after the spring semester.

## Digital Tools in SI-Based on Information from the SI Network and Publications

### Tools for SI Leaders

Internationally, SI Leader tools are very similar to what is used at Lund. Several SI programs have idea banks similar to the one at Lund to store examples of SI materials. Traditionally, these were stored in binders but have been moved to digital environments like Google Drive to make them more accessible and to save physical space and paper. Tools for communication between SI leaders and participants are largely the same internationally compared to Lund. The main media used appears to be Facebook, Messenger, and WhatsApp. There is also an international Facebook group (https://www.facebook.com/groups/supplementalinstructionleaders/) to discuss and share strategies and challenges. The app for SI leaders, SI Cards & Session Planner, has recently been shared with the whole SI community (it is available in the AppStore and on Google Play). In less than a month, there have been 1300+ downloads, so it seems like the app may become a common tool for SI leaders internationally.

### In-Session Tools

There are numerous digital in-session tools used by SI leaders to enrich the participants learning experiences in the SI community. Tools like quizzes and games that require retrieving covered course materials improve memory and learning (Weinstein, Madan, & Sumeracki, 2018). Some of the tools used in the SI community over the past five years are listed below.

- Factile: a free learning platform that allows you to create jeopardy style quiz games
- Kahoot: a software where you can create a quiz that students can connect to via any smart device
- Padlet, Wakelet, Google docs, and Jamboard: tools (bulletin board, document, whiteboard) for joint work in breakout rooms and whole group sharing
- Poll Everywhere, Easypoll, Surveymonkey, Mentimeter, Slido, and Doodle: tools that can be used for polls/surveys
- Plickers: a Q&A software that allows participants to answer questions on online cards
- PurposeGames: software that allows you to create and play games
- JeopardyLabs: allows for the creation of a customized jeopardy template and can be played online

- Kialo Edu: a public discussion platform designed to help students with critical thinking and reasoning skills
- Crossword Puzzle Maker: allows you to generate crossword as handouts
- Perusall: a social annotation tool that allows students to collaboratively mark-up course material (i.e., pdf texts) and bring the discussion to the text
- Bubbl.us: a mind and concept mapping program
- Drawasaurus and skriibl.io: drawing and guessing game software
- Piazza: a Q&A platform
- Flippity: software that can be used for flashcards, crosswords, quizzes, and games
- LibreTexts: a multi-institutional platform with a large library of texts covering numerous subjects available online for free
- Howtostudy.org: an extensive list of resources, tips, and suggestions on how to study
- Easy notecards: a place where students can create, study, and share interactive flashcards based on course material

**Administrative Tools**

Internationally, there are considerably more tools used in SI programs compared to Lund University. Some of the more common ones based on information from the three list-serves are described next. For attendance tracking, institutions used EAB Navigate, Google Sheets, Tutor trac, and Gradesfirst. List-serves are often used for information exchange and questions between SI supervisors. This service is, for instance, provided by the International SI Center at the University of Missouri Kansas City, the Australasian SI-PASS center at the University of Wollongong, the Canadian SI center at the University of Guelph, and the International Academic Peer Learning Network (IAPL) in the UK. Canvas, Microsoft Teams, Blackboard, Kudocollab.com, and Google Drive are examples of software used for administering SI programs and provide a place to store resources like training materials, forms, and how-to guides. Surveymonkey, Google forms, Qualtrics, and Canvas, are examples of software used to create evaluation surveys. Youtube playlists are often used to store SI videos to use for leader training and promotion. Notability and One Note are examples of apps used to document observations and to share notes with the SI leader.

**Synchronous Online SI**

In April 2020, when the Coronavirus has a considerable impact on life in general, there were worldwide efforts and interest in distance education and, as a consequence, in online SI. This has yielded a number of posts on SI list-servers regarding online SI; this included SI supervisors asking for help and information and supervisors with online SI experience responding. Thus, it is possible to get an idea of the extent of online SI in the SI community before the Coronavirus. Although a clear majority of universities did not seem to have online SI, it is rather wide-spread in the SI community. Most online SI programs appear to be small (measured in SI leaders employed and courses supported) and in their infancy.

There are several platforms used in running online SI programs. Some common ones are BigBlueButton, WebEx, Google hangouts/docs/sheets, Adobe connect, MS Lync, and Blackboard Collaborate. However, Zoom seems to be the most popular platform to use when facilitating online SI sessions (used, for instance, by Fresno State University in the US, which is one of the pioneers in online SI, according to the International SI Center at the University of Missouri Kansas City).

Are the essential elements of SI that you have in face-to-face sessions possible to recreate in online sessions? And does online SI provide the same effectiveness in increasing student performance as face-to-face SI? To answer these questions, the authors read eleven papers on online SI that were found on Google Scholar. This is roughly about one to two percent of the research on SI (most of it focusing on face-to-face SI), which reflects that online SI is in its infancy.

According to the literature, there are two main reasons for choosing to have SI online. The most obvious reason is for courses that are offered online (Carter-Hanson & Gadbury-Amyot, 2016; Lim, Anderson, & Mortimer, 2016; Shaw & Holmes, 2014). A second reason is to reach students who have difficulty attending SI on campus (Huijser, Kimmins, & Evans, 2008; Lim, Anderson, & Mortimer, 2016; Nikolic & Nicholls, 2017 ).

How does SI online compare to traditional sessions face to face? In online SI, it is easier for participants to contribute to the session initially, and there is larger flexibility in scheduling sessions (Beaumont et al., 2012). However, online SI requires more time to cover course content, which is less efficient (Beaumont et al., 2012; Hizer et al., 2017). The attendance in online SI is also lower compared to face-to-face (Devine & Jolly, 2016; Hizer et al., 2017; Nikolic & Nicholls, 2017; Watts et al., 2015; Woolrych et al., 2018). Moreover, face-to-face SI is more social (Beaumont et al., 2012), more difficult to build relationships, and the demands on the SI leader are greater since they also have to manage the platform for the SI sessions (Watts et al., 2015). Woolrych et al. (2018), Hizer et al. (2017), and Finlay and Mitchell (2017) found that face to face SI and online SI were equally effective in increasing student performance compared to students not attending either form of SI. This seems very encouraging for the potential in online SI. However, it is probably good not to be overly optimistic; Woolrych et al. (2018) reference a study that did not show any benefits for students attending online SI.

## Discussion

In the past ten years, there has been increased interest in digital tools to help SI leaders plan sessions and facilitate student learning. As a supervisor, it is important to make sure that the technology serves the learning and not the other way around. For instance, there are cases where students grow very fond of using a certain digital tool during SI sessions (e.g., Kahoot), and in the short term, the students and the SI leader are satisfied with the tool. However, without supervision, it is easy to grow overly dependent on the tool, with the long-term consequence of losing variation on the SI sessions, which impairs student learning and the leadership development of the SI leader.

Based on earlier studies, online SI has the potential to provide students with a good learning experience that is close or similar to face-to-face SI. The collaborative nature of SI sessions is achievable in online SI, and the effectiveness from the point of view of student performance on examinations is similar to traditional SI. Some noted drawbacks of online SI are lower attendance and that the social aspect of traditional SI, including building relationships, to some extent get lost. However, the number of studies on online SI is small, and it is hard to know if previous findings are generalizable to all SI sessions. Furthermore, synchronous platforms for online SI are continuously developing, which opens the possibility for an even better digital SI experience.

Again, this was written when the world was experiencing a pandemic caused by the Coronavirus in April 2020. With most of higher education, including SI, switching to an online format, there was suddenly a unique possibility to obtain a huge set of data on online SI. It is reasonable to expect that a lot will be discovered regarding its potential and how it compares to traditional SI.

The SI program at Lund University seems to be at the forefront when it comes to using digital tools in SI. However, when it comes to in-session tools to help students learn and memorize through different types of retrieval practice or to reflect on issues or problems in the course material, SI at Lund University could benefit from surveying the multitude of practices that are used internationally. Similarly, online SI at Lund University is in its infancy and could definitely learn from similar programs at other universities.

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# 3 Teachers' Integration of Technology: What Significance does the Subject Area have in Norwegian Schools?

*Mohamed El Ghami, Erik Bratland & Inger Lise Valstad*

*Abstract:* Although schools have undergone a digital transformation, digitalization has not led to substantial changes in education. Despite extensive research on the use of digital tools in teaching, little is known about teachers' perceptions and use of technology in various subjects. Also, it is not clear why some subjects are more likely to integrate technology into teaching and learning. Based on a validated path model as a conceptual framework, this chapter presents an analysis of two subjects in education (Norwegian and Mathematics). The findings showed that the subject area had a significant impact on integration and had a main effect on teachers' beliefs. However, this effect on integration and beliefs was reduced when compared with multi-subject teachers' responses, indicating the special circumstances that characterize the Norwegian school context. Still, the multi-subject effects do not change the main pattern. This result shows that the subject areas are not homogeneous, and technology integration is decisively shaped by the subject areas, giving rise to the different patterns, which can provide a deeper understanding of teachers' technology integration in education.

## Introduction

The digitalization of education is a global phenomenon, and this development is particularly evident in schools. Authorities in different countries have driven the development, and this is expressed in curricula and strategy documents, which include high expectations for better learning and learning outcomes (Selwyn, 2013). Although different countries have created their own national strategies for digitalization, these appear to be based on the common idea that technology can be integrated into education in a generic way, regardless of differences between different subject areas (Howard & Maton, 2011).

In Norway, the concept of digital competence has gained a central place in curriculum reforms (Erstad, 2010; Krumsvik, 2016), and they have stated that digital tools should be used in all subjects (LK06). Digital competence is a complex concept, but in the school context, the concept has been characterized as a key competence, which will enable teachers and students to use technology in education. Based on this, educational research has emphasized suitable approaches for developing teachers' and students' digital competence in digital school.

A number of studies are concerned with teachers being digitally competent, and there are a number of contributions that describe various elements that should be included in teacher's digital competence (Johannsen, Øgrim, & Giæver, 2014; Lund, Furberg, Bakken, & Englien, 2014). These studies have focused on the teacher's specific digital competence in school, which has contributed to the development of the concept of professional digital competence, a concept that incorporates academic and didactic dimensions, in which ICT should be based on educational objectives in the curriculum (Krumsvik, 2016).

Although the Norwegian school has undergone a digital transformation, with schools with rich access to technology, it has not resulted in a corresponding increase in the use of technology for educational purposes or significant changes in educational practices in the classroom (Blikstad-Balås, 2015; Hatlevik, 2013; Kopcha, 2012; Ludvigsen, & Rasmussen, 2006). Research shows that the use of technology is shaped by established pedagogical practices and that technology use can vary considerably between different subject areas (Arnseth, 2007; Hatlevik, 2013). The government's strategy (UFD, 2004; Kunnskapsdepartementet, 2017), with an emphasis on digital competence or literacies, has not led to the expected integration of technology in education. This may be due to a number of factors, but research has focused on elements related to teachers' specific teaching practices in various subject areas and has considered factors that may have a crucial impact on technology integration in education. Researchers recommend that teachers should be trained to use ICT in a didactic and subject-specific way (Kirshner et al., 2008), arguing that there is a need to develop digital didactics (Krumsvik, 2009). Others have suggested how teachers can use technology in different subject areas (Otnes, 2009). It is emphasized that the individual subject area, as it is designed in the curriculum, constitutes "a separate microcosm" (Goodson, & Mangan, 1995), with its own values and traditions. This insight indicates that teachers' perceptions and practices in various subject areas are key factors for integrating technology into education. However, it is not clear what is meant by the subjects being a separate microcosm.

Although research has gradually begun to emphasize the importance of the various subject areas, these are treated as differences in teachers' perceptions of pedagogies, content knowledge, and learning strategies (Law et al., 2008). While these are central elements of teachers' teaching practices, this type of conceptualization involves a superficial approach to the subject areas, focusing on learning instead of on knowledge and the principles underlying teachers' knowledge practices in separate subject areas (Howard et al., 2015). In this way, the connection between the elements that form teachers' pedagogical practices in subject areas and the underlying educational knowledge remains obscured, which leads to differences between different subject areas that are not clearly understood (Howard & Maton, 2011).

Based on the social and realistic theory, Bratland (2016) and Howard and Maton (2011) demonstrated how teachers' perceptions and practices in the subject area are shaped by underlying organisational principles, which affect how technology is integrated into subject areas. According to this approach, subject areas include various forms of knowledge, which consist of social and epistemic relationships with different strengths. In educational contexts, this determines teachers' perceptions of the subject area, what students need to know, and what kind of knower one needs to be. Teachers' subject area beliefs, based on the nature of the underlying relationships, impacts teachers' perceptions of what it takes to succeed in the subject area, how technology can best support student progress, and how important technology is in acquiring knowledge in a subject.

This research reveals how technology integration is related to teachers' subject area beliefs and why technology clashes or matches with different subject areas. Based on an analysis of the underlying relationships, Howard and Maton (2011) identify a possible clash between mathematics and technology integration, while in English, there is a possible match. This analysis shows how educational knowledge in the subject area helps structure the practices and perceptions of the teachers, and it is only when this perspective is applied that it becomes possible to explore the effect of subject areas on technology integration. Howard et al. (2015) point out that research still needs to explore the effect of subject area on integration and the specific factors that can highlight teachers' technology integration.

## Digitalization in Norwegian Schools

The Norwegian authorities have carried out large-scale digitization in Norwegian schools. The digitalization initiative is based on ambitious plans (UFD, 2006; UFD, 2004; Kunnskapsdepartementet, 2017), and the implementation of the technology in schools has taken place at the county and municipality level. The authorities' digital initiative has resulted in more use of information and communication technologies (ICT) but has not led to significant changes in teaching practices or in teachers' technology integration (Hatlevik, 2013; Hatlevik & Kløvstad, 2009; Ludvigsen & Ramussen, 2006). Teachers' practices appear to be crucial for effective integration of technology (Tamim et al., 2011), but because teachers' practices vary between different subject areas, research needs to explore subject areas as a crucial factor for teachers' integration of technology into education (Howard et al., 2015; Inan, & Lowther, 2010). There is a lot of evidence that teachers' practices in the subject area are a key factor that influences teachers' perceptions and use of technology within the subject area (Ertmer & Ottenbreit-Leftwich, 2010).

At the same time, it is reasonable to believe that the subject's effect on teachers' practices cannot be seen independently of teachers' subject specialization, and whether the school structure allows teachers to teach in a single subject area, or whether they are required to teach in a number of subject areas. School structures vary between different countries, and the structure can open up or limit specialization and the division of labor. The Norwegian school system is characterized by a structure with relatively small schools, which to a lesser extent, allows specialization, where teachers, even in secondary school, are required to teach in a number of subjects. Previous surveys of Norwegian teachers' competence in central subject areas show that Norwegian schools have significant challenges (Carlsten et al., 2014; Lagerstrøm et al., 2014). Thus, the Norwegian teacher model is a factor that may have an impact on how Norwegian teachers integrate technology into education and could conceivably weaken the importance of subject areas as a factor for technology integration.

## A Model for Technology Integration

There are several models developed to explore teachers' technology integration. Several of these models for research on technology integration are affected by the above-mentioned criticism, and an alternative path model should provide an opportunity to explore the effects of a subject area and teacher integration of technology. Inans and Lowther's (2010) model includes factors to explore the relationships between subject areas and technology integration. Howard et al. (2015) developed a path model for the relationship among variables (see Figure 1, adopted from Howard et al., 2015, p. 367).

This model examined the relationships between subject areas and factors that have previously been important for technology integration. Teacher readiness and teacher beliefs have been adopted from Inans and Lowther (2010) and are important factors for technology integration. Inans and Lowther define teacher readiness as teachers' perception of their capabilities and skills required to integrate laptops into classroom instruction, and teacher beliefs as "teachers' perception of laptops' influence on student learning and achievement and impact on classroom instruction and learning activities" (p. 939). Howard et al. (2015) added time into their model, which is an independent variable with the purpose of examining change over a number of years. In their study, this variable aims to shed light on whether participation in the organized laptop program would have a bearing on teachers' integration of technology over time. In the Norwegian context, there is no correspondingly organized laptop program, and

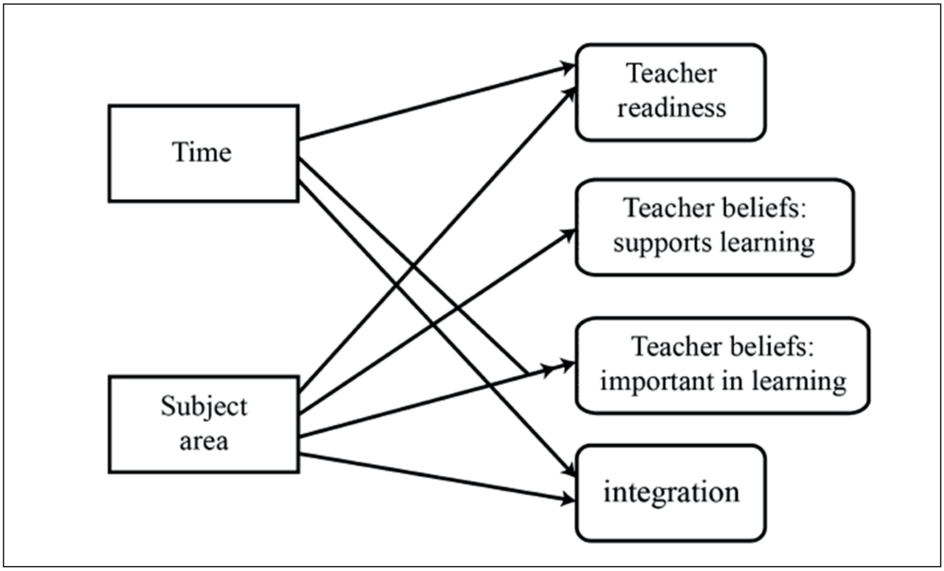


Fig. 1: Path model of teachers' technology integration.

this variable will be continued as a dependent variable that reveals the connection between subject areas and time spent using ICT in classrooms. Accordingly, this chapter explores the effect of the subject area on the variables mentioned. This proposed path model (see Figure 1.) is tested on a new data set, collected at schools in Northern Norway, and the discussion examines the effect of the subject area and whether this should be moderated or reformulated in the face of a Norwegian school context.

## Method

This paper is based on the collection of data by an empirical survey among a number of schools in Northern Norway (Nordland, Troms, and Finnmark). The survey was an online questionnaire that explored teachers' perceptions of subject-area knowledge practices and technology integration. The participants of this study included 144 females (72%) and 56 males (28%) who were teachers of mathematics, Norwegian, English, science, and social science in fifth through tenth grade. The current study compares mathematics and Norwegian teachers' questionnaire responses on what they believe about the use of technology in teaching their main subject areas. The illustrative focus included a total of 122 teachers from mathematics ($n = 47$), Norwegian ($n = 45$), and both subjects ($n = 30$). They responded to the items in 2018–2019.

The analysis presented draws on a subset of 18 items from the teacher questionnaire. Items were selected for their alignment with variable descriptions from Inan and Lowther's model. The independent variables in this analysis were the subject areas of mathematics, Norwegian, and multiple subjects. Teachers were asked to respond in relation to their practices, as well as specify their primary content area of teaching. Table 1 presents the dependent variables as defined in Howard et al. (2015).

Tab. 1: The dependent variables

| Variable | Description |
|---|---|
| Integration | Teachers' self-rating of how frequently they used a computer in teaching |
| Teacher readiness | Teachers' perceptions of their skill level and effectiveness using ICTs in teaching |
| Teacher beliefs: the importance of computers | Teachers' perceptions of how important it is for them to use computers in their work, as well as for students to use computers in their learning |
| Teacher beliefs: supports learning | Teachers' perceptions of how computers support student learning outcomes (e.g., creativity, organisation, understanding, etc.) |

The instrument consisted of one scale for ICT integration in teaching and three subscales with acceptable reliability values: teacher readiness (5 items, = 0.77), teacher beliefs regarding the importance of computers (6 items, = 0.75), and supports learning

(6 items, = 0.78). The combined measure allocates equal weight to each subscale regardless of the number of items representing each subscale.

## Results

The current study compares ICT integration in teaching among mathematics, Norwegian, and multiple-subject teachers. Table 2 and Table 4 present descriptive statistics for teachers' responses to each variable in the two subject areas. Table 5 presents the main analysis. All follow-up pairwise comparisons are with Scheffe adjustment controlling $\alpha$ at .05.

Results of the ANOVA indicated significant main effects of the subject area on the ICT integration in teaching $F(3, 148) = 8.852$, $p < 0.001$ (see Table 3). Mathematics and Norwegian teachers showed significant differences in how often they used computers in their teaching. This differences are presented in Figure 3, which indicates that Norwegian teachers in Northern Norway reported (see Table 2) more use of technology in classroom practices ($M$ =2.04, $SD$ = 0.90) than mathematics teachers ($M$ = 1.42, $SD$ = 0.65; $p < .001$). However, based on the multiple subject teachers' questionnaire responses, this gap was significantly reduced. Even though they reported positive ICT use in Norwegian ($M$ = 1.60, $SD$ = 0.67) compared to mathematics ($M$ = 1.23, $SD$ = 0.62; $p = 0.296 > 0.05$), this difference is not significant. The finding shows negative effects for ICT integration in the same subjects of the multiple subject group, and the pairwise comparisons between groups showed that multiple-subject teachers reported less ICT integration than mathematics teachers ($p > 0.74$) and less integration than Norwegian teachers ($p > 0.09$), though these differences are not significant (see Figure 2).

Tab. 2: ICT Integration in Teaching

| | N | M | SD |
|---|---|---|---|
| Mathematics | 47 | 1,425 | ,6509 |
| Norwegian | 45 | 2,044 | ,9034 |
| Multiple subjects (Integration of ICT in Mathematics) | 30 | 1,233 | ,6260 |
| Multiple subjects (Integration of ICT in Norwegian) | 30 | 1,600 | ,6746 |
| Total | 152 | 1,605 | ,7903 |

Note. Scale, 0 = 'Never'; 1 = '1–2 times a week'; 2 = '3–4 times a week'; 3 = '5–6 times a week'; and 4 = ' 7+ times a week'; M, mean; SD, standard deviation.

Tab. 3: Factorial ANOVA of the Independent Variable: ICT Integration in Teaching.

| | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 14,349 | 3 | 4,783 | 8,852 | ,000 |
| Within Groups | 79,967 | 148 | ,540 | | |
| Total | 94,316 | 151 | | | |

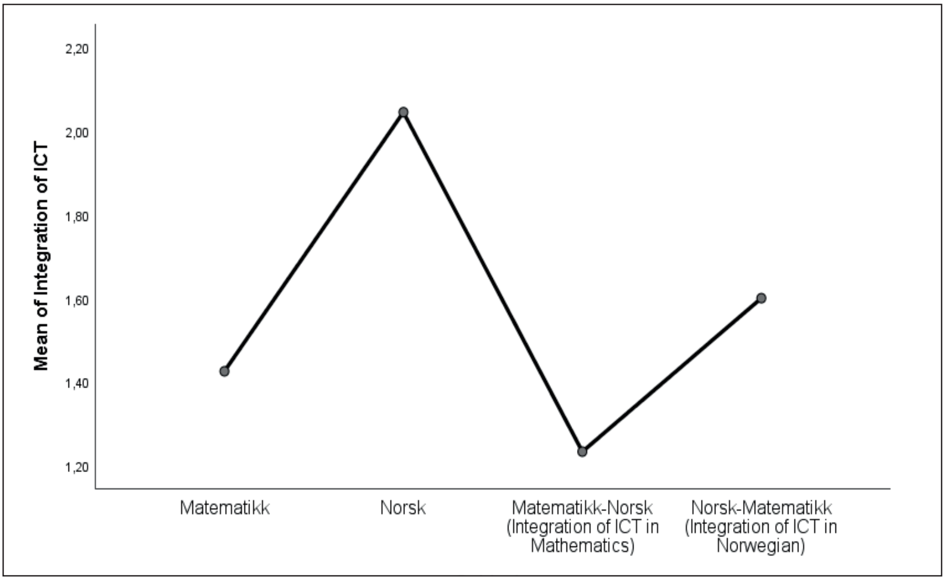


Fig. 2: Computer use in Northern Norway in mathematics (Matematikk) and Norwegian (Norsk).

The findings show that mathematics teachers' computer use in schools in Northern Norway is significantly lower compared to teachers' use of time in Norwegian. However, this effect is reduced when looking at the responses from teachers who teach multiple subjects. In regard to teacher readiness using computers, the analysis showed no main effects for subject area $F(2, 121) = 1.186$, $p = 0.309$ (see Table 5). Follow-up pairwise comparisons showed only a small, non-significant difference between the three groups. Mathematics teachers reported less confidence than teachers in Norwegian ($p > 0.72$) and multiple-subject teachers ($p > 0.31$).

For the two teacher beliefs variables: "ICT is important" and "ICTs support learning" (see Table 4), the findings show a main effect of the subject on teachers' beliefs that ICTs are important $F(2, 121) = 3.369$, $p < 0.05$ and that ICTs support learning $F(2, 121) = 4.420$, $p < 0.05$ (see Table 5). Norwegian teachers reported significantly more positive beliefs about the importance of ICTs than mathematics teachers ($p < 0.05$). Pairwise comparisons between groups also showed that multiple-subject teachers reported more, but not significantly more, positive beliefs than mathematics teachers ($p > 0.22$) and less, but not significantly less than Norwegian teachers ($p > 0.89$; Figure 3). For "ICTs support learning," the findings show that mathematics teachers in Northern Norway ($M = 2.90$, $SD = 0.426$) are significantly lower than Norwegian teachers ($M = 3.16$, $SD = 0.46$, $p < 0.05$). Similar to the teacher beliefs variable, "ICT is important," the pairwise comparisons between groups showed that multiple-subject teachers reported slightly more positive beliefs "ICTs support learning" than mathematics teachers ($p > 0.89$) and less than Norwegian teachers ($p > 0.12$), though these differences were not significant (see Figure 5).

Tab. 4: The main effect of the subject on teachers' beliefs that ICTs are important, and that ICTs support learning.

| | | N | M | SD |
|---|---|---|---|---|
| Teacher beliefs: the importance of computers | Mathematics | 47 | 3,237 | ,483 |
| | Norwegian | 45 | 3,459 | ,402 |
| | Maths-Norwegian | 30 | 3,411 | ,360 |
| | Total | 122 | 3,362 | ,434 |
| Teacher beliefs: supports learning | Mathematics | 47 | 2,900 | ,426 |
| | Norwegian | 45 | 3,166 | ,463 |
| | Maths-Norwegian | 30 | 2,950 | ,457 |
| | Total | 122 | 3,010 | ,460 |
| Teacher readiness | Mathematics | 47 | 3,263 | ,543 |
| | Norwegian | 45 | 3,355 | ,586 |
| | Maths-Norwegian | 30 | 3,460 | ,490 |
| | Total | 122 | 3,345 | ,548 |

Note. Scale, 1 = Strongly disagree; 2=disagree; 3=agree; and 4 = 'Strongly agree'; M, mean; SD, standard deviation.

Tab. 5: Factorial ANOVA of independent variables: Teacher beliefs and teacher readiness

| | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Teacher beliefs: the importance of computers | Between Groups | 1,226 | 2 | ,613 | 3,369 | ,038 |
| | Within Groups | 21,646 | 119 | ,182 | | |
| | Total | 22,872 | 121 | | | |
| Teacher beliefs: supports learning | Between Groups | 1,774 | 2 | ,887 | 4,420 | ,014 |
| | Within Groups | 23,878 | 119 | ,201 | | |
| | Total | 25,652 | 121 | | | |
| Teacher readiness | Between Groups | ,711 | 2 | ,356 | 1,186 | ,309 |
| | Within Groups | 35,692 | 119 | ,300 | | |
| | Total | 36,403 | 121 | | | |

The findings of teacher beliefs about the importance of ICTs and supports learning in Northern Norway are presented in Figure 3 and Figure 4, respectively. This shows that teacher beliefs in mathematics are significantly lower compared to Norwegian. Yet, this effect is reduced when looking at the teachers who teach multiple subjects.

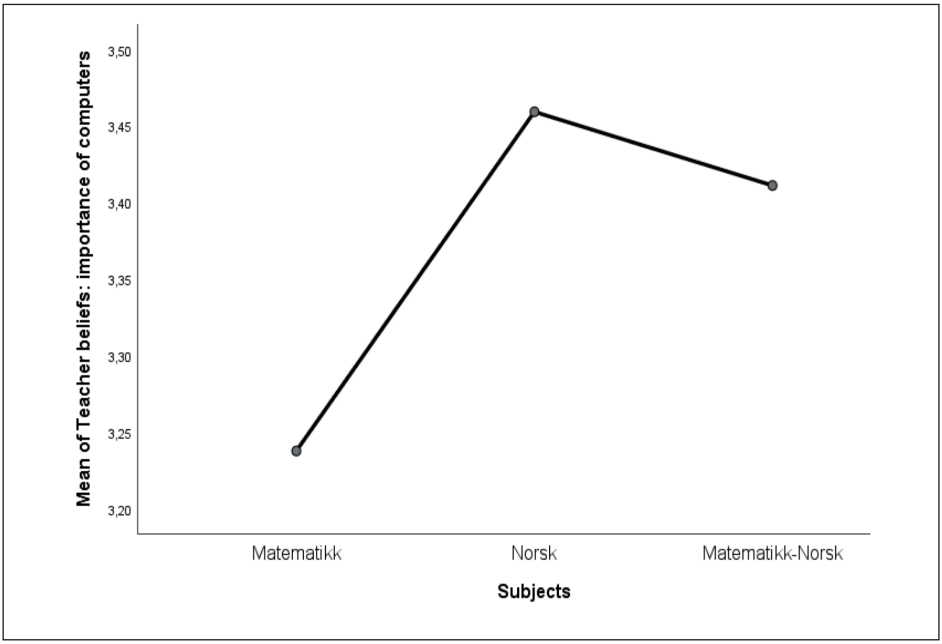


Fig. 3: Teacher Beliefs: The Importance of ICTs (Matematikk=Mathematics, Norsk=Norwegian)

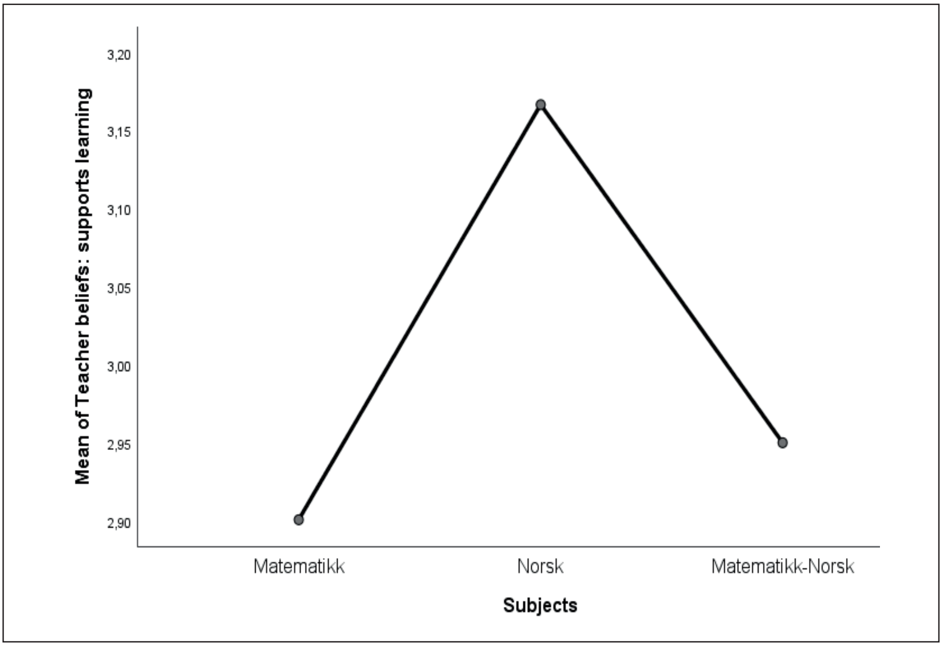


Fig. 4: Teacher beliefs: supports learning (Matematikk=Mathematics, Norsk=Norwegian)

## Discussion and Conclusion

The relationship between subject area and technology integration is an under-researched area, and this chapter examined relationships between subject areas and known factors of technology integration: teacher readiness and teacher beliefs. These factors, which have been proven to have a direct impact on teachers' technology integration (Inan & Lowther, 2010), have been adopted by Howard et al. (2015) and form a part of a newly developed conceptual model (see Figure 1). This model investigates the relationship between the subject area and the other variables. This chapter tested the proposed model on a new dataset collected from schools in Northern Norway. The chapter analyzes the time spent in different subject areas and the relationship between subject areas with teachers' beliefs and readiness to use technology in education. The findings show that the subject area contributes to variations in teachers' beliefs and that the subject area is important for technology integration. At the same time, the results confirmed that these effects are reduced in a Norwegian school context, where teachers typically teach in several subjects. This situation, where the teachers teach in several subjects, is a special feature that characterizes Norwegian schools. This modified multiple-subject effect provides a basis for proposing a new conceptual model that would be suitable for analyzing the relationships between the variables in Norwegian schools.

The results confirmed that subject areas had a significant impact on ICT integration and a main effect on teachers' beliefs. Results showed no effect of subject area on teachers' readiness. However, this effect on integration and beliefs was reduced when compared with multiple-subject teachers' responses, indicating that the number of subjects reduces academic pretensions when teachers use ICTs in teaching and learning. Future research should test this proposed model (see Figure 5). Further, the modified multiple-subject effects will have an affinity to similar research on interdisciplinary and multidisciplinary approaches, where the specified knowledge base of the subject area seems to be blurred (Horlick-Jones, & Sime, 2004; Wheelahan, 2010).

However, the multiple-subject effects do not change the main pattern. The subject area does matter and can explain differences in teachers' beliefs and technology integration. The findings showed that mathematics teachers' use of technology is significantly lower compared to Norwegian teachers. At the same time, there is a significant relationship between the subject area and the teachers' beliefs, which indicates that the subject area is a crucial factor for technology integration. This result shows that the subject areas are not homogeneous, and technology integration is decisively shaped by the subject areas, giving rise to the different patterns expressed by teachers' different perceptions and use of technology in the classrooms. These differences between subject area and technology integration can be conceptualized as clashes and matches between technology practices and knowledge practices in various subjects (Howard, & Maton, 2011).

The present study is a contribution to the study of the importance of subject areas for technology integration in education. The conclusions presented in this study are

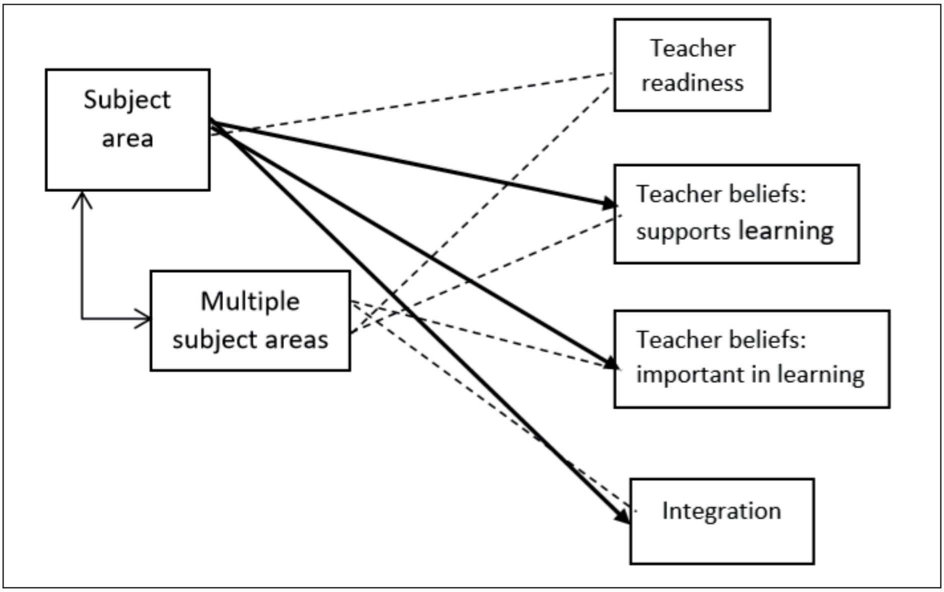


Fig. 5: Proposed Conceptual Model

preliminary, and further studies are required to fully understand the relationships between subject areas and technology integration. In Norwegian schools, teachers are obliged to teach a number of subjects, so there will be a particular need to study the modified multiple-subject effects on technology integration in education. In general, gaining a greater understanding of the connection between the subject area and technology integration will be of crucial importance for educational policy and curriculum. As the results suggest, technology integration in education cannot take place in a generic way but will depend on the subject area, forms of knowledge, and teachers' knowledge practices.

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# 4 Experiences with Lecture Capture: How is Learning Affected?

*Lise Lillebrygfjeld Halse*

*Abstract:* Many institutions have considered recording lectures, often referred to as lecture capture, as a response to the call for increased digitalization in higher education. The literature review in this chapter shows mixed results regarding the effect of lecture capture on attendance and exam results and shows only to a limited extent how this technology affects the learning situation. To build knowledge in this field, this study presents experiences from the introduction of lecture capture at a Norwegian university. The findings shed light on the contested space between the attitudes of students, and lecturers, possible consequences of the implementation of lecture capture, and how the theoretical perspective on learning leads to different conclusions.

## Introduction

Recently, the digitization of teaching in higher education has seen increased attention (Olofsson et al., 2015). There are several drivers of this development: general pressure related to the use of technology, increasing student numbers without a corresponding increase in educational institutions' resources, part-time students, and competition between institutions (Cilesiz, 2015; Freed et al., 2014; Kwok-Wing, 2011). These drivers put increased pressure on institutions to modernize and implement new technologies. Moreover, during the Coronavirus pandemic, schools and universities in many countries closed, leading students into home-schooling situations (Tam & El-Azar, 2020). This has accelerated the use of digital technologies in education, which some predict will change how students are educated in the future.

Digital learning is about the use of digital technology in education, where the purpose is to support the students' learning process. There are various ways that technologies may be applied in educational settings (Kwok-Wing, 2011), including the use of digital presentation technology, digital web-based learning platforms, webpages, smartphones, videos, and podcasts. However, the focus of the present study is on lecture capture, where lectures are recorded in their entirety and then posted online afterward (Edwards & Clinton, 2018). This technology appears to have many advantages, including flexibility, the opportunity for students to review and repeat lecture content, and the ability to manage increasing class sizes without a significant increase in physical infrastructure (Johnston et al., 2013). While there are several advantages associated with lecture capture, there are some concerns regarding the effect of lecture capture on student's learning. In this chapter, this issue is addressed by reviewing the literature on lecture capture technology and presenting experiences from a Norwegian institution in higher education where lecture capture was introduced on a large scale in 2013. Before presenting this case study, theoretical perspectives on learning and findings from previous studies are presented.

## Literature Review

### Theoretical Perspectives on Learning

An important distinction in the theoretical understanding of learning lies within the cognitive perspective and the sociocultural perspective on learning. From the cognitive perspective, learning is analyzed by studying the development of individual actors through their thoughts and understanding (Säljö, 2001). From the sociocultural perspective, the emphasis is on the learning that takes place in a context where actors participate and interact in a community, and where learning is viewed as resulting from a dynamic interaction between the individual and the culture (society) the individual is part of. Thus, cognitive and sociocultural perspectives represent fundamentally different perspectives on learning. The cognitive perspective views learning as mainly an individual process, while the sociocultural perspective focuses on the social and contextual process.

Wenger (2018) claimed that most educational institutions consider their methods of learning an individual process with a beginning and an end, preferably separated from other activities. According to Wenger, learning that involves membership in the communities of practice within the classrooms and other student arenas, official or disorganized, are the most transformative. In this perspective, an important task for educational institutions is to build interconnected professional communities with students, which are a part of their daily lives. A learning environment where students are present, engaged, and involved is fundamental to achieving this (Vygotsky, 1978).

### Lecture Capture

O'Callaghan, Neumann, Jones, and Creed (2017) studied the use of recorded lectures in higher education using the concept of web-based teaching technologies, which includes lecture recordings that have only audio, video, or other media such as a PowerPoint presentation or images. These technologies also cover publishing files that provide video presentations with audio, where students can see and hear the lecturer and other visual information (lecture notes). The files can be distributed in digital format via the internet or by downloading to a computer or handheld device such as a mobile phone. Recording lectures can be done through a video recording of the lecturer, blackboard/whiteboard, or PowerPoint in the lecture situation. Another approach is for the lecturer to record the lecture without students present, either in a studio or in the lecturer's office. Variations include recording the lecturer without illustrations or text, the lecturer embedding text in the recording, or a pure PowerPoint presentation where the voice of the lecturer is placed in the background.

This chapter focuses on recording lectures in an auditorium or lecture room with a lecturer and students, and with subsequent online publishing. Typically, two or three 45-minute lectures are recorded and published online. The term lecture capture is used below to describe this (Edwards & Clinton, 2018).

### The Attitudes of Students and Lecturers

Many studies indicate that students are generally positive about having access to lecture capture and want more of it (Al-Nashash & Gunn, 2013; Bassili & Joordens, 2008; Copley, 2007; Danielson et al., 2014; Heilesen, 2010; Morris et al., 2019; Simcock et al., 2017). This positive attitude can be found irrespective of age, gender, enrolment mode, or attendance pattern (Al-Nashash & Gunn, 2013). An important argument from the students' perspective is that access to lecture capture makes it possible to view the lectures again; it can also serve as a substitute when students are unable to attend lectures, which gives students increased flexibility (Franklin et al., 2011). It has also been reported that students use lecture capture for revision and to review difficult concepts (Davis et al., 2009), specifically before exams (von Konsky et al., 2009). The positive attitudes toward technology improve student satisfaction and affect their course choice (Watt et al., 2013).

Interestingly, little research has been conducted on lecturers' views of lecture capture (Al-Nashash & Gunn, 2013). Contrary to the students' positive attitudes, Maynor, Barrickman, Stamatakis, and Elliott (2013) found that academic staff had several concerns about the concept of it, including concerns about reduced attendance at lectures, reduced academic socialization among students, poorer results from students who are already struggling, and an overall deterioration in results. Only three percent of professionals indicated they had no concerns about the use of lecture capture. Morris et al. (2019) and Dona, Gregory, and Pechenkina (2017) found that lecturers were uncertain about the value of lecture capture and were particularly concerned about reduced attendance at lectures.

### Lecture Attendance

Lecture capture might reduce lecture attendance, given that some students choose to view the recordings instead of attending the lecture. There may be many reasons for this. The students may have conflicting time schedules or other valid reasons for absence. Students may also think that watching lectures online later will be the same as attending, and therefore choose to view the lecture when it is most suitable for them. As Edwards and Clinton (2018) pointed out, "lecture capture availability removes the perceived penalty for missing live lectures as there is a 'second chance' to experience it," and may therefore give students the belief that they can catch up later. While this may seem like a probable consequence of the introduction of lecture capture, the findings from previous studies are mixed.

Paulo Kushnir, Berry, Wyman, and Salajan (2011), Davis et al. (2009), and Lonn and Teasley (2009) all found that students do not drop lectures as a result of recordings of the lectures being made available. Similarly, Walls et al. (2010) found that 89 percent of students reported that they were less likely to drop a lecture when they had a video or audio recordings of the lecture were available.

In contrast, other studies have found that recording and publishing lectures can reduce attendance (Bos et al., 2016; Brotherton & Abowd, 2004; Edwards & Clinton, 2018; Harley et al., 2003; Holbrook & Dupont, 2009; Morris et al., 2019; Traphagan et al., 2010). For example, Gorissen, van Bruggen, and Jochems (2012) found that students use video recordings of the lectures as a substitute for attending lectures. In Franklin et al.'s (2011) study, 14.3 percent of the students reported that the availability of lecture capture would lead to a reduction in attendance.

Edwards and Clinton (2018) based their study on a matched cohort ($N$ = 161) before and after the introduction of lecture recordings; they found that attendance dropped significantly after lecture recordings were made available. They concluded that viewing lecture capture does not compensate for the effect of the low attendance on goal achievement. Studies also indicate that the quality of the lecture and the students' competence may have something to do with the connection between lecture capture and attendance and the way video recording is used. Here, however, there are different and contradictory findings (O'Callaghan et al., 2017).

In the Norwegian context, several surveys have shown that students do not substitute lectures with lecture captures (Fossland, 2015). A Norwegian survey called "Digital tilstand 2011" identified the use of digital tools and media by Norwegian universities and colleges. The survey found that one in five teachers believes that lecture capture leads to lower attendance, but only ten percent of the students reported that access to lecture captures led to reduced attendance (Ørnes, Wilhelmsen, Breivik, & Solstad, 2011). Ørnes et al. (2011) also pointed out that the material in the survey appears to be characterized by a limited amount of experience of accessing video lectures, as there was a relatively large proportion of "do not know" and neutral answers. Another study at the University of Oslo showed that 77 percent of students claimed to have never dropped lectures even though they had them available as podcasts (Fossland, 2015).

## The Effect of Video Lecture

Previous studies have shown varying and contradictory findings regarding the effect of lecture capture on grades (O'Callaghan et al., 2017). In several studies, students report that video lectures helped them increase their learning and receive higher marks (Bassili & Joordens, 2008; Chester et al., 2011; Danielson et al., 2014; Gosper et al., 2008; Paulo Kushnir et al., 2011). Bos et al. (2016) found that students who used recorded lectures to supplement lecture attendance to build their basic knowledge base had better results in assessments. However, when assessing more advanced learning (i.e., higher-order thinking skills), there was no significant difference among students in terms of using recordings or attending lectures.

Franklin et al. (2011) found that although students had the impression that video lectures led to better grades, it actually had no such effect. Several other studies have been unable to find a connection between the use of lecture capture and an improvement in grades (Bassili & Joordens, 2008; Leadbeater et al., 2012). However, Le et al. (2010) found that students who supplemented lectures with lecture captures, and those who used playback functions (such as pause and search), performed poorly on exams. The authors interpret this result as meaning that students who use playback features have a superficial approach to learning.

Paulo Kushnir et al. (2011) found that students perceived that podcasts helped them learn, while in the survey, the researchers found that this did not have such an effect (comparing those who had used podcasts with those who had not). This indicates that students' self-reported experiences may not always match what is measured in terms of grades. For instance, Groen, Quigley, and Herry (2016) investigated the relationship between students' attitudes to lecture capture, self-report of attendance, and exam grades. They found that students with lower grades used lecture capture more than those with higher grades. Simcock et al. (2017) found that the grades were positively correlated with the number of lectures they attended and negatively correlated with the number of lecture captures the students had seen. Similarly, Owston, Lupshenyuk, and Wideman (2011) and Johnston et al. (2013) found a negative correlation between the use of lecture capture and performance.

In a review article, O'Callaghan et al. (2017) claimed that even though existing research suggests a number of benefits of lecture capture, there is not yet clear support from empirical research. They claimed that since students perceive lecture capture positively and no clear negative effects of lecture capture have been found, the use of this technology is overall positive. However, this view is not supported by Edwards and Clinton (2018); they argue that the net effect of video lecture is generally negative and that it is a pitfall to rely too heavily on lecture capture as a substitute for lecture attendance.

## Comments to Previous Research

While previous research agrees that students are overall positive about having access to lecture capture, there are contradictory findings regarding the effect of lecture capture on attendance and grades. An important reason for this may be the different methodological approaches to measuring the effect of lecture capture. Many of these studies base their conclusions on surveys where students report their attitudes toward lecture capture. The findings from previous studies generally show that students want access to lecture recordings. When the surveys also ask whether lecture capture affects their physical attendance in lectures, there may be a reason to believe that the answers provided by the students are influenced by a desire to focus on the positive effects on lecture capture and downplay the negative effects. This may also explain why students and lecturers have different views on this, and that students' self-report of attendance must be viewed from a critical point of view (Chester et al., 2011; Karnad, 2013). Similarly, the same bias may apply to students' reporting that lecture capture strengthens their chances of getting good grades, for which there are no clear findings when real grades are measured. Consequently, to draw conclusions regarding attendance and exam results, the research design must account for the bias of self-reporting.

Although the existing research is extensive, the mixed results indicate a need for more knowledge regarding how lecture capture affects teaching and learning. Furthermore, previous studies are mainly based on quantitative studies with surveys that measure attitudes, attendance, and grades, which may indicate a cognitive perspective. Consequently, there is a need for more research that applies different theoretical and methodological approaches to gain deeper insights into this topic.

## Method

To gain knowledge about how the introduction of lecture capture technology affects learning, the authors took a closer look at a specific case where experiences of lecture capture were made over a number of years. The case in study is Molde University College (MUC), which is a small university in Norway. Following a wave of mergers in Norwegian higher education, this institution is one of very few small university colleges left. MUC has programs at bachelor's, master's, and doctoral levels within logistics, health care, economics, social science, administration, sport management, and IT. MUC has approximately 2500 students and 200 employees. The digitalization of education has been viewed as an important measure to compete in a market with many large institutions. The case study uses mixed methods based on primary and secondary data.

The secondary data encompasses previous studies and surveys carried out among students and employees. These studies include two surveys conducted in 2016 (unpublished note, Gutterberg & Straume, 2016), as well as two student assignments at the bachelor's and master's levels (Vågen, 2015; Midtbø, 2018). The studies address attitude toward lecture capture among students and staff by using both quantitative and qualitative approaches. The student survey covered two bachelor courses in economics and administration and had 198 respondents. The survey among lecturers covered 61 lecturers.

The primary data were collected using a qualitative methodology, and consist of a document study, conversation with lecturers, students and staff, lecture captures in four courses, and a video recording of a meeting with employees and some students where the introduction of lecture capture at MUC was discussed (Waagbø, 2016a). The document study consists of internal documents and newspaper articles concerning lecture capture at the institution. The documents, interviews, and recordings of meetings were investigated to find the reasons for implementing lecture capture technology at this institution, how it was implemented, and the attitudes of management, teachers, and students.

Lecture capture in four courses, selected from the bachelor's and master's programs in logistics, was investigated. The purpose of studying these lectures was to investigate what students who watch lectures online observe and to investigate how recording lectures affected the learning situation of those present in the lecture room. This research design does not allow for any causality to be established between the use of video and educational methods (i.e., the lecturers may have acted in the same way without video recording). The aim, however, is to investigate the possibilities and limitations that lecture capture provides given the way MUC has chosen to implement the technology. To do this, the authors first examined the teaching context, or the physical environment (i.e., layout) and the use of physical aids. To examine the social learning dimension, the authors emphasized studying the communication between lecturers and students who were present in the lectures. The authors primarily studied speech but also examined eye contact, movement, and the extent of each aspect. Finally, while watching the videos, the authors noted how engaged the students were in class.

## Findings

### The Introduction of Lecture Capture at MUC

MUC's open course platform, HiMoldeX, was established in January 2013 and was inspired by massive open online courses (MOOCs). The platform was primarily designed to post lecture recordings online to increase access to lectures (Skuseth, 2013). This was initially an initiative from an entrepreneurial teacher at the university. He started recording his lectures and recruited other lecturers to have as many courses as possible available on the platform. However, not all teachers accepted this invitation for various (individual) reasons. The implementation took place without any discussion among the lecturers or prior reflections on how this could potentially change the premises for learning, knowledge, and teaching.

Later, HiMoldeX was embraced by management and seen as an important strategic measure to meet national expectations in the higher education sector regarding increased digitalization (Kristoffersen, 2018a), and the board of the college adopted a goal of increasing the proportion of courses recorded on video (Waagbø, 2015b). This can also be seen in the light of a strategy to increase the number of students at MUC (Waagbø, 2018) in the wake of the development toward larger units in higher education. According to the college's management, the use of lecture recordings represents a very good opportunity for a small institution to increase the number of students without any expense to learning (Waagbø, 2016c).

HiMoldeX established its own website, which had a maximum of approximately 100 courses available. However, for the 2018–19 academic year, there were 22 active courses for autumn of 2018 and 19 for the spring of 2019 (a total of 41). In the first years of HiMoldeX, most courses were open to everyone, but today most courses are only available to students who registered for the courses. One of the reasons for this is the new privacy regulations (GDPR). Most of the videos posted are recordings of campus-based lectures where viewers can see the lecturer in the lecture room, while presentations from programs such as PowerPoint are displayed in a separate window. All lecture recordings are automatically posted on HiMoldeX a few hours after the lecture has ended. MUC's IT department set up a large screen that shows ongoing recordings in all lecture rooms. Here, employees in the IT department can detect any technical issues and alert the lecturer if there are any problems. However, there is no continuous monitoring, which means that much of the responsibility rests on the lecturers. The lecture captures were primarily intended to be offered to students who do not have the opportunity to physically attend lectures or as an aid in self-study.

### Student Attitudes

The student survey found that 84 percent of the students believed their learning outcomes were greatly improved by watching lecture captures published on HiMoldeX (Waagbø, 2016b). Only one percent strongly agreed that there was less academic benefit from lectures recorded on video. Seventy-nine percent agreed with the statement, "I wish lecture capture was offered in all courses at HiMolde." The wish was even sometimes expressed as a request from the students (Waagbø, 2016b). This became apparent in a staff meeting where some students were present; one student claimed: "That is what the discussion should be about: Not how to improve learning, but whether we should use more video, and the students want more videos. The arguments against video are, in my opinion, completely irrelevant." This requirement from the students created pressure toward the institution and the lecturers. This was an important reason for the board's decision to increase lecture captures (Waagbø, 2015b).

The interviews conducted in a master's thesis (Midtbø, 2018) supported the positive attitudes toward lecture capture found. The students interviewed believed that recording and publishing the lectures (video) was positive for their learning. In particular, the students highlighted the opportunity to repeat the curriculum, the possibility to adjust the speed of the lecture, and that they could follow the teaching in the way that best suited them, regardless of time and place.

### Lecturer Attitudes

Based on the lecturers' survey and interviews, there seemed to be two camps, one of which was positive/indifferent about the extensive use of lecture capture and the other that was skeptical. The positive lecturers considered it an advantage that students had the ability to watch the lectures when they were not able to be present in class. Moreover, these lecturers acknowledged the value of using the recordings for repetition and preparing for exams. The reluctant lecturers were mainly concerned about reduced attendance and that this technology led to less activity among the students who were present in class. In general, the lecturers seemed uncertain about the learning effect of lecture capture. Many lecturers were afraid that student contact would be reduced if lecture capture was used as an alternative to lectures (Midtbø, 2018). In the lecturer survey, 95 percent of the lecturers thought that students watching lectures online could not replace the experience of being physically present in class (Gutterberg & Straume, 2016). Half of those using lecture captures expressed that it had negatively affected student participation (called the HiMoldeX effect). All teachers (both those who use lecture capture and those who do not) were uncertain about the educational benefits that the technology provided. Nineteen of those who did not use lecture capture in their teaching believed that their courses did not fit in the lecture capture format.

In the above-mentioned staff meeting (2016), the founder of HiMoldeX did not see many drawbacks with lecture capture, except for the fact that the students using the recordings were not able to ask questions, which he argued was accommodated for by using Facebook groups and other communication channels. In the meeting, one of the professors expressed concern:

> I wonder that one discusses a specific method used in teaching without talking about learning and learning goals, and the views and thoughts one has about how students learn. It is completely absurd to only come up with a teaching method.

However, the basic attitude at that time was positive, and considered the technology an opportunity to attract new students: "There are two markets: On-campus and off-campus students. I believe that one does not come at the expense of the other". In two later chronicles, the rector emphasized the need for a digital strategy to create more competent students and teachers (Kristoffersen, 2018b) and claimed that the effect of lecture capture was more positive than negative (Kristoffersen, 2018a).

In the last couple of years, the attitude toward lecture capture from the teachers' side has become increasingly negative, especially after a large Norwegian university decided to, by default, not use video lectures. This created an informal discussion where several complained about reduced attendance and student engagement. Even the initiator of lecture capture had to admit that there were challenges associated with the technology, especially when it came to reduced attendance.

## Attendance

In the student survey, 18 percent of students in one course reported that they did not attend lectures and only watched lecture captures later. In the same course, however, 79 percent disagreed with the claim that they had less contact with other students when using lecture captures. In the bachelor's thesis, four lecturers and five students were interviewed, and students were observed in lectures in two different subjects over a period of three weeks (Vågen, 2015). The findings in the study indicated a drop in lecture attendance, which can be illustrated with the quote: "HiMoldeX has made it easier for students to sit at home" (Vågen, 2015, p. 18). Students further stated that the disadvantage of HiMoldeX was that "one does not get the same contact with the lecturer as if one had been in class" (Vågen, 2015, p. 20).

These findings were confirmed later by a master's thesis at MUC (Midtbø, 2018). All respondents expressed that attendance in lectures with lecture capture was lower than in courses without video recordings, "After all, it's the first question that comes up in the first class, 'Is this recorded?' Many students just get up and leave after the first hour, because they want to watch the recording" (Midtbø, 2018, p. 44). The same study interviewed five lecturers, all of whom used lecture capture in their teaching. Three had used lecture capture, and two of them believed that this has led to reduced attendance. One lecturer suggested a reduction in attendance from 50 to 30 percent. Some lecturers reported that reduced attendance affected their motivation.

## What is Captured?

To address the effect lecture capture has on learning, the authors investigated how the technology is used. What is it that the students behind the computer observe, and how does the recording affect the situation in the auditorium or lecture room? To investigate this, three (out of 13) courses at HiMoldeX that were taught at the bachelor's and master's programs in logistics in 2018 were selected. The courses had lecturers with varying experiences (e.g., professors and Ph.D. students). All courses used Canvas as a learning platform, where information, lecture notes, and other resources were published. In total, 18 hours were observed from the lecture captures (4.5 hours per course).

Three of the courses were taught in relatively small rooms with similar size and layout, while one course took place in a large auditorium with room for up to 152 students. In all lecture rooms, the cameras had a limited view angle, which meant that students were out of the camera's field of view, and the lecturer disappeared out of the picture if they moved too far away from the blackboard. This was especially the case in the large auditorium. The lecturer had very limited space to move as the camera was placed very close to the lecturer. The viewer of the recording could see the lecturer, the blackboard, and a canvas for a PowerPoint presentation; the presentation was shown in a window on the computer screen. Viewers could switch between having the PowerPoint presentation and the video recording as a large or small screen. In one of the courses, it was difficult to see one part of the blackboard.

The lecturers had different styles when it came to having contact with the students, but it was apparent that recording lectures created some limitations regarding student interaction. One limitation was physical movement, where the camera's field of view limited the space in which the lecturer could move. One of the lecturers seemed not to care so much about this, with the result that he quite often disappeared out of the camera's field of view. Another important limitation concerned communication between the lecturer and the students. Dialogue with the students worked poorly for the viewers of the recordings, as the lecturers needed to repeat the question from the student as the lecturer was the only person who had a microphone. As soon as there was dialogue, it was difficult for the viewer to understand what was going on. One respondent (IT department) said that the teachers were told to stay within the view angle of the camera and to repeat questions from students before answering. It is worth mentioning that two of the lecturers had no communication nor eye contact with students in these lectures.

### How is Learning Affected?

In the studies presented in the theory chapter, learning was mainly operationalized as an improvement in grades (perceived and actual) as a result of the introduction of lecture capture. In this study, no controlled experiments have been conducted on the change in grades before and after the introduction of lecture capture. However, in the student survey, 75 percent of respondents believed that the availability of lecture capture had a positive effect on their grades (42 percent believed it had a very positive effect). However, there is not necessarily a relationship between student perceptions and their actual grades.

Learning is a complex phenomenon that can be studied from different theoretical perspectives. The two main perspectives presented (i.e., the cognitive and the socio-cultural perspectives of learning) need to be introduced into the analysis to understand the implications of the findings in this case study.

The findings from previous studies and from this case study show that students are generally very positive about having access to lecture captures. The arguments made by the students seem to be associated with a cognitive perspective on learning, where individual self-studies are considered the most important for learning. The emphasis was on watching the lectures whenever, wherever, and however it suits students; using the recordings for repetition and exam preparation illustrates this perspective. Here, learning is mainly disconnected from the context and from participation in a community. Yet, students' attitudes could have a positive effect on learning, which should not be undervalued. Institutions in higher education are competing for students, which means that these positive attitudes also become an argument for the strategic decisions made by these institutions for introducing this technology, which was also illustrated in this case study.

The case study indicates that lecture capture leads to increased absences. From a cognitive perspective on learning, this may not represent a problem as long as the lecture capture is of high quality and gives a good representation of the teaching in the auditorium. However, as the analyzed recordings show, this was not the case, especially when the lecturer moved outside the camera's screen and was talking to the students present in the classroom (which the viewer of the recording could not follow). In light of the rather low quality of the recordings, it is a paradox that the students still want more of these.

From a sociocultural perspective on learning, the reduced attendance represents a problem, even if measures are taken to improve the quality. Primarily for the students who are not present in the class, becoming a part of a community of practice, or have the opportunity to share knowledge with fellow students and the lecturer. However, even for students who are present in the lecture room, the reduction in attendance has implications for the conditions for sociocultural learning. This is illustrated by a quote from one of the lecturers: “In my courses, lecture capture has resulted in the disappearance of social learning.” Likewise, the reaction from one of the lecturers at the staff meeting illustrates a different understanding of learning from that of the students and management. This lecturer wanted to discuss learning and learning goals, while the students in this meeting did not find this relevant and were mainly interested in having more lecture capture. The students claimed that they were “experts on their own learning,” indicating an individual view on learning.

The survey among the lecturers also reflected challenges associated with social learning, where half of the lecturers believed that lecture capture affected student participation. There may be several reasons for this belief. One is that the students are afraid of being recorded, and another is that students and the lecturer change their behavior when the lectures are recorded. The analysis of the lecture recordings may indicate that lecture capture may affect the contact between the lecturer and the students since the system limits physical movement as well as discussions with the students.

Consequently, the reduced attendance may lead to a different lecture dynamic for those left in the lecture room and reduced opportunity for interaction. Findings from the interview also indicate that reduced attendance affects the lecturer’s self-esteem and motivation, which may further impair the quality of teaching. Hence, and from a social perspective on learning, lecture capture may also have a negative impact on the learning conditions for the students present in the lecture room.

## Conclusion

The aim of this study was to increase knowledge about how the introduction and use of lecture capture affect student learning. The literature shows that students welcome this, while lecturers are more reluctant. Furthermore, previous research shows mixed results regarding attendance and learning outcomes when operationalized as students’ perceptions of learning outcomes or exam results. However, previous studies have primarily been surveys measuring students’ perceptions and when and how they use this technology in practice. Less emphasis has been on how lecture capture affects the learning situation and the sociocultural aspects of learning. The findings from the MUC case shed light on the contested space between the attitudes of students and lecturers and the possible consequences of implementing lecture capture.

Students’ positive attitudes toward lecture capture are dominated by arguments such as having the opportunity to see the lecture when and where it suits them and that they can rehearse and play at their own pace. This indicates a primarily cognitive perspective on learning. The arguments from management are rooted in the same perspective, combined with economic and market logic.

The findings of the present study show that introducing video lectures can lead to reduced attendance and that the video format can work toward active learning, even for those who attended lectures. This means that lecture capture conflicts with a sociocultural and situational perspective on learning, where the development of learning communities for learning is key (Lave & Wenger, 1991). Instead, an individual-based perspective seems to be the basis for introducing video lectures, where the student is regarded as an individual consumer that the institutions must adapt to in order to be competitive in an increasingly market-based sector. An alternative approach could be to focus on the societal goals of education and then shape the curriculum, student activities, and facilitation of students' social lives based on that. Technology will undoubtedly play a key role in achieving these goals, but more knowledge is needed on how to combine digital technologies with social learning.

Since this case study was conducted, MUC, like other institutions around the world, has experienced dramatic changes due to the COVID-19 outbreak in 2020. The university in this study was closed, and all teaching had to be done using digital solutions like lecture capture or digital video conference programs like Zoom, Adobe Connect, or Teams. While it is too early to conclude how this affected students' learning, early findings from other institutions show that students want to return to learning with a physical presence. In a study carried out at Agder University in Norway, the students expressed that the conditions for learning have been somewhat worse during this period (Christiansen & Eskedal, 2020). This concerns the opportunities to make relevant experiences and seeing the structure and coherence of the studies. Furthermore, they experienced fewer opportunities to get the attention of lecturers, participation, professional interaction, and social contact. This illustrates the value of creating a social arena of learning, supporting the findings in this study.

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# 5 PASS and the Introduction of Technology at an Irish Higher education Institution

*Aoife Walsh*

*Abstract:* This chapter examines the origins and evolution of the peer-assisted student support (PASS) leadership program introduced at an Irish higher education institution over a decade ago. The functions and operations of the program are explored. In particular, the chapter focuses on the various technologies introduced in PASS training and how they are transferred into practice.

## Introduction

"If we teach today's students as we taught yesterday's, we rob them of tomorrow" (Dewey, 1915, p. 167). Although this quote is over 100 years old, with technological advances, it is more applicable today than ever before. Teaching should continually adapt to meet the changing needs of students and new technology. This chapter demonstrates the myriad advantages that technology can bring to SI/PASS/PAL. The objective is to show how technology has been used to enhance the PASS program from training into practice and beyond. The Athlone Institute of Technology (AIT), formerly known as Athlone Regional Technical College (ARTC), was founded in 1970. Peer-assisted student support (PASS) has been operating at AIT for over a decade. Since its inception, the PASS Program has evolved by implementing innovative technologies based on sound pedagogical knowledge.

## An Irish PASS Programme

### History of PASS at AIT

PASS was first piloted at AIT in October 2009. It commenced as a collaborative project with the Galway-Mayo Institute of Technology (GMIT). AIT and GMIT jointly launched PASS in an effort to support first-year students in their transition to higher education. Their pilot was based on the PAL program developed by Bournemouth University (BU) in the UK. AIT extended the project for a number of years with funding from the Dormant Accounts Initiative. The program was introduced to the college by the Learning and Teaching Unit and now operates from the Student Resource Center (as an Access Initiative). PASS aims to help first-year students:

- adjust quickly to higher education,
- acquire a clear view of course direction and expectations,
- develop their independent learning and study skills to meet the requirements of higher education,

- enhance their understanding of the subject matter of their program through collaborative group discussion,
- prepare better for assessed work and examinations.

### The PASS Leadership Module

PASS leadership is an optional module that students can apply for and complete during the second year of their studies. Training takes place over two days and includes role-plays, simulated sessions, IT, library and counseling sessions, interactive activities, and modeling to prepare students to be a PASS leader. Training is composed of eight worksheets that are completed using various techniques such as think-pair-share, "know, want to know, learned" (KWL), Venn diagrams, and jigsaw.

As part of their practice, leaders complete a journal containing session plans and review forms, attendance sheets, information related to running PASS sessions, and college-specific information to enable leaders them to perform their role. In addition to this journal, each leader receives an A5 hardback manual. Leaders add to the journal from the start of training, throughout practice, and conclude with a 1,000-word reflection. The manual contains over 100 pages of additional reading with topics such as facilitating groups, managing group discussions, good study habits, taking notes, time management, presentations, essay writing, and referencing. The manual is consultative in that it helps leaders construct their sessions and structure student learning. Moreover, the journal is constantly updated and is submitted at the end of the year.

PASS leaders volunteer roughly 2.5 hours per week during the semester to plan, facilitate, and review PASS sessions. They prepare weekly plans, take attendance, review sessions, and debrief with the PASS coordinator to discuss problems or gain fresh ideas. PASS leaders facilitate the first two sessions unsupervised and are encouraged to attend debriefs during that period. Their third session is supervised, and leaders subsequently attend midterm training to help them to reflect on their learning progress up to that point. Leaders typically facilitate six to ten sessions during their first semester.

There is some formative assessment during this period: an observation and a self-assessment. There is one high stake summative assessment—a portfolio of work—that is submitted at the beginning of their second semester. Leaders are encouraged to attend a group session held in an IT lab to help them prepare their portfolio. Students who do not complete the portfolio receive no marks and, therefore, no credits. All of these elements are assessed, and the leader can gain five ECTS credits in addition to their academic course credits. The PASS program has developed a module descriptor that includes learning outcomes and assessment strategies and is examined by an external expert to ensure academic integrity.

Classroom assessment techniques (CATs) are used in training by facilitators and PASS leaders during their sessions. The CATs employed by the PASS program are utilized via different media (e.g., post-it notes, raising of hands, or classroom response systems). During PASS training, many CATs are carried out at the end of activities; others like KWL can be revisited at different points during training to reassess understanding after further dissemination of information. CATs cannot be discussed without mentioning Angelo and Cross (1993), whose seminal handbook defined them as practices that show teachers what information was learned and how well students acquired it. CATs provide feedback (usually anonymous) on student learning to improve the quality of classes (Angelo & Cross, 1993). Further, CATs were introduced into PASS training for a number of reasons: to assess student learning and identify areas of misunderstanding, to evaluate changes to aspects of training, and to model the use of CATs for leaders. PASS leaders are encouraged to use CATs in their sessions with first-year students to help them reflect on the effectiveness of sessions, assess student learning, and empower them in their role.

Anonymity is important in CATs because it allows students to give feedback about difficulties, gives shy or anxious students a voice, shows that the lecturer cares about what the student has learned and increase student motivation, helps students feel involved in the learning process, and it encourages them to reflect on what they learned (Kelly, 2005). Anonymity is vital, especially for PASS leaders who are often working with shy and nervous first-year students who are not used to speaking up during class.

## Program Changes and the Introduction of Technology

The student perspective of technology in higher education is that it enhances learning but cannot replace teachers (O'Donnell, 2010). This is echoed by Couros (2014), who states that technology is simply a tool: "it will never replace teachers, but in the hands of great teachers, it's transformational". Gradually, PASS training has been transformed from being traditional, stale, and monotonous to current, continuously evolving, and exciting; it uses tools and technology, including instructional technologies, screencasts, audio feedback, and a website. These transformations were slowly introduced as facilitators noticed an energy dip at different points in the training and began to research alternatives to make it more exciting. While the introduction of technology began with training, these changes were introduced organically into practice as students emulated the technology and introduced their own during sessions. Additionally, there was a need to find an easier, more collaborative tool to share resources.

After examining the learning outcomes for the module, some changes to the assessment breakdown were proposed to empower students to complete the journal submission. Black and William (1998) state that giving students feedback without grades (i.e., formative assessment) can result in more learning. Gibbs (2015) states that "the most powerful way to improve feedback would be a significant shift from summative to formative feedback" (p. 2). This has been implemented at the University of Oxford; receiving feedback is about ten times as frequent as the allocation of marks, which are usually only received at the end of the module "after all the learning from feedback has taken place" (Gibbs, 2015, p. 2). Butler (1988, as cited in Nicol and Macfarlane-Dick, 2006) argues that feedback-only enhances students' interest in learning and allows them to focus on improving their work, thereby promoting positive motivation and self-esteem. Therefore, the addition of formative assessment should enhance both student motivation and completion rates. All of this evidence culminated in introducing supplementary formative assessment to the PASS program.

**Training**

Instructional technologies such as Padlet, Kahoot, and Mentimeter were gradually introduced into training with great success. Facilitators can use Padlet to gain feedback, anonymous if required, to any question posed. Users simply click on the link and click anywhere on the screen to type their answers (depending on how it is set up). Founded in 2012, Kahoot is a game-based educational web-app that allows users to set up multiple-choice questions. Mentimeter can be used to create live polls, quizzes, and word clouds. These three technologies allow for real-time feedback from students with answers displayed on the screen. Incidentally, Kahoot was first encountered during a PASS session that was being observed by the PASS coordinator. These instructional technologies or classroom response systems allow students to submit anonymous responses to questions and enable facilitators to collate and analyze data quickly (Bruff, 2009). One of the advantages of identifying where students' difficulties lie is that facilitators can adapt their lesson plans or structure a discussion in response to the points raised (Bruff, 2009).

In previous training sessions, when KWL was used, the facilitators had no insight into students' difficulties or areas of misunderstanding. Introducing Padlet made the activity more interactive and prompted discussion. In addition, Padlet can be returned to periodically during training to identify new areas of confusion and learning among students. A boundaries worksheet that was monotonous and laborious was given a new lease of life with Kahoot. These classroom response systems are innovative, provide variety and immediate feedback, and improve student engagement (JISC, 2010). For each of these activities, students used their phones and wireless technology to contribute their responses to pre-set questions.

Other technologies introduced into training were Google forms and audio feedback. Google forms replaced the final worksheet. This was innovative as the results were displayed live on the whiteboard as students completed the survey on their phones. Students are given audio and written feedback after training. Lunt and Curran (2010) noted that the provision of auditory feedback enhances student learning; that is, students can listen to the feedback as often as they want and wherever they choose (Lunt & Curran, 2010; Hennessey & Forrester, 2014). The PASS leader manual was reformatted as a website to reduce costs and provide an easy-to-access tool.

One of the most innovative introductions was a virtual learning environment (VLE) or course management system (CMS). Moodle™ is an online open-source system CMS used in AIT (Moodle, 2017). It allows staff to create effective collaborative online private learning experiences for students (Moodle, 2017). The PASS leader Moodle page has many functions, including reinforcing training, choosing debriefing times, planning sessions, submitting session plans and reviews, sharing resources, and submitting their portfolios.

VLEs take a constructivist approach to education; students integrate their current knowledge with new information to build a framework of ideas (Surgenor, 2010). For students, the increased availability of technology allows them to access information more easily and at any time (O'Donnell, 2010). VLEs should provide interactive, audio, and visual formats as well as static text to appeal to different learning preferences and allow students to personalize their learning experience (European Commission, 2014). Providing notes, screencasts, additional readings, and interactive resources via Moodle in multiple media will, therefore, benefit the student population. This has been reiterated by Garrison and Vaughan (2008), who state that "both face-to-face and online learning are made better by the presence of each other" (p. 52).

PASS leaders go on to use the aforementioned classroom response systems to help them to evaluate first years' learning and plan subsequent sessions. They set up Moodle pages or Facebook groups to communicate and share resources with their first-year group between sessions. Once sessions have concluded, they complete an evaluation on Survey Monkey to help them reflect on their time and identify any skills they may have enhanced through the program. Their completed journals are submitted through Turnitin® on Moodle. As mentioned, leaders can populate a Moodle page for their first-year students. PASS Training includes an hour-long IT session. During this session, students have access to their Moodle page and are guided through completing tasks using a worksheet.

As training occurs a couple of weeks before their first PASS session, students are provided with a screencast explaining how to edit and populate PASS leader Moodle pages. A screencast is a video recording of the computer screen, including an audio explanation (Patton, 2015). Screencasts allow students to watch videos at their own pace, receive direct instruction at their convenience (Simon, 2019), watch as often as they want, and refer back to earlier sections for help (Scott, 2011). This allowed them to access the information covered in the IT session with the hope of encouraging them to use their Moodle page. In the 2018–19 academic year, seven of the 17 PASS sessions had some information on Moodle (roughly 40%). After the introduction of the screencast, this number jumped to 90%. The quality and quantity of the information on these Moodle pages also increased, with leaders posting a variety of resources from links and labels to word documents and PDFs. This information is collated every year and added to the PASS website.

## Practice

Due to the move to online submissions and the increase in leader numbers, a number of technological changes were introduced. Session plan and review forms are now submitted through Moodle. This took a few years to perfect as different formats such as databases were trialed. Exemplars from previous years are made available to students before they submit their first entry. Exemplars are beneficial because they define standards that students can compare themselves to (Nicol & Macfarlane-Dick, 2006). Through the use of peer feedback and exemplars, students should be encouraged to feedforward to the final journal. Leaders submit their first plans as an assignment and receive written feedback, including a shaded rubric, before their first session occurs. The steady rise in leader numbers also led to developing debrief sessions (instead of drop-ins). Leaders use the choice feature in Moodle or the poll feature on Facebook to indicate their preferred day and time. It is hoped that they will then use these tools to ask for ideas from first-year students.

Midterm training has been identified as a critical feedback moment. O'Donovan (2010, as cited in O'Donovan, Rust, & Price, 2015) defines this as a challenging time when additional resources are required to enhance learning. This has been acknowledged as an opportunity to assist with journal submission. Midterm training is held after students have completed two sessions and have been observed during their third session. Immediately after the observation, leaders are asked to complete a self-assessment, which is the same observation feedback form as the markers complete. At the beginning of midterm training, students complete another self-evaluation. Midterm training was moved to an IT lab to encourage students to complete some of the work for their journal at this stage. The leader journals are assessed by annotating the uploaded documents, including overall audio feedback (i.e., technology-enabled written feedback).

## Reflection

Tab. 1: PASS leadership module completion rates since 2009

| | Completed Journal | PASS Leaders | % Completed Module |
|---|---|---|---|
| 2019/20 | | 18 | |
| 2018/19 | 20 | 22 | 91% |
| 2017/18 | 12 | 23 | 52% |
| 2016/17 | 24 | 33 | 73% |
| 2015/16 | 22 | 23 | 96% |
| 2014/15 | 20 | 23 | 87% |
| 2013/14 | 30 | 31 | 97% |
| 2012/13 | 21 | 26 | 81% |
| 2011/12 | 13 | 30 | 43% |
| 2010/11 | 12 | 23 | 52% |
| 2009/10 | N/A | 20 | N/A |
| 2009 | N/A | 7 | N/A |

The move from paper to online submissions initially resulted in a decrease in submissions. Over the years, the PASS assessment strategy was continuously evaluated and redesigned. In 2018, there was some concern noted over the completion rates of the PASS leadership module. In 2017–18, only half of the PASS leaders completed the module. This figure has been decreasing from a high of 97% in 2013–14 when all but one student completed the module. Table 1 contains the completion rates for PASS since the module was introduced in 2010–11.

### The Future

It is vital to adapt and capitalize on technology changes in education. With the unfolding situation (COVID-19) and the move, however temporary, to online learning, technology will be more important than ever. Equally, face-to-face peer support will need to be replaced by an online alternative (AHEAD, 2020). PASS sessions, with a little tweaking, will seamlessly fill this void. The plan at AIT is to introduce the flipped classroom technique and possibly reduce the two-day training to two half-days using a mixture of synchronous, asynchronous, and in-person activities. Flipping a classroom involves the acquisition of information before class, followed by an in-class activity that enables students to synthesize the learning material (Brame, 2013). Students could be asked to watch videos and read additional material in advance of the training, leaving the synchronous time for valuable discussion and questions. PASS sessions will move online. Now that the reliance on technology has increased, role-plays and simulated sessions need to be adapted to the online environment. These online interactive activities and modeling will be more important than ever in preparing leaders for PASS sessions and the real world as it exists today.

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# 6 Driving Simulators in Teaching and Learning: A Qualitative Study

*Gunhild B. Sætren, Jonas R. Vaag, Pål A. Pedersen, Toril F. Birkeland, Thor O. Holmquist, Catharina Lindheim, Martin Rasmussen Skogstad*

*Abstract:* Different learning styles require different teaching methods, and using simulators as learning tools can be an important contribution to driver instruction. Road traffic is a highly complex and high-risk environment. For this reason, driver training is an important factor in providing road safety. Educating professional driving instructors is an important contribution to increased road safety and fewer dead and injured in road traffic. This study explored how simulator training in driver education could be beneficial by investigating authorized driver instructors as well as driving students' perceptions after testing the simulator. The research question was: Which factors influence perception and use of driving simulators in teaching and learning driving skills? For this study, 28 individual semi-structured interviews were conducted with driving instructors and students in three rounds over a period of one year. Thematic analysis was used for analyzing the data. Perceived transferability (main category) is important when teaching and learning driving skills through the use of a simulator. The transferability depends on two underlying factors (categories) that influence the perception and use of the simulator: a technological focus or a pedagogical focus. While holding a mainly technological focus, the simulator is viewed as a tool or pedagogical multimedium that provides learning by itself. On the other hand, a pedagogical focus sees the simulator as a tool that should be used in a larger pedagogical context. The authors found that increased experience using the simulator made the instructors and students shift from a technological focus to a more pedagogical focus. A driving simulator can be beneficial for learning and teaching the complexity of driving, from technical maneuvering to strategic decision making, but for the instructor to effectively use a simulator for teaching, there needs to be a sense of perceived transferability for the instructor. As increased use of the simulator seems to shift the instructor focus from a more technological to a pedagogical focus, experience with and use of the simulator as a pedagogical tool should be implemented in the educational program for driving instructors.

## Introduction

Simulation-based education can provide safe and effective learning environments (Ziv et al., 2003). However, simulators are seldomly used in driving instructor and driver training education in Norway (Sætren et al., 2018). Road traffic is a complex system in a potentially hazardous environment where human error can cause injury and death. The risks of this environment include elements such as drivers' risk perception, technical maneuvering of the car, other drivers' behaviors, weather conditions, lighting, and road structure. Driving, therefore, requires a specific set of technical and non-technical skills, optimal decision making, and precise behavior, all of which are important factors in driver training. It is essential for driving instructors to use optimal learning tools to provide optimal learning outcomes.

Even though Norway's driver training is extensive, it could significantly benefit from studying the training experiences of other high-risk industries. For the past decade, driver training has been rather stable in how it is conducted and in the technology that is used for training purposes in Norway. In other high-risk industries, simulator for training is extensive, such as in aviation (Salas et al., 1998), nuclear (Bye et al., 2011), and medicine, including nursing (McGaghie et al., 2010; Verkuyl et al., 2020). In the surgical field, for example, a typical stress intervention training consists of didactic learning, simulation-based exercises, and individualized and specific feedback on technical and non-technical aspects of performance (Sonal et al., 2016). In Norwegian driver training, however, the use of simulators is rare, and it is estimated that between five and ten driving schools out of Norway's existing 1,056 (NPRA, 2020) have a simulator (Sætren et al., 2018).

Research from the past ten years focuses on learning driving skills using a simulator has included a health perspective for conditions such as stroke, sleep deprivation, motoric challenges, and age (McKay et al., 2011; Sawula et al., 2018), transferability to real-life driving (Gemou, 2013), or training related to dark or eco-driving (Jamson et al., 2015; Sætren et al., 2019b). However, there have been few studies about using driving simulators for standard learner driving (Sætren et al., 2019b), and there is a conspicuous gap from pedagogical, driving instructor, and student perspectives. Moreover, there is limited knowledge about which factors influence the perception and use of such simulators.

Thus, the research question is: Which factors influence perceptions and use of driving simulators in teaching and learning driving skills?

The chapter focuses on teaching and learning driving skills with a driving simulator, as viewed by experienced instructors and students learning to become driver instructors. First, the authors present simulation-based education in driver training and experiential learning theory, and then they present the technology acceptance model. After that, they introduce the pedagogical theoretical framework of driver training, driver instructor education, and pedagogy in Norway. They then present the methods, results, discussion, and conclusion.

This study is a part of a four-year project exploring if and how driving simulators can improve driving instructor education and driver training, which is called the SitT-project (Simulation in Driver Education; Sætren et al., 2018, 2019a, 2019b, 2020a).

## Simulation-Based Education in Driver Training

Driver training has traditionally relied on the apprenticeship model, which is when practitioners train with a learning driver in real-life traffic. Although this hands-on learning provides valuable experience, simulation-based learning allows for a safe learning context and an opportunity to gain basic knowledge prior to entering a high-risk context. Simulation-based education is not easy or intuitive, and the educational context is of great importance. As medicine has a long tradition of using simulators in an educational setting, this chapter provides a critical review of twelve general features and best practices (McGaghie et al., 2010) that are most likely to be generally applicable to simulation-based education. These twelve factors are feedback on performance, deliberate practice, curriculum integration, outcome measurement, simulation fidelity, skills acquisition and maintenance, mastery learning, transfer to practice, team training, high-stakes testing, instructor training, and educational and professional contexts.

There are benefits and challenges regarding the use of simulators in driver training (Sætren et al., 2018). The advantages of simulator driver training include repeatability, reproducibility, and standardization of training programs. This includes access to different scenarios that would be unethical to train in or difficult to encounter during training, such as accident scenarios and dangerous contexts, darkness and difficult weather conditions, and extreme traffic density. The ability to make errors in a safe environment makes simulator training a much different learning context than real-life traffic. More general advantages include cost-effectiveness and environmentally friendly training (de Winter et al., 2012; Hirsch & Bellavance, 2016; Sætren et al., 2018).

However, challenges are important to consider as well; these can include a variety of driving simulators with varying degrees of fidelity in curricula-based training programs and simulator sickness, which is increasingly common for people over the age of 30. Nausea and discomfort will negatively affect training outcomes (de Winter et al., 2012).

## Experiential Learning and Simulation as a Pedagogical Method

Simulation as a pedagogical methodology is based on the premise that hands-on experience plays a central role in learning; its use in different sectors, such as the healthcare sector (Jeffries, 2005), draws on theories of experiential learning (Kolb, 1984, 2014), situated learning (Lave & Wenger, 1991), and social learning theory (Bandura & Walters, 1977).

Kolb (1984, 2014) has stated that knowledge is created by grasping and transforming experience. Experiential learning theory is based on the idea that learning is a process in which knowledge is created through the interaction between a person and the environment. In Kolb's learning cycle, knowledge is created and re-created through concrete experience, reflective observation, abstract conceptualization, and active experimentation. When using a driving simulator, the learner is given a chance to participate in a new experience (concrete experience), during which the learner can reflect on these experiences (reflective observation), develop a new conceptual understanding of the importance of specific behaviors and skills (abstract conceptualization), and actively experiment with what was learned in future practice (active experimentation). With the use of a driving simulator, the process of active experimentation may result in the desire to test different behaviors and skills, generating a new cycle of learning while acting in a safe environment.

## Technology Acceptance Model

To explore common perceptions regarding new technology and actual use, the technology acceptance model (TAM) is valid and robust (Davies, 1989; King & He, 2006; Venkatesh et al., 2003). This psychological model is based on the theory of reasoned action (Fishbein & Ajzen, 1975) and was designed to explain a user's intention to actually use new technological equipment. The assumption of the model is that an individual's reaction to technological use will affect the intention and, thus, the actual use of the technology. In other words, the user experience will influence the user's perception of the technology. The TAM consists of two primary predictors: ease of use and perceived usefulness. In addition, behavioral intention is the dependent variable. The idea is that if a technology is perceived as useful, it probably will be used, even though the user must spend time learning how to operate the technology. On the other hand, a system that is easy to use and easy to learn might not be used if the end-user does not perceive it as useful (Davies, 1989; Venkatesh et al., 2003).

## The Pedagogical Theoretical Framework of Driver Training in Norway

In the 1980s and 1990s, the main focus of driver training in Norway was completing a sufficient number of training hours, primarily in technical maneuvering. One of the most comprehensive revisions of the Norwegian driver trainer model was undertaken by the NPRS in 1998; they recommended creating training in terms of the actual behavioral and learning objectives from the curricula rather than simply number of hours trained. Curricula were revised to focus on reflections and understanding concepts such as risk and development of the learners' risk perceptions. This was a turning point from a more objectivistic view of training, in which elements such as the numbers of hours and technical handling of the vehicle were essential to a more constructivist and social constructivist paradigm (Sætren et al., 2019b). Thus the focus shifts from the lower levels of learning to also include higher learning levels according to Bloom's taxonomy. This taxonomy consists of six levels of learning: basic remembering through understanding, applying, analyzing, evaluating, and creating. These six steps represent a continuum of increasing cognitive complexity and span from concrete knowledge to abstract knowledge (Anderson et al., 2000), which is a continuum that coincides with the Norwegian driver training curricula.

This view of driver training – that reflection and understanding are more important than technical skills – is the basis of all further curricula developments. Thus, the curricula focus more on the learners' learning objectives and self-reflection and on the process of learning for the student driver, all to achieve the safest drivers possible. The focus is to teach student drivers to make safe decisions while driving, rather than merely ensuring optimal handling of the vehicle. Driving education students learn to adapt different pedagogical tools for individual training and reflection for different student drivers (NPRA, 2017).

This shift of focus from a more positivistic to a more constructivist view in Norwegian driver training was also a result of the development of the European Goals for Driver Education (GDE) matrix (Hatakka et al., 2002). The GDE matrix is the foundation of most European driver training, although the actual driver training system has developed differently from country to country. In Norway, this has resulted in an extensive four-level driver training system (e.g., NPRA, 2017; Sætren et al., 2020b).

The progressive Norwegian driver training system consists of four levels, and it is recommended that students take two years starting at 16 years of age. Level one is a basic theoretical introductory course. This consists of 17 forty-minute lectures with subjects ranging from risk perception and the road traffic system to first aid and dark driving. No practical driving is conducted by the student driver at this first stage. Level two considers the technical skills necessary for mastering the vehicle. At this stage, the objective is not to be attentive to other road users but rather learning to maneuver the car (e.g., braking, gearing). This level does not have a set number of hours; instead, the driving instructor and the learner decide when the student driver has sufficient skills to enter the next level. This is determined through a mandatory level assessment lecture, during which the student driver reflects on their behavior and understanding with the driving instructor. Level three is aimed at the student driver's skills in different road and traffic environments and understanding legal requirements. At the end of this level, the student driver should be very close to driving and be ready to pass the practical driving test. In level four, the aim is for the student driver to have an in-depth understanding of risk perception and be aware of their limitations as a driver. Thus, at this level, a safety course is mandatory. The curricula also state that mandatory training alone is not sufficient to obtain a class B driver's license. Rather, it is expected that the student driver will have sufficient training at a driving school as well as at home with an experienced driver (NPRA, 2017).

In Norway, it is legal and recommended for experienced drivers to provide student drivers with extra practice. This is usually conducted with parents; the official requirements are that the person learning to drive has completed the theoretical introductory course and that the experienced driver has held a driver's license continuously for a minimum of five years without penalties or endorsements (FOR, 2017).

## Norwegian Driver Instructor Education and Pedagogy

Norway has the only driving instructor education program that includes a two-year university education to be authorized as a driver instructor in the world. During those two years, traffic pedagogy, road traffic law, and traffic psychology are taught in addition to physics and technology (Nord University, 2020). Two universities offer this education; however, because Nord University educates approximately 100 instructors each year and OsloMet only about 10–15, the chapter focuses on Nord University's education. This university is home to Norway's largest driving school, with approximately 100 student drivers at any given time. At Nord University, driving pedagogy is largely affected by practice, which is an integrated part of future instructors' education. The students function as the instructors of the driving school and are guided by praxis lecturers. The students are organized in groups of six to seven students, with a praxis lecturer who has overall responsibility for both the students' and their driving students' progress. This system, called guided praxis, is implemented during a student's first month and persists throughout the two-year education (Nord University, 2020). The guided praxis is integrated with the theoretical approach, and the education includes theory praxis, which emphasizes learning and teaching operational, tactical, and strategic driving skills (Michon, 1985; Peräaho et al., 2003). Until 2019, the student instructors at Nord university only used real-life cars as tools to teach their regular student drivers.

Driving instructor education consists of different approaches, including lectures for up to 100 students, seminars for smaller groups, guided praxis groups, problem-based learning for smaller groups, and individual reflection. Supplemental instruction is offered for physics and road traffic law. Thus, the pedagogy consists of varied methods for individual and group learning (Nord University, 2020).

## Methodology

A qualitative approach using semi-structured interviews was used to collect data (Kvale, 1997). Interviews were conducted with driving instructor students and with driving instructors who had experience using simulators in driver training in Norway. This study is part of a four-year project about using driving simulators in driver training in Norway. This study was the first initiative for exploring the potential use of driving simulators in driver training with a driving instructor present. The methodology was chosen to explore a theme that was not widespread.

## Participants and Procedures

Three rounds of interviews were conducted with 28 participants. The first round was with five driving instructors in Norway who had used simulators in driver training for some time (Sætren et al., 2019a). The interviews were conducted face-to-face at driving instructors' workplaces and were situated in different parts of Norway (Kvale, 1997). The second round was with driving instructor students who had tried the simulator on their own and in groups prior to their praxis. All first-year students received a lecture in advance with guided instructions on how to use it and which programs they were expected to test. After this round, six interviews were conducted. The third round was after the students used the simulator in their teaching (approximately six months after the second round). Here, two students from each praxis group received lectures about how to use and what lesson to teach in the simulator. The groups selected which two students were to participate in this. The lesson and instruction resembled how this would be conducted prior to lessons in cars. The interviews in this round were conducted immediately following the lesson to ensure participants were providing their private opinions without discussing the experience of teaching, as both the student pedagogical observer and the student who had the role as the instructor for each group were interviewed. In all, 38 students completed the simulator instruction, and seventeen instructor students were interviewed in the third round, fourteen males and three females. All interviews lasted about one hour, and they were recorded and transcribed. Participation was voluntary and based on informed consent.

Tab. 1: Overview of the groups of informants and number of interviews.

| | Informants | | |
|---|---|---|---|
| Round 1 | 5 experienced instructors | | |
| Round 2 | | 6 students trying on their own | |
| Round 3 | | | 17 students using simulator to teach |

## Equipment

The simulators were basic driving simulators with a driver's seat, steering wheel, pedals, and three screens. The instructor sat in a chair beside the learner, and the pedagogical observer sat in a chair behind them. The software was designed for Norwegian driver curricula, mainly based on level two but also formatted in some respects for level three. All interviews were conducted with people who had prior experience with the same type of software and the same type of simulator.

Fig. 1: An example of a simulator used in this study.

## Analysis

Thematic analysis (Braun & Clarke, 2006) was used for this dataset, and Nvivo12 (NVivo12, 2020) was used to categorize the data. Thematic analysis is a theoretically flexible approach to analyzing qualitative data. The six steps developed by Braun and Clarke (2006) are familiarizing the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. The authors wanted to explore factors related to learning and teaching when using simulators for driver training. Thus, each interview was conducted by the researchers, transcribed, and read through prior to being coded in as many themes as found relevant to the issue. Then, the themes within and between interviews were compared and coded. Even though there was an interview guide, the codes were not necessarily the same as the topics in the guide. The main focus for analysis was to explore how the informants viewed the simulator as a tool for teaching and how they perceived their learners' learning outcomes. Additionally, the instructor students' perspectives were of particular importance, as they allowed insight into their views while in a learning process themselves as they learned how to use the simulator as a tool. Thus, the analysis was data-driven rather than theory-driven and had an inductive perspective.

After the first round of analysis, there were many coded categories and sub-categories. However, for the second round of analysis, it became clear which categories would be developed into broader and more abstract themes. One example was that it became evident that the informants held different views concerning whether the simulator was regarded as useful. Thus, perceived transferability emerged. It became clear that some informants saw this as a useful tool, and some did not, and the main difference between the informants was interpreted to be in this theme regarding teaching and learning with a driving simulator. From there, the themes of pedagogical and technological focus emerged from the data as the analysis progressed. A thorough explanation of the themes is in the results section.

## Validity

Validity is assessing the quality of research. There are many different approaches for establishing the validity of qualitative research (e.g., Elliott et al., 1999; Kvale, 1997; Yardley, 2000). Yardley's (2000) four principles for assessing validity together with Elliot et al.'s (1999) seven guidelines for qualitative research form the basic methods for assessing the quality of the current research. Yardley's (2000) four principles are sensitivity to context, commitment and rigor, transparency and coherence, and impact and importance. Elliot et al. (1999) refer to seven guidelines shared by both qualitative and quantitative research as well as an additional seven guidelines pertinent to qualitative research. The seven guidelines directly related to qualitative research are owning one's perspective, situating the sample, grounding in examples, providing credibility checks, coherence, accomplishing general versus specific research tasks, and resonating with readers.

Yardley's first principle is sensitivity to context, which is similar to owning one's perspective and situating the sample guidelines from Elliot et al. As an example, this relates to specifying the theoretical orientation, social context of the participants, as well as personal anticipations, values, and interest of the authors, which helps the reader interpret the data. Thus, a theoretical background of the research is provided for the reader. Additionally, a sociocultural explanation of the program and pedagogical context of the education being explored is provided.

Yardley's second principle, rigor and commitment, involves explaining the authors' engagement in the research context, their methodological skills, how the data collection was conducted, and the process of the analysis. In terms of data collection, analysis, reporting in accordance to rigor and coherence (Yardley, 2000), grounding in examples, and providing coherence according to Elliot et al. (1999), the authors explained how the data collection was conducted and in what settings, as well as how the analysis was conducted. In addition, they also have quotations explaining the categories to ensure the categories are grounded in the data as a credibility check.

Yardley's third principle, transparency and coherence, relates to clarity in the explanations, which is similar to resonating with the reader and coherence by Elliot et al. (1999) and involves having a fit between theory and method. Based on the above validity elements, this research has transparency and consistency regarding the research question, literature, and methods. Further, findings are presented in a coherent way using the structures of the findings to map the interactions between the categories, which Elliott et al. (1999) stress as important. The discussion was based on the research question and related to the findings of the study as well as the literature presented in the theory section and introduction for coherence. The fourth and last principle of Yardley, impact and importance, is presented later in this chapter.

## Ethics

This project was approved by the Norwegian Centre for Research Data (NSD) prior to collecting data. This was to ensure that the research was in accordance with privacy guidelines and regulations. Identification and confidentiality were ensured through various methods, including restricting access to the recordings and de-identifying the transcriptions. The transcripts were not available to anyone but the researchers. Furthermore, all participation was voluntary and based on informed consent.

## Results

The main data category found was *perceived transferability*, which reflected whether the participants found the simulator useful for the purposes of teaching and learning driving skills. This category was affected by whether the informants held a *technical focus* or a *pedagogy focus*, which were the two subcategories. Regarding perceived transferability, this category reflects whether the instructors and instructor students perceived the simulator as a tool that would be useful for effectively transferring knowledge from the simulator to real-life driving.

## Technology Focus

Those who held more negative perceptions toward using the simulator related their answers to technical aspects, arguing that the simulator experience was not realistic enough, that the software was underdeveloped, or that the graphics were not up to expected standards. The main issue for this group was whether the simulator would replace real cars for instruction. It was interpreted that, for this group, teaching and learning using a real-life car was perceived as optimal and that a simulator could never replace this optimal way of teaching and learning how to drive a car.

> We discussed the simulator experience in the praxis group. Most said it was unrealistic. That it would not replace cars. (Student 1)

Further, another view was related to whether the simulator was to be used with a driver instructor present. An example of this was the differences between the instructor students and the established instructors' perceptions of usefulness regarding vocal instructions in the software. This seems to be based on perceived usefulness in regard to expected use. Instructors with a more technological focus seemed to think that the simulator would be optimal if it could be used without an instructor present and with a voice and text present for the learner. However, many of the instructor students commented that the voice was distracting and hindered their teaching. They did not perceive the usefulness of the simulator to be related to student drivers using the simulator to teach themselves, but rather as a tool where they were present and plan the session for the simulator the same way they would for a car lesson.

> Like in the simulator we use, there is a voice and text that enters the screen. I think that is a little misleading because when we are prepared to teach one thing, and the screen and voice start commenting on something else (this is regarding the same practice on level 2). This can be confusing for the learner… I think it is easier if you do not have software that interferes so much so that you can use your role as an instructor instead. (Student 2)

## Pedagogy Focus

Pursuant to previous results, those who had a more positive experience seemed to have a more pedagogical view of the situation, in the sense that they took a more abstract look at the simulator as a tool. They planned what to do, why, and investigated how the use of the simulator could provide a probable learning process according to the curricula.

> I prepared for the lesson the same way I have done when I teach in a car. Which goals I had for the lesson and the learner's premise and so forth. I wrote down how I thought it would be conducted and tried it out in the simulator on my own prior to the lesson to see how the exercise was built so I could plan it. So, planning the lesson in advance is quite like how I would have done it using a car. (Student 3)

In addition, efficiency and learning environment was mentioned in this regard, as the simulator would make it easier to find specific learning locations, and the learning context was inherently calmer than real-world driving. By gaining easy access to these areas, the instructor would not have to spend time driving around to find a suitable teaching environment, and one could be certain that the exact planned training goal would be one that they could train for. As a learning tool, the simulator allows access to exactly what an instructor has aimed for and prevents any other interruptions.

> It is easier for some training. You have more space. It is easier to find a place to train. Here you have all opportunities. (Student 4)

> One thing that is good is that the learner is much more relaxed in a simulator and can, to a larger degree, focus on things that we might not be able to focus so much on in a real-life car because we have to watch out for so many other things. To focus on one thing in a simulator without it being at the sacrifice of other things is a huge benefit. (Student 3)

The *perceived transferability* changed based on experience, as represented by the arrow from technological focus to pedagogical focus in Figure 2. Even though all informants mentioned that the simulator was easy to use at all stages, the perceived benefit of using it to instruct others depended on how much experience the informant had with the device. From the first round, when the students tried it themselves, more students were preoccupied with the idea that it would not teach learners much. They believed that the simulator could be used for beginners or learner riders who had never experienced sitting in a car. A typical comment was something like:

> If you have a very novice student driver who never drove a car before, it could be okay. You get gearing and clutching and steering. (Student 1)

> The goal is probably to have a start-up of learning. I think it could work with gearing and clutching. (Student 5)

During the second round, more informants saw that it was beneficial, but many still seemed to think it would not be very beneficial for levels above the one they were in now. Thus, it seems that by using the simulator, students' focus may shift from a technological focus to a more pedagogical focus.

> I had low expectations. I did not think it would be useful after I had tried it out myself because I found it unrealistic. But when I experienced my student driver try it, I saw that it was useful for her. I think she got a lot from it. (Student 6)

> If I had a simulator, I would probably use it at the very beginning, like we are now, on level 2. I do not think it is useful for level 3 and 4. (Student 5)

However, instructors who had more experience reflected on how the simulator could be used for levels three and four as well.

> Perhaps even more in level 3 with the tactical driving. Things you cannot create in real-life training, you can show the student driver in a simulator. How you react in different situations. (Driver instructor 1)

The shift in perceived transferability for the students is interpreted as closely connected to the students' experience, and thus their learning process on how to use the simulator as a tool.

## Discussion

Simulators are not commonly used in Norwegian driver training, although simulation-based education has several benefits in other industries. In this study, the research question was: Which factors influence perception and use of driving simulators in teaching and learning driving skills? For instructors and instructor students, the perception and use of a simulator depend on the perceived transferability from the simulator to a real-life setting, and that this depends on whether the focus is more

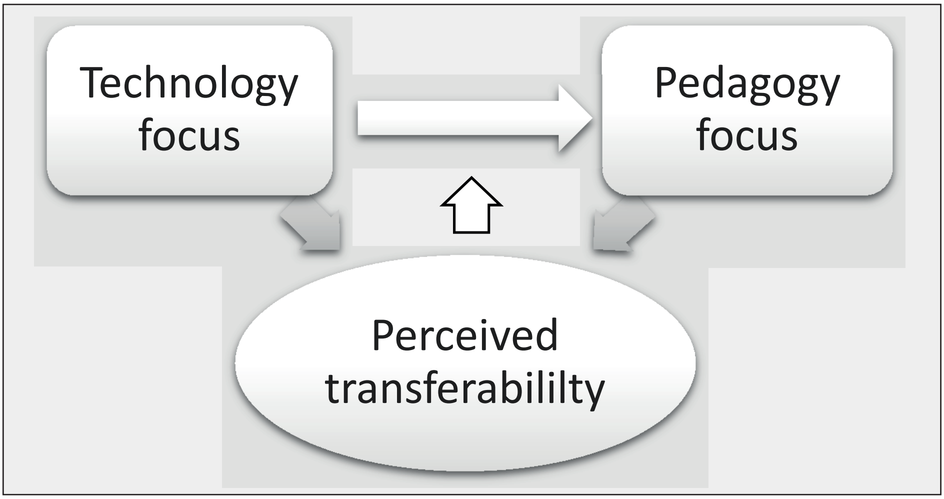


Fig. 2: Categories of the perception of usefulness of a driving simulator.

technological or more pedagogical. Another important point is that experience shifts the focus from a more technological to a more pedagogical perspective. These results, based on the previously presented literature and a model created from the findings, are discussed (see Figure 2).

## Use of Driving Simulator for Teaching

The main category, perceived transferability, is conceptually closely connected to the category of perceived usability in the technology acceptance model and depends on whether the perceived transferability is more of a pedagogical or technological nature. This is related to what kind of usability the instructor expects. On the one hand, if the usefulness is closely connected to replacing a car directly, it is more likely that the simulator is not regarded as useful. On the other hand, if usefulness is linked to a broader pedagogical view of the technology, it is regarded as useful, and the informants are more positive toward using it in the future. This is according to the theory of technology acceptance, which states that if a person sees the technology as useful, actually using it would be more probable than if a person does not see the technology as useful for solving the tasks the person expects (Davies, 1983; Venkatesh et al., 2003).

In addition, how much experience they have with a simulator plays an important role. As the students experienced the simulator, their positive attitude toward using it as a pedagogical tool increased. However, it seems that they need to experience it to understand the benefits. For instance, while they are teaching at level two, they do not see how it can be beneficial for level 3, and their perception of the simulator's usefulness stops at the level they are at themselves. Further, how to use it includes factors such as whether the instructor should be present and whether to plan for the lesson in advance.

The simulator further provides a calmer teaching environment. As stress level lowers, the learning context becomes more optimal. For learning the skills required in a highly complex, high-risk context, a safe and calm environment would be beneficial for avoiding issues such as cognitive overload. Then, when entering a high-risk road traffic setting, the instructor and the learner will have more capacity to focus on the other elements that are included in a real-life traffic context. This goes for every part of the curricula and every level. For instance, on level two, the simulator could be used to train with gearing and clutching before entering roads with traffic. On level three, a practice such as merging onto high-speed roads could be beneficial to practice on a simulator before entering a real-life scenario for the first time at 80 km/h. The simulator provides the opportunity to focus solely on the selected learning goal prior to entering a complex context. This would be less stressful for the instructor as well as for the learner. Additionally, it is less stressful for the student in an instructor role, who is also in a learning process.

The degree of fidelity is a feature that has a gap in understanding (McGaghie et al. 2010). There is still a question of how much fidelity is enough or too much. According to the results, how the user views the simulator (from a technological or a pedagogical perspective) and their experience with it are factors in this question. If the user, as with the instructor, views this from a technological perspective, the simulator has a lesser chance to be used, as the perceived usefulness will be low (Venkatesh et al., 2003). From this perspective, the simulator industry could benefit from making higher fidelity simulators to reach a broader client segment. However, a higher fidelity simulator would probably further increase the costs of acquiring a simulator as well as taking up more room, and the balance of learning outcome and costs would be important.

For a new tool to be used by educational institutions, educators need to demonstrate results such as improved learning outcomes and road safety. However, these elements are difficult to measure (Kardamanidis et al., 2010). Regarding improved learning outcomes, what is tested in, for instance, dark driving with a multiple-choice test, resembles the lower levels of learning according to Bloom's taxonomy. The basic theoretical foundation of dark driving is found to be learned as well or even slightly better in a simulator than outdoors on a track (Sætren et al., 2019b). This is important learning, but for a simulator to be of extensional use, it should also be important also for higher levels of learning.

## Simulators and the Learning Process

Experiences are catalysts for learning, and actual learning occurs in the debrief and reflection during and after the experience. Thus, educators and learners can reflect together and analyze their performances. A preferred factor in using a simulator for such learning is that it makes standardization possible. Learning to handle complexity while performing tasks is a complicated learning process. To ensure that the learner has the necessary experience, some degree of standardized learning is preferred.

According to Bloom's taxonomy of learning, knowledge and comprehension are the simplest levels of learning. The driving simulator was a great benefit for such levels, both for learning how to gear and steer and for training terminology. However, when learning processes are the main focus, the ability for a learner to apply and analyze knowledge is a better indicator of competence regarding learning (Anderson et al., 2000). Simulation can also allow the learner to move from knowledge to analysis (Zigmont et al., 2011). A simulator can be used for gaining skills with elements that are important in the curricula, such as reflection. Perhaps the instructor's most important task is to guide the learner to reflect on their decisions and behavior to be as safe as possible. Level three is an example of the student driver's ability to reflect on their behavior and provides the ability to test this. In addition, the ability to discuss the complex and dangerous road context in a calm and safe environment is an advantage of the simulator (Chow & Naik, 2008; de Winter et al., 2012; Kolb, 1984; Zigmont et al., 2011).

However, the question of how to view the function from the instructor student's perspective of a simulator is relevant because it relates to learning how to use the simulator for teaching and how they perceive it affects students' learning. The authors found that the informants with mainly a technological focus addressed the quality and absorption in the specific experience the simulator provides. When viewing the simulator as a tool for experience, the quality of the design and content of the simulator was important. On the other hand, in accordance with Kolb's (1984, 2014) learning cycle, those with a pedagogical focus exhibit a more abstract understanding of the function of the simulator as a part of a larger circular learning process. The simulator is not the tool that provides learning, but instead is a part of a simulation process. Students that described that they had prepared before simulation and engaged in reflection, abstract conceptualization, and active experimentation, and brought in aspects of what they wanted to try in the simulation setting (concrete experience). These informants (both instructors and students) holding a pedagogical focus also reported that their learners had a positive learning outcome. They reported that trying it out in a less complex environment was a benefit that allowed them to focus on the task prior to entering a more complex scenario in real-life traffic.

Nevertheless, it is important to note and possibly act on the information given by informants with a technological focus. The technological focus could also be due to the experience not being lifelike enough, which breached the learning cycle and direct focus toward details. In the field of gamification and gamified learning, as well as in traditional multimedia and game design, the aspect of a medium's *immersiveness* is often put forward as an important aspect when providing users with an experience (Jennet et al., 2008). Immersion is the experience of being absorbed in an experience where the world one is exposed to is perceived as real. This element of absorption is often linked to a feeling of flow (Csikszentimihalyi & LeFevre, 1989), in which participation in the process is experienced as more important than completing the task (Nakamura & Csikszentmihalyi, 2014). It is reasonable to imagine that a lack of immersion due to lower fidelity, during which the perception is a lack of realistic and engaging content in the simulator, could, in the context of the experiential learning theory (Kolb, 1984, 2014), breach the learning cycle for those who do not view simulation as a pedagogical process.

This breach in immersiveness could also be due to previous experiences of using media content, where the difference in age group and experience could come into play. Young people are used to technology and videogames, including games involving car driving. In this study, it was the experienced instructors who had gotten rid of the driving simulator that was not positive in this regard. It was not due to safety aspects so much as the practical issues they had experienced. Furthermore, instructor students showed more enthusiasm about using a simulator, which shows a difference in experience. Additionally, guided simulator praxis for students provided an experience that made a shift to a more pedagogical and positive attitude. Thus, experience alone might not be sufficient. Yet, the experience should be based on guided instructions in accordance with the twelve features of McGaghie et al. (2010).

Will the simulator be beneficial for learning? It seems that the perception of whether it will depends on whether one views the world through a technological or pedagogical focus. In addition, experience seems to play a part. When assignments are given to students that include a simulator and reflection, the view seems to change over time. Thus, learning by experiencing is important. The use of a simulator is not intuitive, which coincides with the finding that the self-taught experienced driver instructors were less successful; those educating future driving instructors need to guide students in how to use it and give them an opportunity to practice with it. It is also possible that the ones with a pedagogical focus may have a more self-driven learning process, while the ones with a technological focus could benefit from being facilitated into the sequential parts of the learning cycle.

## Implications and Further Research

The authors argue that using a simulator as a learning tool and for learning to teach others is beneficial. They do not argue that the entire learning process should be conducted in a simulator, but rather for practice, including at higher learning levels, prior to entering a real-life context, to learn during these levels in a safe environment. Including simulators in driver training can provide a calm, safe learning context that is environmentally friendly and without the complexity that would be a distraction for the learner and instructor.

Further, this paper was written during the COVID-19 crisis in 2020. Driving schools are also facing major challenges since they are not allowed to teach in cars because the learner and the instructor would be in too-close proximity to each other. The schools have been closed for weeks and months at this point, as well as the university. A simulator would allow the distance between the instructor and the learner to increase to the mandatory two meters, as the chair for the instructor can be moved further from the learner in the same room. Thus, the use of a simulator has the possibility to benefit the industry for safety regarding infection control in the future. It would also allow the university to continue educating students. Because alternative training methods are beneficial for several reasons, more in-depth research on the use of simulators in driver training is needed.

Examples of topics for further research might be exploring how personality affects learning and teaching using simulators. This research has shown that different perspectives affect perceptions of usefulness, and this might be linked to personality and abstract thinking ability. Further, it would be of interest to explore the views of student drivers. The current research takes on the perspective of the instructor role, but what about the learner's role? Additionally, there is a knowledge gap regarding simulator instructor training to educate, evaluate, and perhaps certify professional simulator educators. For the training to be optimal, the simulator instructor must also be properly skilled. Finally, conducting experiments with quantifiable measures to see if the learning outcome is as good in a simulator as it is in a car, for instance, at level three, would help understand more about the actual learning outcomes for the student driver.

## Conclusion

Simulation-based training allows educators to create experiences that encourage learning in a safe environment. A driving simulator can be beneficial for learning and teaching the complexity of driving on all levels, from technical maneuvering to strategic decision making. The entire learning process should not be conducted in a simulator, but some parts could, for instance, be taught in a simulator prior to entering real-life traffic. To increase the chance of instructors using a simulator for teaching, there needs to be a sense of perceived transferability to real-life settings. This depends on if one sees the pedagogical potential in the use of a simulator in the learning process. Simulation-instructor education and experience using the simulator should be implemented in the educational program for driving instructors.

## Acknowledgment

We are very grateful to the Norwegian Research Council's FINNUT program (grant number 26524) that funded this research.

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# 7 Digital Technologies within the Supply Chain Management Curriculum:

## An Experiential Learning Approach to Understanding Knowledge Co-Creation (An Essay)

*Antonina Tsvetkova, Terje Bach & Bjørn Jæger*

*Abstract:* This study explores how knowledge co-creation in the learning process is affected and facilitated by digital technologies, in particular 3D printing and RFID reading. A qualitative single-case study presents the learning process in class based on a model of intermodal transportation with RFID reading and 3D-printed objects. Data from five semi-structured interviews, questionnaires, situation observations in three experiential labs, and archival materials are interpreted through the experiential learning approach to emphasize the role of 3D printing in learning and knowledge creation. The study reveals how digital technologies transform the learning process to help students develop practical skills in the supply chain management (SCM) field. The active experimentation further shows that the use of 3D printing and RFID reading encourage meaningful communication between students and lecturers and increases students' active engagement in learning and knowledge creation. The findings reveal that the learning process in the digital era becomes transformed into increasingly new forms of integrative knowledge and competence, emphasizing practical and technical skills. It results in a shift from passive to active learning or from a teacher-centered to a student-centered approach to developing students' practical skills for companies' needs when adopting new technology in practice. The study shows the potential of digital technologies for further adoption in SCM and logistics curriculums beyond the so-called STEM disciplines.

More empirical studies applying experiential learning are suggested on how learning from formal education and so-called strategic learning from companies' experience can be integrated into the process of knowledge co-creation based on digital technology.

## Introduction

The co-creation of knowledge has recently gained attention as an educational approach. In contrast to traditional institutionally-driven formal education, this approach can help understand the role of technology in providing educational facilitation (rather than teaching), students' self-efficacy, and practical skill development (García-Peñalvo et al., 2015). As new technology has developed and grown at a rapid pace in practice, the opportunity to shape a more effective education and learning process has also increased. Taking advantage of these advances, however, requires integrating insights between university education and practical experience. Several scholars have called to incorporate practical skills into higher-business education (Datar et al., 2010; Jæger et al., 2015). However, the integration of formal educational processes dominated by curriculum and expertise with companies' demands for new digitalization competencies still present significant organisational and educational challenges (García-Peñalvo et al., 2015).

The literature on education and learning process mostly concentrates on students' engagement (Zhao & Kuh, 2004), students' motivation (Stefanou & Salisbury-Glennon, 2002), students' success, and effectiveness of instruction (Vermeulen & Schmidt, 2008). So, research is still framed by a discourse on the social and experiential nature of learning in pedagogical theories. Several scholars have pointed out that university education has not adequately responded to the need for new competencies, especially regarding how to bridge the knowing-doing gap between theoretical knowledge and practical skills (Jæger et al., 2015).

At the same time, digitalization-related skills like three-dimensional (3D) printing and radio frequency identification (RFID) are not widely taught (Ford & Minshall, 2019), yet, many universities update their curriculums to adapt to the demand for interdisciplinary competencies (Jæger & Rudra, 2013). It is not surprising that the adoption of 3D printing and RFID reading is most mature in university engineering and computer graphics design courses within so-called STEM (science, technology, engineering, and mathematics) disciplines (Ford & Minshall, 2019). In non-STEM subjects like the social sciences, including supply chain management (SCM), logistics, and political science, however, there are only a few documented examples of 3D printing's adoption during in-class teaching (Kostakis et al., 2015; Ford & Minshall, 2019). Further, several scholars have emphasized the role of digital technology in education as a teaching and learning tool to develop students' competence and practical skills, as well as make teachers familiar with 3D printed products (Kostakis et al., 2015; Srivastava & Dey, 2018). However, it seems like there is a lack of understanding of how the learning process in the digital era becomes transformed to help students to develop practical skills, particularly in the SCM field. Moreover, how universities integrate these processes based on practical and technical skills are still underexplored. Thus, this chapter explores how knowledge co-creation in the learning process is affected and facilitated by digital technologies, in particular 3D printing and RFID reading.

Current knowledge of how the learning process changes due to the emergence of new technology is mostly incomplete in the literature, and the primary means of uncovering details of these effects is through laboratory experiments. This study is part of an ongoing research project. This project aims to tentatively examine the extent to which technological capabilities of 3D printing can serve as a means of learning and a way of meaningful communication among master students within the SCM discipline in a Norwegian university to help develop practical skills. Therefore, an active learning approach called experiential learning is applied (Itin, 1999; Kolb & Kolb, 2005).

The next section outlines the field of 3D-printing and knowledge co-creation in the learning process in more detail. The research method follows with a description of the educational scenario, research design, and experiential labs. The fourth section presents the case study. Then, the authors discuss experiential learning outcomes in the following section. The chapter concludes with implications for theory and practice, as well as giving an outline for future research opportunities.

## Literature Review

### 3D Printing in the Learning Process

New digital technologies like 3D printing have a profoundly transformative effect on developing new business models, which increases their competitive advantage. The literature has largely addressed 3D printing as a form of additive manufacturing that builds 3D objects by adding layers of a particular material like plastic or metal to create the final product (Rayna & Striukova, 2016). This technology suggests an entirely different way of traditional subtractive manufacturing, which uses computer numerically controlled machines to identify a product as something that is created by machining operations (e.g., drilling, cutting, milling, boring, or sanding raw materials) into the desired shape (Watson & Taminger, 2018). In contrast, using the principles of additive manufacturing, 3D printers transform digital models of a product into a 3D object by laying down layers using appropriate materials (i.e., the printing process). Various manufacturers already apply 3D printing for prototype production because of its flexibility, cost, and time-saving advantages inherent in the technology.

The first stage of 3D printing involves creating a digital model of the object to be printed. This stage is usually done with 3D modeling software, using dedicated software provided by 3D printing services, or 3D scanners to create a model of an existing object automatically. The second stage includes the decomposition of the 3D model to add the layers that are printed one at a time (Rayna & Striukova, 2016).

The 3D printing platforms have primarily emerged to serve particular needs in business practice rendering low volume production economical and enabling mass-customization (Rayna & Striukova, 2016). While technical advances continue due to the predictive throughput and quality, educational disciplines still seem to inhibit the broader adoption of technology, including 3D printing, in the learning process (Simpson et al., 2017). This has been confirmed by recent literature reviews that have pointed to the increasing use of prototyping technology in curriculums only within engineering and design courses (Ford & Minshall, 2019). In social sciences like SCM and logistics, 3D printing in class has not been largely adopted. It can relate to an issue that it is not possible to let students experiment with real logistics and production systems because the complexity and stochastic nature of these systems are inherently difficult to grasp (Lundin & Marklund, 2008). Although 3D printing has been recognized as potentially transformative for SCM practices due to its ability to create products closer to customers around the world, it has the ability to customize those products in real-time and reduce inventory, shipping costs, and capital expenditures on factories and warehouses (Chen, 2016; Khajavi et al., 2014).

At the same time, several scholars have revealed 3D printing as a supportive technology during teaching to produce objects that aid learning, creating assistive technologies, and supporting outreach activities (Ford & Minshall, 2019; Kostakis et al., 2015). The use of 3D printing raises student engagement and motivation (Carpenter et al., 2016; Cook et al., 2015; Kostakis et al., 2015; Pantazis & Priavolou, 2017), as well as interest in the subject material (Letnikova & Xu, 2017). Further, 3D printing can facilitate the learning process (Berry et al., 2010; Schelly et al., 2015; Srivastava & Dey, 2018) from active student participation and through cross-curriculum student engagement that can help create a sense of empowerment (Schelly et al., 2015). Also, the adoption of 3D printing provides an opportunity to implement new ways of learning, like experiential learning (Blikstein, 2013; Jaksic, 2014; Kostakis et al., 2015; Pantazis & Priavolou, 2017). Adopting 3D printing has revealed the development of students' practical skills through active experimentation with 3D printing as an integrated part of the learning process (Kostakis et al., 2015; Trust & Maloy, 2017; Srivastava & Dey, 2018). The students developed competencies like 3D modeling, creativity, technology literacy, problem-solving, self-directed learning, critical thinking, and perseverance that are in line with practical skills reported as being essential for the companies' demands for new digitalization competencies (Trust & Maloy, 2017).

**Knowledge Co-Creation in the Learning Process**

Creating new knowledge is fundamental to the learning process. Knowledge is created when tacit knowledge transforms into explicit knowledge at the group and organisational level (Nonaka & Takeuchi, 1995). Tacit and explicit knowledge are two possible states of knowledge and should not be considered as two separate types. While tacit knowledge is a set of subjective perceptions and insights that are difficult to express in a semantic and visual way, explicit knowledge is objective, theoretical, rational, and structured to be expressed in a formal and systematic language (Ramirez et al., 2011).

Traditionally, knowledge has been viewed from two theoretical perspectives. The first perspective has focused on the resource-based view where knowledge is seen as a set of strategically essential entities that exist independently of their creators and are context-independent, so the role of individuals and organisations is to apply knowledge. The second perspective is based on social constructivism, which views knowledge as a set of shared beliefs constructed through social interactions and embedded within the social contexts in which knowledge is created, so the role of individuals and organisations is to create knowledge (Berger & Luckmann, 1966; Fong, 2005).

Paavola and Hakkarainen (2005) have identified three approaches to knowledge-creation. Learning can be a process of knowledge acquisition by individual learners (i.e., a monological approach). This acquisition view relies on the idea that knowledge is a property of an individual mind; an individual is a basic unit of knowing and learning (Paavola & Hakkarainen, 2005). According to an alternative dialogical approach, learning is an interactive process of participating in various cultural practices and shared learning activities that shape cognitive activity in many ways, rather than something that happens in individuals' minds. At the same time, a trialogical (i.e., knowledge creation approach) exists, which is when learning is a process of knowledge creation that concentrates on mediated processes where common objects of activity are developed collaboratively (Paavola et al., 2002). The third approach focuses on the way people collaboratively develop mediating artifacts (Paavola & Hakkarainen, 2005).

With the rapid advancement and application of new technologies, like 3D printing, in education, knowledge (co-)creation has increasingly become a new educational approach. Technology plays an essential role in providing a medium of communication, transparent engagement, empowering learner self-organisation, and integration of disparate fragments of experience to enable educational facilitation (rather than teaching), and learner self-efficacy (García-Peñalvo et al., 2015). The availability of specific tools like 3D-printed objects helps teachers and students advance and create knowledge (Paavola & Hakkarainen, 2005).

Kolb (1984) has defined learning in the context of the experiential learning process as "a process whereby knowledge is created through the transformation of experience" (p. 38). Experiential learning or active learning by doing is "a process of constructing knowledge that involves a creative tension among four learning abilities," or experiencing, reflecting, thinking, and acting (McCarthy, 2016, p. 92). Itin (1999) has viewed experiential learning as "the change in an individual that results from reflection on direct experience and results in new abstractions and applications" (p. 92).

In this study, the experiential learning approach was adopted to provide students direct experience using new emerging digital technologies in a business context and, thereby, encourage the process of jointly creating knowledge. Based on learning experience, the process of knowledge creation combines theoretical knowledge with practical skills (Itin, 1999; Kolb & Kolb, 2005). Specifically, it addresses active experimentation in Kolb's model (Kolb & Kolb, 2005). Experiential learning requires that students do not passively acquire knowledge; instead, they are actively involved in the learning process and knowledge creation (McCarthy, 2016). Brickner and Etter (2008) assert that it can promote greater interest in the subject material, increases understanding of course material, enhances intrinsic learning satisfaction, improves communication and critical thinking skills of the students, as well as interpersonal involvement.

In practice, knowledge is usually created through the transformation of experience (McCarthy, 2016). Companies that adopt new digital technologies, like additive manufacturing processes based on 3D printing, are pioneers in the market. They extend their existing practice beyond the scope of their experience (March, 1991). They need to process new experiences and learn from them to reduce the risk of uncertainty and costs, and thereby increase the feasibility of the implementation of new technologies. This is so-called strategic learning is when companies transform information from their past and novel experiences into knowledge (Gupta & Bose, 2019). Also, this knowledge needs to be supported by a fundamental theoretical basis and employee competencies to realize the intended business objectives. According to several researchers (Kuwada, 1998; Thomas et al., 2001), the process of strategic learning involves strategic knowledge acquisition, interpretation, and implementation. Strategic knowledge acquisition enables individuals to gather environmental information to extend their current knowledge through an exploratory process. New knowledge is synthesized in the process of interpretation, and finally, the process of implementation is institutionalizing the strategic knowledge developed earlier (Gupta & Bose, 2019).

The literature on knowledge creation is still quite limited (Fong, 2005). Recognition of this fact has encouraged this study to emphasize the knowledge-creation approach in extending the use of digital technology like 3D printing in education and addressing outcomes for the learning process.

## Method

### Educational Scenario

This study documents the first phase of the ongoing research project that started in January 2020. Specifically, this first phase tentatively examines the technological capabilities of 3D printing as an educational tool in a small sample of students at a Norwegian university to develop practical skills. The research project was inspired by the experience of an instructor at the Norwegian university who previously worked as an engineer designing small electrical appliances using 3D design tools, as well as making prototypes using 3D printing.

Therefore, the authors apply an action research approach based on the experiential learning literature (Itin, 1999; Kolb & Kolb, 2005). The experiential learning environment was achieved by using three labs: the Computer-aided design (CAD) lab for 3D designers, the Radio-frequency identification (RFID) lab for trace and track applications by students in logistics, and the 3D printer lab provided by the industry (usually used by manufacturing engineers). Each of these labs was used by specialists within separate academic and practical fields.

The knowledge co-creation environment was created by letting the students design their objects, attach an RFID tag to the objects to be tracked by tracking software at the lab, and use the 3D printing lab for printing both original objects drawn in the 3D design lab and spare parts upon failure of authentic parts.

Thirty-five students took part in the research project by attending several seminars within a particular course in supply chain visibility with RFID and Internet-of-things (IoT) technologies. The primary learning purpose was to teach students how new digital technologies can be applied to make existing life cycle management processes for a product more efficient and sustainable. To begin, the students studied the concept of 3D design using simplified software and the basics of 3D printing as part of the living experience. The authors took into account that students learn better if they are in charge of their learning processes (Freire, 2005), so they let them explore the project activities themselves within the framework of organized teaching. The students explored the process through trial-and-error to develop a creative way of thinking and create 3D objects.

The learning activities began with an introduction to the concepts of RFID tracking and 3D printing technology through lecture-based classes. Then, students were introduced to an industrial business context in which a new component of a product was needed. The students used 3D design software to design a new component. A model of the new component was stored as a standard stereolithographic file. Further, the students gave the component a unique ID stored in an RFID-tag and linked the ID with the STL-file with the 3D-model. The next learning activity had the students print the component using a 3D printer, fixed the RFID-tag with the unique ID to the component, taking into account the necessity of component's replacement when it is broken. Then, they scanned the RFID-tag to get the ID, used the ID to look up the 3D file with the STL-drawing, and finally printed a new component using the 3D printer. In the last learning activity, the students wrote reports on their artifacts and provided some information on 3D printing technology. Therefore, the learning outcomes were about the development of the students' practical skills using 3D CAD design, RFID, and additive manufacturing, applying 3D printing to support, repair, and remanufacture products.

To sum up, the process of learning and knowledge co-creation used to create and implement the educational scenario was rooted in the qualitative case study research approach. This approach allowed the authors to capture the contextual settings of the experiential learning process. It helped reveal how students developed their knowledge, practical skills, and perception of the way that 3D printing technologies affected communication between the lecturers and students.

### Experiential Labs and Data Collection

The authors used multiple data sources, including five semi-structured face-to-face interviews, questionnaires to students, situation observations, as well as secondary data (i.e., literature review) and archival materials. The interviews were conducted with lecturers, students, and representatives of businesses that adopted 3D printing. The findings were supported by situation observations using three experiential labs that collected action-research data about the learning activities and knowledge co-creation. This allowed the authors to experience the complex relationships between the students, lecturers, and learning processes in class.

### The CAD Design Lab in the High School

The CAD design lab was presented at the Norwegian university. The students used standard 3D-Design software from Tinkercad Online and Microsoft 3D Builder.

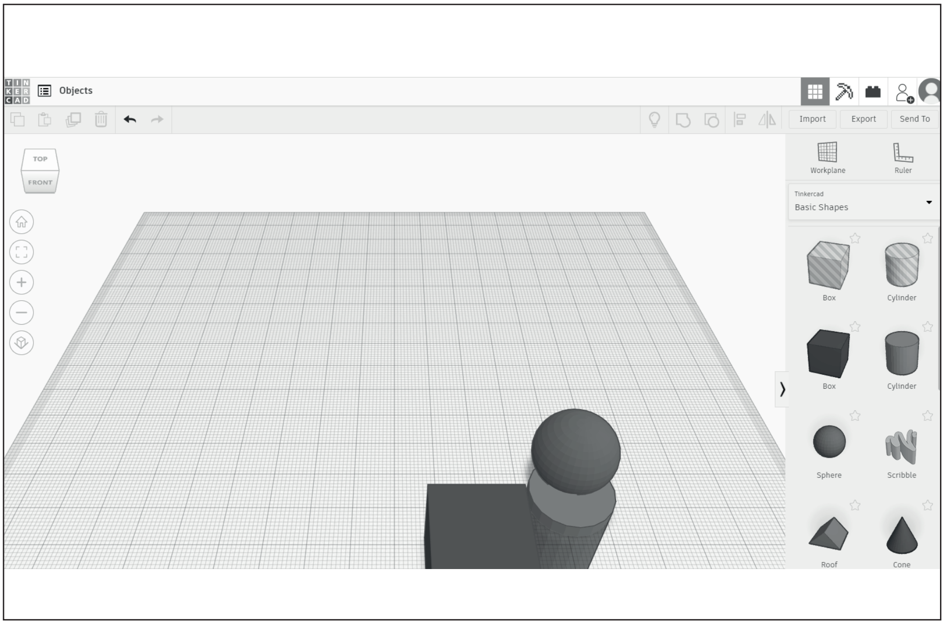


Fig. 1: TinkerCad 3D Design User Interface

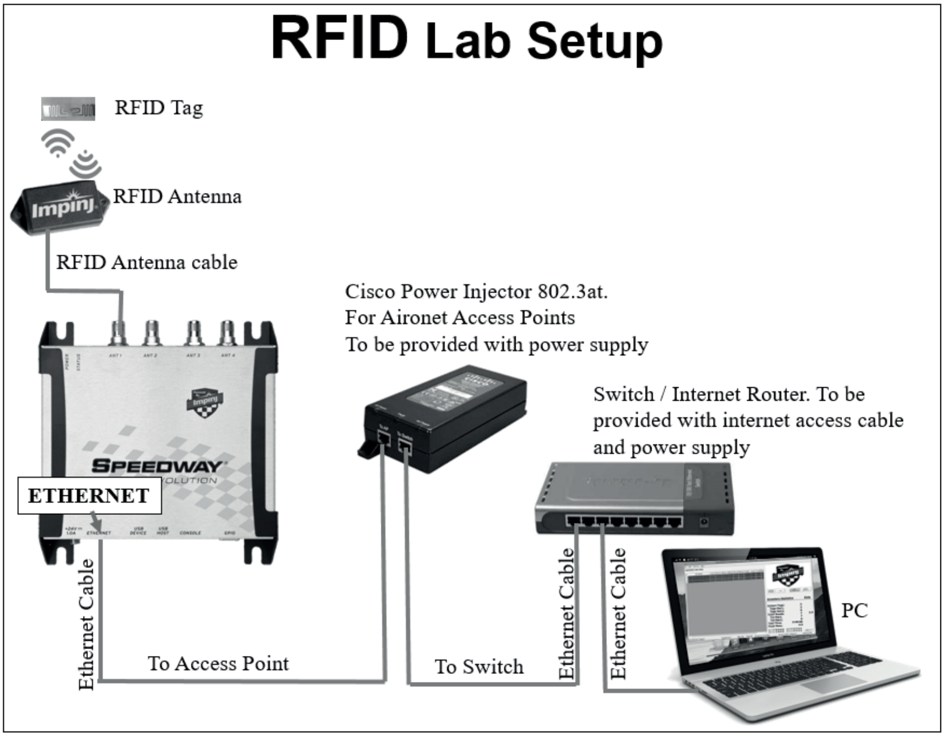


Fig. 2: The RFID Lab Setup

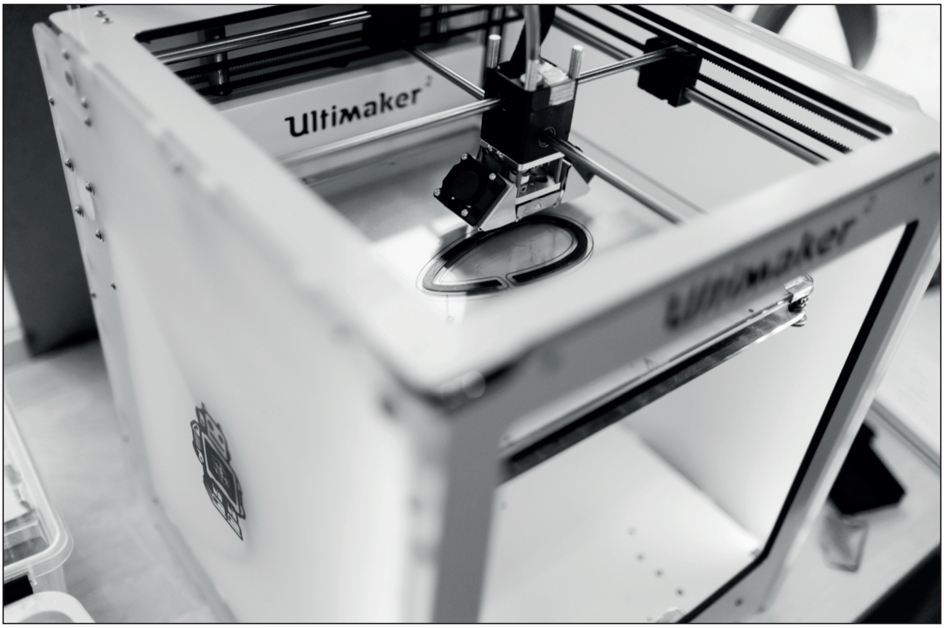


Fig. 3: The UltiMaker 3D Printer at iKuben

**The RFID Lab in the High School**

The RFID-lab consists of RFID tags (one per student), four RFID antennas, and an RFID reader with four antenna ports connected to the computer. The Power Injector is connected to a switch/internet router that is connected to the Internet and a computer with Impinj Multireader Software to display RFID events (see Figure 2).

**The 3D Printing Lab in the High School**

The 3D Printing Lab consists of a 3D printer, virtual reality hardware, software, and other innovation lab facilities. NCE iKuben is a cross-industrial cluster facilitated for fast and continuous business development, with a particular focus on digitalization, sustainability, and new business models for the Norwegian industry. The students used the 3D printer to print objects designed in the CAD design lab. RFID tags were attached to the 3D printed objects.

An action research approach was used. One lab provided by the industry (3D printing lab) was combined with a 3D industrial software design lab and an RFID lab at the university.

**Data and 3D Printed Product Analysis**

Upon completion of the Product Lifecycle Scenario using three labs, the students handed in their 3D-printed objects with a report. In the report, they presented their results and described how using 3D printed objects would affect the life cycle maintenance of products. The lecturers analyzed the reports, including the 3D models and physical objects created by the 3D printer, and provided feedback to the students.

## Learning by Active Experimentation: Case Presentation

### Container Tracking Using RFID-Reading

The first part of the active experimentation provides the students with competencies on how to track containers with RFID tags during intermodal transportation. The physical part of the lab simulates a simplified real-life distribution chain from a distribution center to a store and consists of small scale models of trucks, containers, and a railway.

The shipping containers are manufactured to customers' specifications, and there are subtle differences between them. They need to be stored and shipped in a way that they can be found quickly and easily to deliver to customers (e.g., the store in this case). So, the containers are equipped with RFID tags with a unique ID. RFID is an automatic identification technology in which information can be stored and remotely retrieved. RFID tags are like "little radio towers or transponders that send out information to a reader" (Robbins et al., 2014). The RFID system includes tags, tag readers, computer servers, and software (see Figure 4).

In the experiential case, four RFID reader antennas are located at different points within the distribution chain and connected to a computer server with RFID reader software. A feature of RFID tags is that they can be read at a distance, even through crates or other packing materials.

Figure 5 illustrates the distribution chain, including three shipments: 1) between the distribution center and the departing railway station by road, 2) between the departing railway station and the arriving railway station by railway, and 3) between the arriving railway station and the store by road. The location information of a sample container was transmitted in real-time to the computer server.

The scenario of the sample container shipment is organized as follows. Initially, the sample container is loaded onto the truck at the distribution center and leaves for its final destination, the store. When the truck crosses the gate, the RFID tag on the container is automatically read. The tag's ID is sent to the computer server of the logistics company, which adds a timestamp before registering the reading in the database. Second, when the truck arrives at the train station, the sample container is scanned again, and the database is updated. The sample container is then loaded onto the train carriage. Third, when the train arrives at the destination train station, the container is again scanned; the database is updated before the container is loaded onto a new truck to be shipped to the store. Finally, when the truck enters the loading ramp at the store, the container is scanned for the last time.

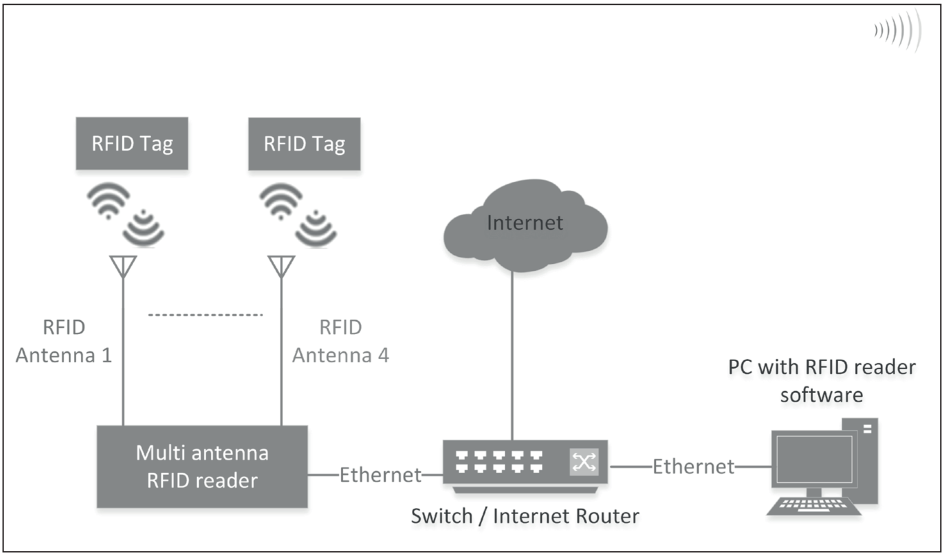


Fig. 4: The RFID System

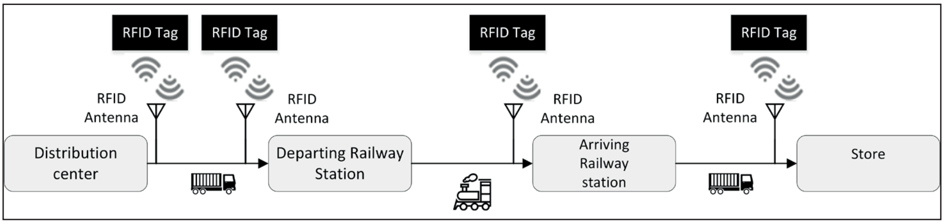


Fig. 5: Distribution Chain

Thus, the database contains four readings, including timestamps from four intermediate locations throughout the distribution chain. The collected information represents the status of the shipment of one specific container. This instance-level information is useful in tracking and monitoring the distribution process of a particular shipment. The RFID container tracking system eliminates the problem of lost containers, avoids delivery mix-ups, and reduces the cost of leasing extra forklifts at busy times (Robbins et al., 2014). As told one of the students involved in this experimentation stated:

> I feel more motivated during this active learning because I understand more how digital technologies like RFID work in real practice. I believe this wonderful experience will be useful for me to find a good job. Also, I think I perceive better how the adoption of new technology makes contemporary supply chains easier when tracking and collecting data during the container shipments and thereby facilitate their operational performance.

As told one of the lecturers involved in this experimentation said:

> Usually, the lecturers have significant theoretical knowledge and practical experience to endow students. However, I feel that our conceptual knowledge is not enough when a novel technology like 3d printing is adopted in the educational system. So, the lecturers act like a mentor rather than a leader during active experimentation in class. I can find a new collaboration between students and lecturers in creating knowledge on the spread of technology in curriculums.

**Replacing a Tracking System's Component with 3D Printing**

The second part of the active experimentation deals with a case when a simple component in the tracking system got damaged and has to be replaced. If the tracking system of the containers works wrong, the shipment of any container from the distribution center to the store faces many issues in performing operations. Operational issues include time wasted in finding the right containers, containers that cannot be found, or incorrect containers delivered to customers. Further, the logistics company and customers would have problems knowing whether the particular container has left the distribution center. Schedules for container movement would be broken, which results in supply chain delays and disruptions.

The logistics company had a discussion on how to, in the future, organize the supply of a specific tracking system component in case of its possible failure. The existing solution of sourcing from external suppliers is faced with several challenges. The logistics company had two alternatives: buy a new component from a supplier or create it using 3D printing technology. They decided to implement 3D printing due to cost and time-saving advantages instead of sourcing from the supplier for this specific component. The students in the active experimentation performed the role of maintenance personnel of the logistics company to realize this decision.

Initially, the students created a 3D model of the component as a 3D object by using 3D-design software. They stored the 3D-model as a standard STL-file. Then, they gave the component a unique ID stored in an RFID-tag and linked the ID with the STL-file with the 3D-model. An RFID tag with the unique ID was then fixed to the existing component, making it ready for replacement by 3D printing in case of component failure. After a few days, the original component in the tracking system experienced failure and had to be replaced.

Then the students scanned the RFID tag of the failed component to get the unique component's ID, which was used to look up the 3D file with the STL-drawing (see Figure 6). Then, the students printed a new component using the 3D printer and fixed an RFID-tag with the correct unique ID to the newly printed component. The 3D printed component was replaced in the tracking system instead of the previous one.

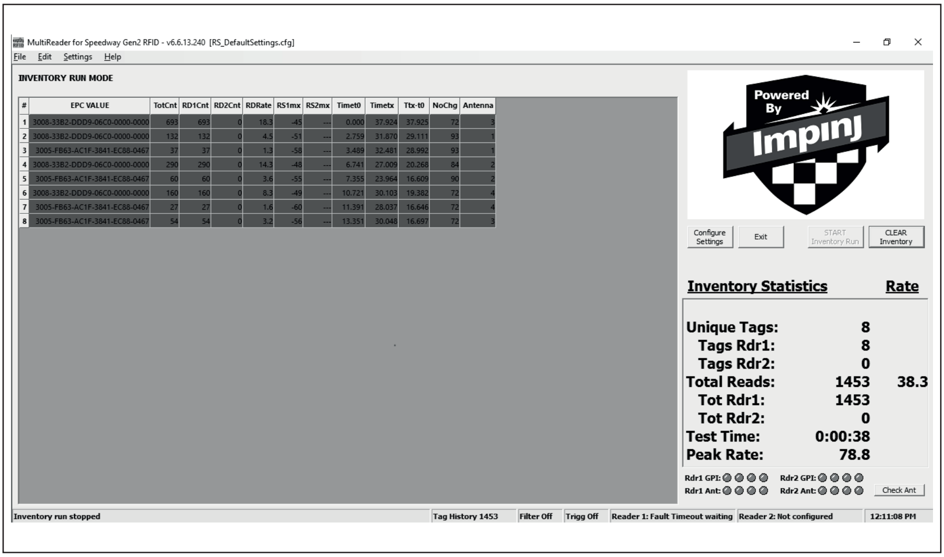


Fig. 6: Reading RFID Real-Time Events

As told by one of the lecturers:

> During this active experimentation, students could perceive how supply chain strategies are implemented in real practice and refer to a particular digital fabrication strategy. This active learning took students outside the class and into the global supply chain environment.

### 3D Printing Components and Results

In total, nine 3D components were designed, and six of them are presented in Figure 7. These components were relatively simple objects because the 3D printing time was a couple of hours per a simple object, and there was only one 3D printer assigned for the case. After a 3D printed object was made, an RFID tag containing the product identifier was attached to the object. All the objects were functional in practice.

As emphasized by one of the lecturers:

> The students successfully printed the components. At the same time, most important was to have them present during the process of 3D printing and discuss the issues of creating 3D objects and attaching an RFID tag with the product ID on the components. Also, it was nice to get the students' initiatives on how to make adjustments to the 3D printing components in real-time.

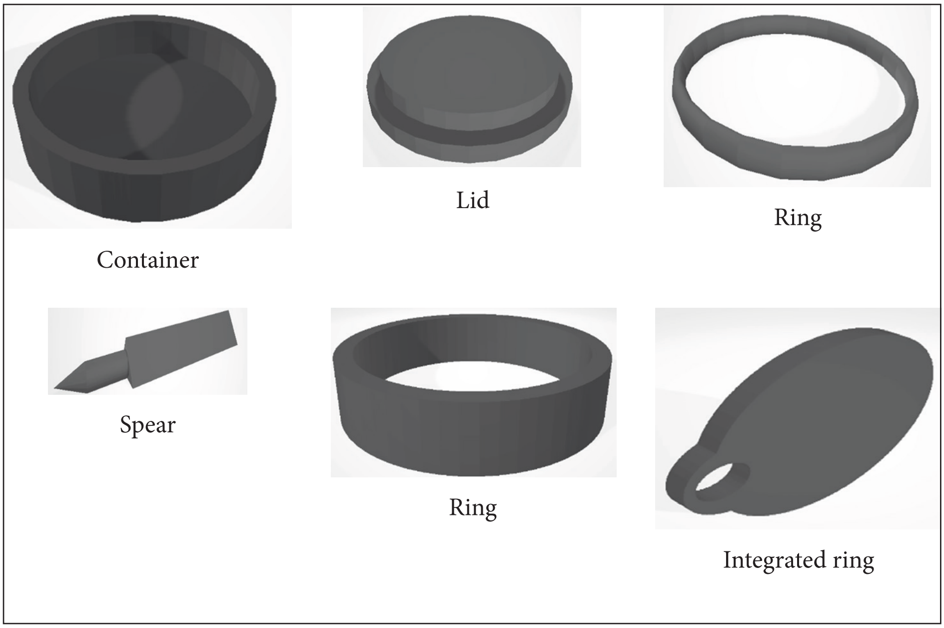


Fig. 7: Student Examples of 3D-Designed Objects

## Conclusion and Implications for Theory and Practice

The active experimentation with digital technologies presented in this study has shown the transformative educational potential for students and lecturers within SCM curriculums. The experiential learning approach has shown that new technologies like 3D printing expand communication and knowledge co-creation in the learning process through the co-creation of 3D design, RFID tags, and 3D printing in a realistic industrial context.

The findings show that laboratory classes enable students to move from the concrete by observing phenomena to the abstract by understanding the theoretical foundations that are derived from the observation of phenomena. Pedagogically, this is important in laboratory classes for co-creating knowledge using digital technologies. At the same time, educational labs and workshops are limited in the range of equipment, experiments, and experiences that businesses need. So, the adoption of digital technology and experiential learning within SCM and logistics curriculums has not been widespread. The active experimentation has, however, identified that the knowledge-creation approach becomes practically relevant when there are available technical tools like RFID tags and 3D printing to achieve lifelong learning outcomes.

The use of digital technologies in the learning process encourages meaningful communication between students and lecturers and increases students' active engagement in learning and knowledge creation. Therefore, the findings revealed that experiential learning facilitates an increased understanding between students and lecturers of newly emerging technologies via workshop participation and active experimentation. This happens as they learn about their environmental, economic, and social effects (e.g., operational management of container shipping and avoiding storing large amounts of inventory that make SCM practices more effective). So, this educational experience shows the potential of digital technologies for further adoption in SCM and logistics curriculums beyond STEM disciplines.

The study reveals that the learning process in the digital era becomes transformed into increasingly new forms of integrative knowledge and competence, emphasizing practical and technical skills. This leads to a shift from passive to active learning or from a teacher-centered to a student-centered approach to developing students' practical skills for companies' needs when adopting new technology.

Further, as companies act as pioneers in the market when adopting new digital technology, the findings will be valuable for managers responsible for the realization of these technological projects. The active learning process through experimentation helps students deal with new digital technologies and helps them develop practical skills. Knowledge creation in active learning (i.e., by doing) processes become more valuable for businesses because it considers the complexity and stochastic nature of SCM practices and logistics operations that do not let students experiment with real supply and distribution chains.

Managers will gain new employees (former students) with special competencies who are able to realize the intended business goals when adopting new projects with digital technologies. This is particularly relevant when extending formal education to the use of companies' experiences in the learning processes in education and practice.

## Limitations and Future Research

The findings are based on a single-case study of the instance-level information from the readings of the RFID tags about the status of one container shipment at a point in time. At the same time, if the same experimentation with data collection about several separate shipments within the same supply and distribution chain is continued, then data can be received at the process-level. The process-level data can be evaluated using statistical tools and quantitative methods to determine the minimum-maximum, average shipment time, and delays in predicting supply chain disruptions. The authors suggest that more investigations on experiential learning at the process-level should be conducted to provide insights into how to overcome complex and stochastic issues in real logistics and supply chains to help students develop practical skills in the SCM field (Lundin & Marklund, 2008).

Further, in this study, knowledge co-creation in the learning process is described in the formal education system. A better understanding is needed of how developing practical skills in 3D printing and RFID reading can occur beyond the formal educational system and how learning from formal education and strategic learning from companies' experiences can be integrated into the process of knowledge co-creation.

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## List of Contributors


Terje Bach (Research Fellow)
Faculty of Logistics, Molde University College, Kristiansund Campus, Kristiansund, Norway

Toril F. Birkeland (Lecturer)
Business School, Nord University, Stjørdal campus, Norway

Erik Bratland (Dosent)
Faculty of Teacher Education, Art and Culture, Nord University, Nesna Campus, Norway

Johan Fredriksson (Project Manager)
Faculty of Engineering, Lund University, Lund, Sweden

Mohamed El Ghami (Professor)
Faculty of Teacher Education, Art and Culture, Nord University, Nesna Campus, Norway

Lise Lillebrygfjeld Halse (Associate Professor)
Molde University College, Molde, Norway

Roger Helde (Senior Lecturer)
Business School, Nord University, Stjørdal campus, Norway

Thor O. Holmquist (Lecturer)
Business School, Nord University, Stjørdal campus, Norway

Bjørn Jæger (Associate Professor)
Molde University College, Molde, Norway

Catharina Lindheim (Researcher)
Norwegian University of Science and Technology (NTNU), Social Research, Trondheim, Norway

Joakim Malm (Associate Professor)
Lund University, Lund, Sweden

Pål Pedersen (Professor)
Business School, Nord University, Bodø campus, Norway

Gunhild Brigitte Sætren (Associate Professor)
Business School, Nord University, Stjørdal campus, Norway

Martin Rasmussen Skogstad (Postdoc.)
Norwegian University of Science and Technology (NTNU), Institute for Psychology, Trondheim, Norway

Abbas Strømmen-Bakhtiar (Professor)
Business School, Nord University, Bodø campus, Norway

Elisabeth Suzen (Associate Professor)
Business School, Nord University, Stjørdal campus, Norway

Antonina Tsvetkova (Associate Professor)
Faculty of Logistics, Molde University College, Molde, Norway

Jonas Vaag (Associate Professor)
Faculty of Nursing and Health Science, Levanger Campus, Nord University

Inger Lise Valstad (Lecturer)
Faculty of Teacher Education, Art and Culture, Nord University, Nesna Campus, Norway

Aoife Walsh (PASS Coordinator)
Athlone Institute of Technology, Athlone, Co Westmeath, Ireland