JYU DISSERTATIONS 2

Mikko Myllymäki

Development and Evaluation Study of a Video-Based Blended Education Model

UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF INFORMATION TECHNOLOGY

JYU DISSERTATIONS 2

Mikko Myllymäki

Development and Evaluation Study of a Video-Based Blended Education Model

Esitetään Jyväskylän yliopiston informaatioteknologian tiedekunnan suostumuksella
julkisesti tarkastettavaksi Kokkolan yliopistokeskus Chydeniuksen Ulappa-salissa
elokuun 24. päivänä 2018 kello 12.

Academic dissertation to be publicly discussed, by permission of
the Faculty of Information Technology of the University of Jyväskylä,
in Kokkola University Consortium Chydenius, Ulappa hall, on August 24, 2018 at 12 o'clock noon.

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2018

Editors
Timo Männikkö
Faculty of Information Technology, University of Jyväskylä
Ville Korkiakangas
Open Science Centre, University of Jyväskylä

Permanent link to this publication: http://urn.fi/URN:ISBN:978-951-39-7496-1

ISBN 978-951-39-7496-1 (PDF)
URN:ISBN:978-951-39-7496-1
ISSN 2489-9003

ABSTRACT

Myllymäki, Mikko
Development and evaluation study of a video-based blended education model
Jyväskylä: University of Jyväskylä, 2018, 110 p. (+included articles)
(JYU Dissertations
ISSN 2489-9003; 2)
ISBN 978-951-39-7496-1 (PDF)
Finnish summary
Diss.

The basis for this dissertation has been the need to create a new education model to be used in master studies in mathematical information technology at Kokkola University Consortium Chydenius. This education model has been created as the result of the design science research. The solution heavily utilizes educational technologies, especially streamed lecture videos and associated practices. The primary goal of the education model has been to make education more accessible by offering students more flexible participation opportunities.
The essential goal of this dissertation is to describe and evaluate the achieved education model. The purpose of evaluating the model was to determine the functionality of the model and its impacts from the viewpoints of the model's various participants, including students, lecturers, and the educational organization. The evaluation is applied to both the functionality of the technological solutions of the education model, as well as the practices formed around these. Evaluation is carried out in various case studies reported in publications that form parts of this dissertation. The introduction section of the dissertation provides a synthesis based on these publications and presents an overall evaluation of the education model.

The evaluation of the education model's functionality was performed by examining its cost efficiency, operational reliability and transparency. According to the results, the education model is highly functional in these respects. The goals set for the education solution with regard to its impacts were also achieved very successfully and were even above expectations. Accessibility was also increased to a highly favorable level. Improvements to accessibility also had positive impacts on learning outcomes. The research results indicate that, from a learning standpoint, studying with videos is at least equally effective as studying via contact teaching. In summary, it can be stated that it is possible to form an education solution based on both contact teaching and the use of videos that is meaningful for students, lecturers and the organizer of education alike.

Keywords: blended learning, video lectures, learning technologies, streaming video, education model

Author

Mikko Myllymäki
Kokkola University Consortium Chydenius
University of Jyväskylä
Finland

Supervisors

Professor Ismo Hakala
Kokkola University Consortium Chydenius
University of Jyväskylä
Finland

Professor Tommi Kärkkäinen
Faculty of Information Technology
University of Jyväskylä
Finland

Reviewers

Professor Petri Nokelainen
Industrial and Information Management
Tampere University of Technology
Finland

Professor Erkki Sutinen
Faculty of Science and Engineering
University of Turku
Finland

Opponent

Professor Jari Multisilta
TUT Game Lab
Tampere University of Technology, Pori
Finland

ACKNOWLEDGEMENTS

When writing this part of the dissertation, I am happy to be at the final stage of my Ph.D. studies. Making this dissertation has been a long process. However, it has taught me a lot. During the research work I have been involved in a number of fine conferences and events, met many inspiring people and managed to create a number of important networks. I am grateful for all the experiences that this dissertation has brought with it.

First and foremost, I would like to thank my first supervisor, Professor Ismo Hakala for giving me a possibility to work for the university. I express my deepest appreciation for his patience, guidance, and support throughout the long thesis process. Our discussions and her feedback have been invaluable. I also would like to thank my second supervisor, Professor Tommi Kärkkäinen, for providing me with support for my dissertation. I would like to express my appreciation to my thesis opponent and reviewers for their valuable opinions and suggestions for this thesis.

I would like to thank the coauthors of the papers related to this work. I am grateful to them for the valuable contribution they have given to those publications. Their work and ideas have been valuable for this thesis. I would also like to thank all other colleagues who has worked with me in research projects.

The Kokkola University Consortium Chydenius has been a good place to start an academic career and gain experience as a researcher. University Consortium has been innovative and supportive working environment and it has provided the good environment for self-development. So thank you for giving me an opportunity to be part of the academic community.

I am also deeply grateful to you, with whom I have had many endless discussions about the thesis and the writing process. I have benefited so much from those conversations with you. Your existence is important to me.

I also want to thank my parents for giving me the support needed to pursue my interests. Last but not least, I would like to thank my children, who patiently gave up their time with me when dissertation and doctoral studies required my focus. This would not have been possible without your support given to me at all times. You remind me of the priorities of life.

Thank you all very much for your support throughout the years!

Kokkola, 20.6.2018
Mikko Myllymäki

LIST OF FIGURES

LIST OF TABLES

CONTENTS

LIST OF INCLUDED PUBLICATIONS

PI Hakala, I., Laine S., Myllymäki, M., Penttilä J., "The Effect of Time and Place Dependence When Utilizing Video Lectures", Proceedings of the 20th EAEEIE Annual Conference on Innovation in Education for Electrical and Information Engineering, Valencia, Spain, p. 6, 2009.

PII Hakala, I., Myllymäki, M., "A Blended Learning Solution and the Impacts on Attendance and Learning Outcomes", International Journal of Emerging Technologies in Learning, vol. 6, special issue, pp. 42-49, 2011.

PIII Hakala, I., Myllymäki, M., "The use of lecture videos: attendance and student performance", In V. Uskov (Ed.), Proceedings of the 14th International Conference on Computers and Advanced Technology in Education, Cambridge, United Kingdom, p. 7, 2011.

PIV Myllymäki, M., Hakala I., "Choosing a Study Mode in Blended Learning", In Goldweber, & Goelman (Eds.), Proceedings of the 17th Annual Conference on Innovation and Technology in Computer Science Education, Haifa, Israel, pp. 291-296, 2012.

PV Myllymäki, M., Hakala, I., "Video-based Blended Learning Practice in Master Studies", In V. Uskov (Ed.), Proceedings of the Iasted International Conference on Web-based Education, Insbruck, Austria, pp. 872-878, 2013.

PVI Myllymäki, M., Penttilä J., Hakala, I., "Producing Lecture Videos from Face-to-Face Teaching", International Journal of Information and Education Technology, vol. 4, no. 1, pp. 18-24, 2013.

PVII Myllymäki, M., Hakala, I., "Temporal Differences in Participation Modes in Video-Based Blended Learning Practice", In L. G. Chova, A. L. Martínez, & I. C. Torres (Eds.), Proceedings of the 6th International Conference on Education and New Learning Technologies, Barcelona, Spain, pp. 2000-2006, 2014.

1 INTRODUCTION

The increasing competition, as well as quick and dynamic changes occurring in various fields of business, emphasize the role of lifelong learning. The focus on lifelong learning in the Finnish educational system is nowadays becoming more common in degree program studies. Continuous societal change necessitates continuous learning, which has become an important process for people and communities. Educational organizations are often undergoing continuous changes, and the development of operations plays an important role. Providers of modern education must be able to respond to a number of new challenges, such as the increasing demand for flexibility and teaching methods that take into account students' varied life situations. Furthermore, one of the most significant boundary conditions when searching for new solutions these days is the call for better cost efficiency in education.

Responding to challenges requires more flexible means of participating in education. Participation can be facilitated up to a certain point by taking students' various needs into account when designing schedules. However, as long as participation in education is equal for all, and the choices that are made apply to all students, responding to individual needs is difficult. In this situation, solutions can be sought from technology. One of the biggest topics in the education field today is, in fact, the utilization of educational technology as a part of everyday teaching.

The versatile use of educational technologies provides functional solutions for increasing flexibility. Education can be organized as pure distance learning supported by the use of technology, or as a combination of traditional contact teaching and distance learning, i.e., blended learning. Organizing teaching by utilizing the principles of blended learning is a trend that is becoming more popular in higher education as well.

Blended learning refers to education that combines contact teaching and distance learning (Graham 2013, Dziuban, Hartman & Moskal 2004). In other words, in addition to contact teaching, blended learning makes use of the environments and interaction channels offered by information and communications technologies. In practice, this means that in blended learning, activities tied to a

time and place are blended with activities that are unrestricted by these constraints. The concept of blended learning becomes hard to define when it is examined in relation to contact teaching and distance learning. It is difficult to determine exactly the point where contact teaching augmented with the use of technology becomes blended learning and, on the other hand, how much contact teaching must be involved before distance learning can be called blended learning. Some definitions have eschewed drawing such boundaries (e.g., Graham 2013), while others make use of, e.g., percentages to determine these distinctions (e.g., Allen, Seaman & Garrett 2007).

The purpose of a blended learning approach can be an attempt to increase the flexibility of participation, and this way give students more choices for participation. In addition to increased flexibility, blended learning can also be used to achieve various other benefits. Graham et al. (2005) highlight factors such as improved pedagogics and cost efficiency. From a pedagogic point of view, the blended learning approach is considered to increase or at least enable, e.g., active learning strategies and student-oriented strategies (Graham 2006). Thus, education following the blended learning model allows educators to achieve more versatile pedagogic solutions. Taken to its furthest, the blended model allows for pedagogic solutions that would not be possible without the use of educational technologies (Graham 2006).

Particularly in recent years, education-related discussions have often paid attention to the cost-effectiveness of education. The economically challenging times have created pressure to seek savings also in organizing teaching. Educational institutions have to think about how to serve students and maintain the quality of teaching with diminishing resources. From the viewpoint of cost efficiency, the blended learning approach provides benefits in the form of, e.g., decreased usage of classroom facilities, less need to travel, and flexibility in scheduling (Dziuban, Hartman & Moskal 2004, Bonk & Graham 2006). The greatest reduction in costs attributed to blended learning is typically the reduced need for physical infrastructure. An education organizer can, for example, schedule many course sections in the same classroom. The resulting savings naturally require that there is meaningful use for the released teaching facilities. Savings can also be pursued by, for example, transferring work-intensive tasks to the technology. This can be achieved through, for example, the effective use of online course management systems, automated assessments and shared resources.

Blended learning can be utilized in a variety of ways. Graham, for instance, discusses the levels of blended learning (Graham 2006). At the most moderate level, blended learning strategies are visible in the realization of individual activities (Graham 2006), meaning that only specific parts of a course make use of blended learning. At the next level, entire courses are provided using blended learning (Graham 2006). However, this still only applies to individual courses. The third level consists of an education model that permeates an entire degree program; and on the final level, blended learning is the goal and operating principle of the entire educational organization (Graham 2006).

One functional and widely used solution in transforming education into using the blended learning is implementing video technologies as a part of education. Videos can be used in a variety of ways to make teaching more versatile. However, if the main purpose is to increase the flexibility of studying, lectures can be recorded on video and provided to students as an alternative to contact teaching. The increased flexibility provided by videos naturally improves students' opportunities to participate in education in a manner that is not restricted to specific times. Students can also utilize the absence of time constraints by studying when they feel the most energetic. With videos, students can pace their studying better; for example, by taking breaks when they feel like doing so. Videos also enable studying that is not tied to a specific location. Studying can be done at one's own pace, which suits some students well. Furthermore, video recordings naturally make it possible to repeat difficult parts multiple times.

As mentioned before, a flexible blended education model can be realized at the level of individual courses by making course-specific solutions in order to add variation to the teaching. However, to increase flexibility in the entire degree program by using lecture videos, the selection of videos must cover all courses. Large-scale video production poses requirements for, e.g., the cost efficiency of the production and the establishment of production processes that are suited to various facilities and teaching situations.

A natural choice of production process is to record videos of contact teaching classes. Even though contact teaching situations pose many challenges for video production, the solution is still above all cost efficient when the contact teaching aspect is intended to be retained. Recordings made of lectures this way must feature first-class operational reliability. The recordings cannot be redone in the event of failures. The recording itself must be non-invasive for the actual teaching. In other words, the presence of technology must not distract the lecturer or students in the classroom. In this dissertation, the non-invasiveness of technological solutions for teaching is referred to as transparency. On the other hand, cost efficiency, operational reliability, the scope of production, and transparency must not detract from, the visibility of the learning materials showed in the videos. The intention of the lecture videos is naturally to provide remote students the same assets for learning as contact teaching classes.

Retaining contact teaching in addition to the videos provides students a more versatile selection of ways to participate in the education. In the best case, students can choose between contact teaching, real-time video streaming and on-demand video based on other factors imposing limits for participation, such as distance and schedules. The availability of real-time video also enables the realisation of interactivity as a part of lecture videos. This further increases the applicability of videos as an alternative way of participating in education.

Studying using videos is obviously different from traditional methods based on contact teaching. The most notable differences are related to the concepts of interaction and presence. Interaction as a part of studying is limited when using videos. Modes of interaction that compensate for this can be provided by utilising various technologies. A feeling of being present as a part of a

group is typically missing from studying with videos. Isolation has previously been found to be highly detrimental for learning (Löfström & Nevgi 2007). Grouping up can also be promoted with technological solutions, such as virtual learning spaces, group work tools, discussion forums, or solutions where all contact teaching and distance learning students can see each other via video.

1.1 The research environment

The master's degree program in mathematical information technology at Kokkola University Consortium Chydenius consists of adult students, most of whom have families and jobs. For students like these, time constraints can be a significant hindrance, as they may find it difficult to participate in traditional contact teaching. To answer these challenges, an education model where flexibility is realized especially by using lecture videos was developed. The development work has followed the principles of design science research. In addition to lecture videos, at the core of the education model are the required production hardware and above all, the practices formed around these technologies. The system used in the education model has been tailored for its needs, and it covers all aspects from production to distribution. In this dissertation, the term "blended education model" is used, instead of blended learning model. It is intended in this respect to emphasize the perspective of the education provider.

The main contribution of the new education model has been to offer an opportunity to participate in lectures flexibly, and through this to make the entire degree program more accessible. The students are expected to pass their courses more successfully thanks to improved accessibility. One of the goals was to come up with a solution that is transparent for both lecturers and students, and which does not weaken students' grades in comparison to traditional contact teaching solutions. The solution was also intended to not force students to radically alter their studying habits, but to instead allow them to utilize the solution in accordance with their individual needs.

All teaching in the degree program is organized as contact teaching, which is recorded and distributed as real-time and on-demand videos for students. In other words, the contact teaching situations also double as production situations for the lecture videos. In addition to the videos, the degree program also utilizes a web-based learning management system (LMS) as well as technologies that enable remote guidance. In this education model, the degree program students can choose their mode of participation by selecting from contact teaching, real-time video or on-demand video on a lecture-specific basis, to best suit their circumstances at a given time. The choice can be based on the students' own studying preferences or, e.g., the schedules imposed by their jobs or personal lives. This freedom of choice makes this education model highly unique. The students themselves can determine the level of blending in their studies. They can also choose to study entirely via contact teaching or distance learning.

In addition to offering flexibility, the solution aims to support various types of learning.

1.2 Objectives and scope of the research

This study is part of a larger design science research, which seeks to find a solution for making teaching more accessible in a way that is meaningful for both students and the educational organization. The result is an artifact which in this study is education model that that improves accessibility of education. This artifact is based on educational technology solutions, especially lecture videos and practices that enable the utilization of said technologies. The education model follows the principles of blended learning. In this education model, students can participate in all teaching in the degree program in a way that best suits their life situation, either by attending contact teaching or viewing real-time or on-demand videos. Students can decide the method of participation for themselves on a lecture-specific basis.

This dissertation presents an essential stage of design science research; an evaluation of the artifact. Evaluation is focused on the realization of the artifact, which is the video-based blended education model implemented at Kokkola University Consortium Chydenius' master's degree program in mathematical information technology. The evaluation is based on the starting points of development of the education model. The research questions of the study are presented as follows:

RQ1: Is the education model technically functional?
RQ2: What are the impacts of the education model?

From the organization's point of view, the solution's technical functionality can be examined in relation to its cost efficiency and operational reliability. The impactss of the education model are especially important from the students' point of view. These impacts can be assessed by examining whether the blended education model makes teaching more accessible and how the model affects learning outcomes. Following the principles of design science research, the model's impacts on the learning environment should also be examined as a part of the evaluation (March & Smith 1995). The new education model has a considerable impact on the role of contact teaching. For this reason, the role of contact teaching has been included as one of the subjects of evaluation in this dissertation. Assessing the role of contact teaching provides information regarding the significance of contact teaching as a part of a blended learning solution, and allows one to evaluate whether contact teaching should be continued as usual. The intention has been to make the education solution as transparent as possible to the lecturer. Because of this, the impacts are not being examined from the lecturer’s viewpoint in particular. The realization of transparency has, however, been examined by assessing how well the selected technical solutions allows transparency. In this dissertation, the examination of transparency thus refers to

the assessment of technical functionality rather than the impacts. In summary, the evaluation criteria are as follows:

Evaluation of functionality
- Cost efficiency
- Operational reliability
- Transparency

Evaluation of the impacts
- Accessibility of education
- Learning outcomes
- Changes in the role of contact teaching

The evaluation criteria are presented in more detailed in section 5.1

The examination performed in this dissertation focuses on working adult students, higher education and the information technology program. This scope of research was determined primarily because the available research data falls into these limits. However, the results' applicability for generalization is, considered at the end of the dissertation from all of these viewpoints.

As a result, the educational organization gets a picture of how well the video-based blended education model fulfils its goals. This way the profitability of an education model like this can be evaluated. Documentation of the operations also helps to form a complete picture of all the factors related to them, as well as possible sites of development. An examination from the students' point of view also has benefits in the form of making their motivations and purposes of use known to the organization. At its best, this can be used as a guiding principle in developing the model in the future.

1.3 The need for this research

There are multiple research publications available regarding blended learning. However, many of these studies are not empirical, but focus instead on the definition, models and potential of blended learning. This is typical in the early stages of developing new solutions, where more time is often spent on design and development, rather than research (Halverson et al. 2012). Likely for the same reason, it is difficult to find research regarding the evaluation of video-based education models. There have been examinations into the functionality of individual partial solutions, but there is not much in the way of evaluations of entire education models. Very often the evaluations also focus on entities that are much smaller than a degree program. This is partially due to the lack of implemented solutions that cover entire programs.

According to a review by Halverson et al. (2014), only about a fourth of publications on blended learning have examined learning outcomes. The researchers also highlight how learning outcomes have clearly received less atten-

tion in top-cited publications than in theses or dissertations. The results of evaluations focusing on learning outcomes are somewhat contradictory, as explained later in the section 2.2.5. Some results show clear benefits while others draw attention to advantages offered only in some sectors of learning and some of the research even reports negative results from blended learning. These contradictions underline the versatility of ways in which blended learning has been implemented and are intrinsically bound to the context in which they have been realized.

There is a vast selection of technological solutions for organizing education based on blended learning. These can be implemented in an education model environment in a variety of ways. In other words, it is difficult to generalize the results of evaluations. Thus, in environments where blended learning has an essential role, evaluations should be performed case-specifically, instead of merely by interpreting research done elsewhere.

The education model examined in this research is unique in the sense that it allows the students themselves to decide the degree of blending in their studies, i.e., what is blended and to what degree. There is a clear need for the evaluation of this education model from this standpoint as well.

1.4 Research design

The present dissertation is built on the background work of a long development that aims to form a solution, a so-called artifact, using design science research to increase the accessibility of education. The problems the background development work has attempted to alleviate have risen from the challenges identified in the Kokkola University Consortium Chydenius' master's degree program in mathematical information technology.

The essential goal of this dissertation has been to describe the achieved artifact as a whole and to evaluate it. The created artifact has been demonstrated by implementing it in the master's degree program. The evaluation of the artifact presented in this dissertation focuses on this realization of the artifact. Educational solution includes the required technological solutions, as well as the various practices that have formed around them.

The publications included in this dissertation examine from the different viewpoints how the education model operates and what impacts it has on the learning environment and the users. Table 1 collectively shows how each paper contributes to the research questions, what data was used and what the data source and data collection method were. The data is introduced more closely in section 5.

In this introduction part of the dissertation, the results of individual publications are compiled and the education model is evaluated as based on them. The evaluation is approached from two angles: the technological functionality of the education model itself as well as the value and benefit to the users generated by the model. Thus, the impacts of the model are assessed in addition to its

functionality. The evaluation is carried out by comparing the video-based education model to its development goals.

Data for this research was collected from the examined master's degree program in mathematical information technology between 2008 and 2012. One of the studies also uses attendance records from 2005, when the education model was not yet in use. The publications that make up the research were published between 2009–2014. The evaluation studies that make up the publication are spread across a relatively long period of time. There is some variation between students in the data used in individual case studies. The data has been expanded to cover more students and courses as new data has become available. The variability of the data does not, however, cause problems for the overall evaluation, since all students examined in the data represent typical participants of the degree program in all essential respects. As such, the data describes the student masses who enroll in the master's degree program in information technology as well.

TABLE 1 Contribution of original research articles to the research questions

Article	Research Question(s)	Data	Data Source / Method of Data Collection	Design
PI	**RQ2**	Viewing figures for lecture videos in 2008. Includes 16 courses and 87 students.	Log file data from media server.	Snapshot Case Study
PII	**RQ2**	Viewing figures for lecture videos in 2008-2010, attendance records in 2008-2010, study records, answers for questionnaire 2009. Includes 25 courses and 85 students.	Log file data from media server, attendance logs from contact teaching situations, log file data from the university study records, structured online questionnaire.	Snapshot Case Study
PIII	**RQ2**	Viewing figures for lecture videos in 2008-2010, attendance records in 2008-2010, study records, answers for interviews in 2010. Includes 22 courses and 74 students.	Log file data from media server, attendance logs from contact teaching situations, log file data from the university study records, structured interview.	Snapshot Case Study
PIV	**RQ2**	Viewing figures for lecture videos in 2008-2010, attendance records in 2008-2010, answers for interviews in 2010. Includes 25 courses and 56 students.	Log file data from media server, attendance logs from contact teaching situations, structured interview.	Snapshot Case Study

(continues)

TABLE 1 (continues)

Article	Research Question(s)	Data	Data Source / Method of Data Collection	Design
PV	**RQ1 & RQ2**	Viewing figures for lecture videos in 2005 and 2010, attendance records in 2005 and 2010, study records, answers for interviews in 2010. Includes 10 courses and 34 students in 2005, and 13 courses and 58 students in 2010.	Log file data from media server, attendance logs from contact teaching situations, log file data from the university study records, structured interview.	Pre-Post Case Study
PVI	**RQ1**	Viewing figures for lecture videos in 2008-2011, attendance records in 2008-2011, study records, answers for interviews in 2010, statistics about the streaming events in 2008-2011, statistics about problems related to video production in 2008-2011. Includes 30 courses and 80 students.	Log file data from media server, attendance logs from contact teaching situations, log file data from the university study records, structured interview, log file data of the classroom reservation system at the University Consortium Chydenius, video production error log data.	Snapshot and longitudinal Case Studies
PVII	**RQ2**	Viewing figures for lecture videos in 2008-2012, attendance records in 2008-2012, study records. Includes 38 courses and 77 students.	Log file data from media server, attendance logs from contact teaching situations, log file data from the university study records	Snapshot Case Study

During the period of this research, the essential parts of the education model have remained unchanged. Changes have mostly been related to technical hardware updates. Operating models and practices regarding video production, its utilization, and the overall architecture of the production have remained constant throughout the data collection period.

1.5 Summary of publications and author's contributions

The publications that make up this dissertation evaluate the video-based blended learning solution from various viewpoints. The author of the dissertation actively cooperated with other research personnel in the design, development and construction of the examined education model. The publications included in the dissertation were primarily produced in close cooperation with Professor Hakala, the head of the research group, who is also the leading developer behind the publication's ideas. None of the publications have been used as part of

any previous dissertation. The publications were written and published between 2009–2014.

Throughout this dissertation, the publications included are cited in bold using the letter P, followed by the Roman numeral of the publication. Reprints of all original publications are attached at the end of this thesis.

Publication PI provided information on how the media server logs can be used in future researches. This information has been utilized in practice in other included publications. The publication also described the use of video in the study environment. Publications PII and PIII examined the impacts of the use of video through a variety of classifications. The classifications used in PII were very tight. PIII used a looser classification. Publication PIV extends the results of PIII by treating the results of broad learning outcomes in the classes used in PIII. Publication PV focuses primarily on highlighting the change that has taken place between 2005 and 2010 in the education program. PVI contains experiences of the training model and evaluated the functionality of the practices. In publications PII-PIV, the students were classified as based on the amount of video usage, i.e., distance learning. Publication PVII extends the view of previous studies by focusing on examining students according to how they are studying with respect to time. A summary of the publications and the author's contributions are presented below.

Publication I: This publication examines the media server's log files and their collection and processing. The log files are used to examine students' use of the videos.

The publication was produced in cooperation with other research personnel. Design, planning, production and interpretation of the publication were completed in cooperation. The statistical processing of the data was performed primarily by other writers.

Publication II: The publication briefly describes the practices of the master's degree program related to the videos, and examines their use numerically, as well as their impacts on attendance and learning outcomes using various data classification methods.

The publication was designed, planned and realized in cooperation between its authors. The co-author had a larger responsibility in the classification and statistical analysis of the data. The analysis and interpretation of data was carried out in close cooperation between the authors.

Publication III: This publication examines the impacts of the use of the videos on attendance rates, grades, and course pass rates using various data classification methods.

The publication was designed, planned and realized in cooperation between its authors. The co-author had a larger responsibility in the classification and statistical analysis of the data. The analysis and interpretation of data were carried out in close cooperation between the authors.

Publication IV: This publication uses the results of a wide-scale student questionnaire to analyze differences between students using different methods to participate in the education. The publication answers questions regarding the impacts of students' motives and external factors in the choice of participation method.

The publication was designed, planned and realized in cooperation with another author. The author of the present dissertation was responsible for processing the data. Analysis and interpretation of the data were done in cooperation. The author of the present dissertation was the main author of the publication.

Publication V: This publication describes the training practices of the video-based education model and assesses its cost efficiency. Additionally, changes resulting from implementing the videos as well as students' opinions are examined from the viewpoint of participation.

The publication was designed, planned and realized in cooperation with another author. The author of the present dissertation was primarily responsible for processing the data. Analysis of the data and interpretation of the results were done in cooperation. The author of the present dissertation was the main author of the publication.

Publication VI: This publication focuses on the challenges, practices and solutions related to the production of lecture videos. The publication showcases the video production realized as a part of Kokkola University Consortium's master's degree program in mathematical information technology, and analyzes its functionality from the viewpoints of transparency, cost efficiency and operational reliability.

The publication was designed, planned and realized in cooperation with a research group. The author of the present dissertation participated in collecting the data and this aspect has been his particular responsibility. The author of the present dissertation was also responsible for processing the data. Analyzing the data and interpreting the results were completed in cooperation with a research group. The author of the present dissertation was the main author of the publication.

Publication VII: The publication examines, through the help of temporal classification the impacts of implementing the lecture videos from the viewpoints of students partaking in the education.

The publication was designed, planned and realized in cooperation with another author. The author of the present dissertation was responsible for collecting the data and processing it statistically. The analysis and interpretation of data was carried out in close cooperation between the authors. The author of the present dissertation was the main author of the publication.

1.6 Structure of the dissertation

The present dissertation is structured in the following way: The following section (2) presents the essential background regarding the concepts of blended learning, student participation and the use of videos in education. Section 3 introduces the research principles and methods used in this study. Section 4 describes the created artifact, the development work behind it, and the education model created as a result of the realization of the artifact. Section 5 presents the evaluation criteria and results by subject of analysis. Section 6 features discussion and draws conclusions based on the results in relation to research questions. This section also evaluates the quality of the research. Finally, section 7 presents the final conclusions and discusses possible future research.

2 BACKGROUND

This section focuses on the use of technologies in education. The beginning of the section examines the terminology used in discussing educational technologies. Analysis of the wealth of relevant theories is limited to the ones essential for the present dissertation, while the concept of blended learning is explored in greater detail. Other examined concepts related to blended learning include accessibility, interactivity and cost efficiency. This section also reviews studies on the impacts of blended learning. Particularly participation in education based on blended learning is often slightly different from traditional models. Besides the participation, the impacts are also analyzed from the viewpoint of learning outcomes. The end of the section provides a look into the use of videos in education.

2.1 Terminology used in the field of educational technology

Educational technologies and related fields are undergoing constant development. The terms that are used to refer to the use of various technologies alongside teaching are not particularly established as of yet (Lowenthal, Wilson & Parrish 2009, Volery & Lord 2000). There is also plenty of variation between countries in the use of these terms.

Distance learning can be considered a kind of umbrella term for all learning that takes place away from the location where the teaching takes place. Distance learning has been used as a term already long before current educational technologies became available (Spector et al. 2008, Haythornthwaite & Andrews 2011). As such, the term itself refers to methods of learning beyond technological ones. With the development of technology, however, distance learning has begun to be used to describe teaching methods such as e-learning, mediated learning, online collaborative learning, virtual learning, and web-based learning, etc. (Conrad 2006). An essential common feature of these methods is that the lecturer and student are at different physical locations and/or teaching and

learning happen at different times. The terms distance learning and distance education are often used synonymously, but when trying to determine their differences, distance learning is usually considered to be the result of distance education (Anohina 2005).

The term e-learning (or e-education) can also be seen as an umbrella term that covers all learning that utilizes electronic appliances, i.e., either electronic learning materials or electronic learning environments. Nowadays, almost all higher education includes the use of electronic materials to at least some degree. It is also becoming increasingly common to offer entire courses or at least parts of courses remotely via the internet. However, some studies present a stricter interpretation of the phenomenon, suggesting that e-learning specifically means using the internet in education (Anohina 2005, Zhang & Nunamaker 2003, Gunasekaran, McNeil & Shaul 2002). There are also intermediate definitions, such as that of Lai and Liou (2010), whose definition excludes external storage media, such as CD-ROMs, outside the scope of e-learning. Their definition instead emphasizes the role of information and communications technologies, especially telecommunications (Internet, mobile and wireless networks) as a means to access information. Even though e-learning does not have a universal definition, the term has achieved an established position in discourse on digital IT-based teaching, especially in the English language (e.g., Young 2002). A part of the reason why the term has been difficult to define has been the discord between its technological and psychological learning aspects. These two features are being develop independently of and while also having an effect on each other (Haythornthwaite & Andrews 2011, Servage 2005).

Discussion regarding online-learning often refers to being connected to a computer network or the internet (Anohina 2005). In a wider sense, the term refers to the existence of a network, but according to a more specific definition, this network has to be the internet (Anohina 2005). There are also parallel terms for this type of teaching, such as internet-learning and web-learning.

Anohina (2005) describes a relationship (Figure 1) between the terms computer-based learning, distance learning, e-learning, internet-based learning, online learning, resource-based learning, technology-based learning and web-based learning. According to her, internet-based learning is a larger concept than web-based learning, since the web is only one form of internet service. Other services related to the internet that can be utilized in education include email and file transfers, etc. Online learning, on the other hand, can be realized over any network, making internet-based learning one of its subcategories. According to Anohina's (2005) definition, computer-based learning utilizes computers, but not networks. The learning materials are thus localized, such as CD-ROMs or DVDs. As previously stated, e-learning refers to the use of any electronic media, making online learning and computer-based learning subcategories within it, while distance learning covers the mediation of both electronic and non-electronic learning. In other words, e-learning is one of the subcategories of distance learning (Anohina 2005, Gunasekaran, McNeil & Shaul 2002). According to Anohina's (2005) definition, technology-based learning is mediat-

ed using any type technology, meaning that it includes distance learning as well. The widest term in this definition is thus resource-based learning. In resource-based learning, the learners themselves have a more significant role than the lecturers. The learners actively utilize various types of resources (Anohina 2005), which can include, e.g., printed or electronic books, documents, maps, illustrations, magazines, videos, computer software, TV, and other people, etc. A lecturer's task in a learning environment like this is to motivate students to seek information through various means and from various sources (Anohina 2005).

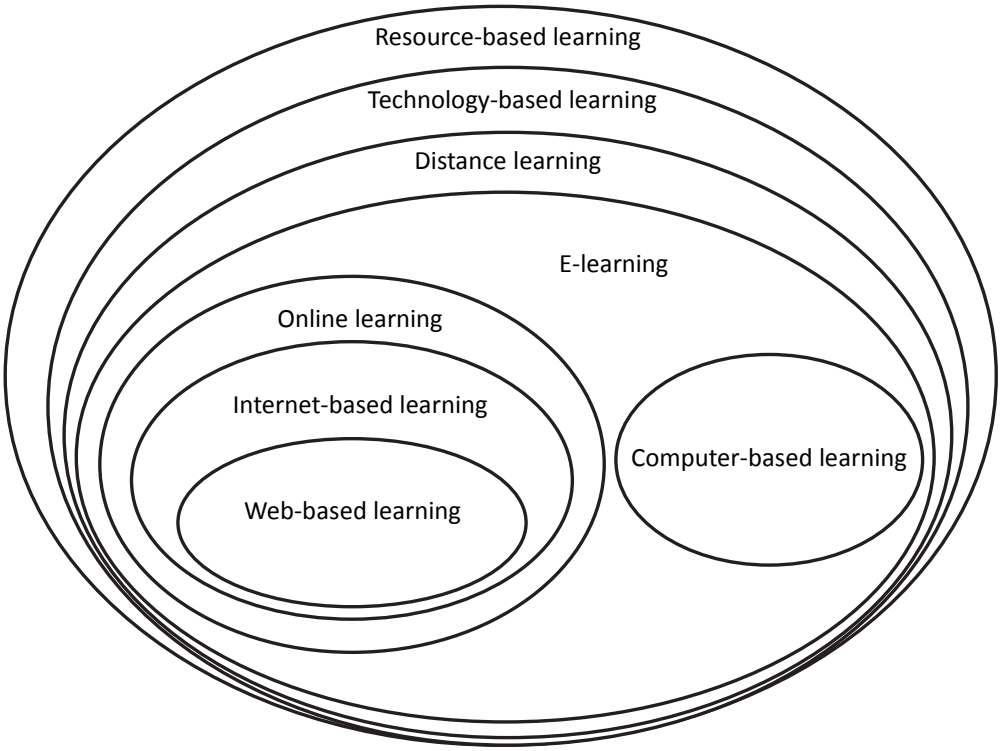

FIGURE 1 The subset relationships between the terms (Anohina 2005).

Anohina's aforementioned definition covers all virtual teaching. Procter (2003) on the other hand introduces an entire spectrum of e-learning solutions using a linear graph (Figure 2), where one of the ends is contact teaching. The inclusion of contact teaching in the definition enables blended learning to also be presented as part of the classification. The line in this figure represents the portion of electronically mediated teaching. The scale is flexible, and the terms often receive accurate definitions only after implementation.

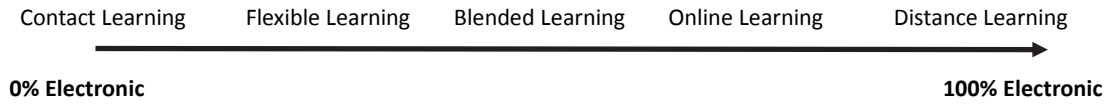

FIGURE 2 The spectrum of e-learning solutions (Procter 2003).

The education model analyzed in this dissertation is based on blended learning, which according to Procter's classification (Procter 2003) falls somewhere between contact teaching and distance learning, depending on the amount of electronically mediated teaching. In Ahohina's classification (Anohina 2005), blended learning is included in the framework of distance learning, which essentially covers the entire framework of e-learning. From time to time, the terms blended learning and blended education are used in confusion. The blended learning can be seen as a final goal. For blended learning to exist, the existence of blended education is required. There is a small difference in emphasis and perspective between the terms. Blended learning emphasizes the students' active role, while blended education emphasizes more teacher-centered perspective and the perspective of the education provider. Typically, however, both terms refer to the same thing in the literature. This dissertation aims to use blended education when it comes to organizing education and blended learning when it comes to a student-oriented perspective. When using sources, the terms have not been changed but are presented as such.

2.2 Blended learning

There have been many suggestions for the definition of blended learning, all of which have slight differences (Dziuban, Hartman & Moskal 2004, Bonk & Graham 2006, Littlejohn & Pegler 2007). One way to define blended learning is to examine what is being blended, an approach that has also resulted in various definitions of the term (Graham 2006, Oliver & Trigwell 2005, e.g., Sharpe et al. 2006). Although there are multiple definitions for blended learning, it is commonly understood as a combination of contact teaching and distance learning (Graham 2013, Dziuban, Hartman & Moskal 2004). In blended learning, various teaching elements and processes, as well as IT and telecommunications environments and interaction methods, are integrated into the educational environment. Activities bound to a time and place, such as traditional contact teaching, are blended with activities that are unrestricted by place constraints: for example, real-time videos and activities unrestricted by time constraints like on-demand videos. However, it still remains difficult to determine whether blended learning should refer to contact teaching supplemented with distance learning, or online learning supplemented with contact teaching, together with what ratio these methods need to be used to consider the education to be blended (Dziuban, Hartman & Moskal 2004). There are various definitions regarding how to refer to education where a portion of the teaching is organized online (Watson et al. 2010, Allen & Seaman 2007). Measuring quantities that cannot be accurately represented with, e.g., percentages likewise makes coming up with a clear definition for blended learning more challenging. It is also important to note that blended learning does not attempt to exacerbate the juxtaposition of online learning and contact teaching. On the contrary, the goal is to meaningful-

ly combine distance learning and contact teaching in ways that support the strengths of both methods (Garrison & Vaughan 2008).

Blended learning can be viewed as a change in the relationship between contact teaching and distance learning. Before, contact teaching and distance learning were separate concepts that were mostly realized as separate strategies. Courses were divided into contact teaching and distance learning courses, with most education typically being organized as contact teaching. No applicable technologies were in use and, on the other hand, the potential of blending was not recognized (Graham 2006). In the current situation, contact teaching and distance learning can be flexibly combined into blended learning. Graham (2006), among others, has presented a vision where almost all future education would consist of blended learning, and the education would increasingly emphasize online learning. It has even been estimated that in the future, blended learning will be a completely normal method of providing higher education (Norberg, Dziuban & Moskal 2011). According to the New Media Consortium Horizon Report: 2017 Higher Education, blended learning designs are one of the short-term key trends accelerating technology adoption in higher education (Becker et al. 2017)

Lately, researchers have also brought up the matter of so-called blending of time (Norberg, Dziuban & Moskal 2011), in which the focus is on blending synchronous and asynchronous activities. The terms synchronous and asynchronous were originally used in conjunction with the definitions of e-learning (Zhang & Nunamaker 2003, Githens 2006, Bondarouk & Ruël 2010), but these can also be applied to blended learning. In synchronous teaching, distance and contact students participate in the teaching simultaneously, though possibly from different locations (Zhang & Nunamaker 2003). Synchronous teaching can be realized by combining real-time videos and contact teaching, for instance. This approach naturally enables some degree of real-time interaction and promotes solidarity among students (Zhang & Nunamaker 2003). A downside of synchronous classrooms is the lack of temporal flexibility, as well as challenging technical production requirements (Zhang & Nunamaker 2003). In asynchronous teaching, students themselves can choose the most suitable time for learning. Although asynchronous teaching makes interaction more difficult, technological solutions can be used to form channels of interaction like discussion forums.

Graham et al. (2013) present a slightly different approach, in which they focus on whether the amount of contact teaching is reduced as a result of blended learning, or if contact learning sessions are conversely added to supplement distance learning (Figure 3). According to them, technology-assisted learning and, on the other hand, learning that mostly takes place online are erroneously categorized under blended learning, whereas their definitions state otherwise.

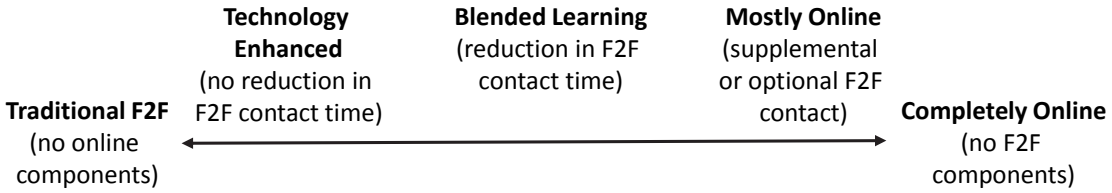

FIGURE 3 Methods of mediating courses in higher education, adapted from Graham et al. (2013)

When examining the definition of blended learning, it is also important to note that the terminology used in Finland is slightly different from its international counterparts. This is primarily because Finnish institutions use their own term: multiform learning. In international discourse, blended learning covers the same features that multiform learning refers to in Finnish. Finland has chosen to use a separate definition for blended learning, precisely because multiform learning was already an established concept when the latter was introduced. In Finnish terminology, multiform learning refers to education that combines various teaching methods, whereas the concept of blended learning emphasizes a combination of various learning environments.

Generally speaking, the combination of the upsides of both contact teaching and distance learning can be seen as the motivation for blended learning. By utilizing multiple learning strategies, one can benefit from their respective strengths (Sims et al. 2008). Graham et al. (2013) suggest more specifically that blended learning should be organized because it enables better pedagogic practices, and improves flexibility, accessibility and cost efficiency.

Graham divides blended learning solutions into three categories based on the purpose of the blending (Graham 2006): enabling, enhancing and transformative blends. In enabling blending, the focus is on the accessibility of the teaching. This category includes blended solutions meant to increase the flexibility of studying as well as solutions which, by utilizing various teaching methods, attempt to offer the same opportunities or learning experiences as traditional teaching. Promoting blending sees some changes to pedagogic practice, though the methods of teaching and learning remain mostly the same. For example, a traditional contact teaching situation can be augmented with methods such as online learning materials. Transformative blending allows even radical pedagogic changes to be made. These can be, e.g., solutions where the blending of education transforms students from recipients of information into active builders of information as a result of various solutions that dynamically increase interactivity. In other words, transformative blended solutions benefit activities that have been impossible in practice before the existence of modern technology. It is important to note that blended solutions can represent multiple categories at once. Likewise, it should be noted that none of these categories are necessarily invalid, but that they only have a different goal (Graham 2006).

Blended learning can also be realized on many levels. Graham (2006) defines four: activity level, course level, program level and institutional level. Ac-

tivity level refers to situations where an individual learning activity involves both a contact teaching situation and technologically assisted elements. An example of this could be a solution where the interaction of a contact teaching course is partly realized through an online learning platform. Another example of activity-level blending is having an expert attend a contact teaching situation through video conferencing. At course-level blending, part of a course is organized as contact teaching and another part as computer-assisted distance learning. These parts of a course can overlap temporally or take place chronologically. The course level is the most typical level of blended learning. In program-level blended learning, some courses are usually offered as distance learning and others as contact teaching (Graham 2006). The choice between courses can be made either by students or the educational organization. At higher education institutes, blending is often done precisely at the program level (Ross & Gage 2006). At the institutional level, the decision to use blended learning is made by the organization. In these cases, the organization, for instance, decides that all of its courses will feature blending or that all graduating students must have experience with online courses. An important consideration for identifying institution-level blending is an organization's centralized attempts to achieve a situation where students can make use of both ends of the spectrum in their studies (Graham 2006). At program and institutional levels of blending, the organization itself has an important role in achieving the blending. At activity and course levels, the degree of blending is usually decided by the organization or lecturer.

Shrestha et al. (2017) have presented their classification of blended learning solutions. According to them, blended learning can be designed from the three distinct design approaches. In low-Blend approach, extra online activities are added to blend the traditional face-to-face model. In the medium-Blend approach, few course activities are replaced by a more effective online version of them. High-Blend activities include full redesign in the course activities in order to blend them.

2.2.1 Accessibility in the blended education model

Organizing traditional contact teaching naturally limits the accessibility of education. Only those who are able to attend the classroom physically at a determined time can participate in it. Accessibility of education is one of the key elements working at the background of learning environments that enable distance learning (Bonk et al. 2002). In spite of this, there have been very few studies on accessibility in relation to blended learning (Graham 2013). Since blending can be done on multiple levels (see section 2.2), accessibility can naturally also be examined on multiple levels (for example, accessibility of the institution, accessibility of the degree program and accessibility of the individual course).

Blended education with the focus on accessibility can be organized for various reasons. In their extensive study, Picciano and Seaman (2007) highlighted five:

- offering courses that otherwise could not be organized by the school,
- catering to the needs of a special group,
- offering courses from a higher level of education,
- reducing scheduling conflicts, and
- providing opportunities to re-take courses for students who have failed courses.

From the viewpoint of adult students, the importance of avoiding scheduling conflicts is naturally one of the biggest motivations, and this is often the reason why blended learning is employed in adult education programs. Students often prefer the flexibility provided by distance learning, but are not willing to give up the social interaction they are used to in contact teaching (Graham 2006). At its best, a well-planned blended education model supported with appropriate technological solutions can facilitate a balance between functional interaction and accessibility. The study of Mayisela (2013) concludes that mobile technology has the potential to increase both, accessibility and interaction in a blended learning course.

A central aspect in increasing accessibility is that the quality of education must not diminish as a result. If quality suffers, the improved accessibility does not provide any benefits (Shea 2007). It is therefore important to take quality into account when planning blended education models. On the other hand, one should also keep in mind that even high-quality teaching is useless if it is not accessible.

2.2.2 Interaction in the blended education model

One of the key differences between blended education models and traditional contact teaching is interaction. Whereas traditional teaching involves interaction between students and a lecturer in the same physical location, blended education models can utilize the solutions of information and communication technologies to enable various modes of interaction. In any case, interactivity takes different forms in these solutions.

A common problem in distance teaching is its nature of simply relaying information instead of supporting interactive learning strategies (Waddoups & Howell 2002). Online courses typically introduce a large amount of information that students are expected to learn independently from others, which can be challenging for many students. Blended learning environments are one way to balance independent studying and human interaction (Morgan 2002). For example, incorporating contact teaching into a distance education course can facilitate social interaction and thus promote later online discussion (Willett 2002).

The relationship between traditional contact teaching and the blended education model can be examined using Graham's (2006) four critical dimensions of interaction regarding teaching (Figure 4). These dimensions of interaction are present in both traditional contact teaching and distance learning environments. The dimensions are space, time, fidelity and the the humaness. The extreme ends of the dimensions are contact teaching and distance learning. On the left in

the figure is the interactivity of traditional contact teaching, with the interactivity of distance education on the right. Developments in information and communication technologies over the last few years have moved the interactivity of distance education towards the left side of the figure, closer to the types of interaction that have typically only been present in contact teaching. In the time dimension, for example, communication technologies such as real-time lecture videos and video conferences also enable distance learners to communicate in real time. Using videos to achieve interactivity also has the same effect in the dimension of fidelity. Communicating with videos can at best be almost equal to a contact teaching environment (Graham 2006). Virtual solutions and, e.g., social media tools enable improved cooperation opportunities between human beings, thus bringing the extreme ends of the humaness dimension closer to each other. The goal of virtual reality environments is to have the same effect on the space dimension.

It's been identified that collaboration and social presence are a contributors to successful learning outcomes (Parker, Maor & Herrington 2013). Also Garner and Rouser (2016) concluded in their study that a balance between interactive face-to-face activities on campus along with asynchronous online learning activities supports learner engagement and satisfaction. Their research indicated that it was the inclusion of contact and a social presence in the online learning environment, which was most influential. Still the significance of the role of interactivity in a blended education model is not self-evident. Some research results indicate that students appreciate the interaction of contact teaching in blended models, whereas others suggest that contact teaching periods are meaningless from this perspective (Graham 2006).

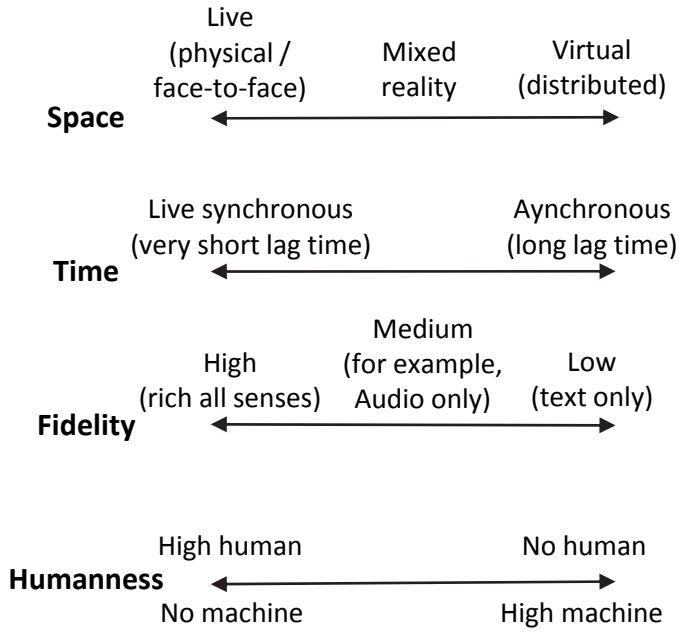

FIGURE 4 The four dimensions of the relationship between contact and distance teaching (Graham 2006)

2.2.3 Cost efficiency of the video-based blended education model

For higher education institutes, improving cost efficiency is one of the most important reasons for implementing blended learning (Betts, Hartman & Oxholm 2009). Cost efficiency can be examined from two angles. First, it can refer to the cost efficiency of education. In this case, the costs of education following blended learning are compared to the costs of the earlier, traditional model of education. The blended education model may allow the educational organization to save money, for example in the form of reduced numbers of contact teaching lessons. This can lead to savings in, e.g., the upkeep costs of facilities and the reduced need to travel between locations. However, it should be noted that the method of realizing the blended education model affects how it impacts a lecturer's workload. Even though the amount of contact teaching lessons may be reduced, a lecturer's workload may not be diminished; rather, this may consist of alternative duties. A blended education model can, however, be realized in a way that reduces the amount of work a lecturer has to do. One motivation for implementing a blended education model can thus be savings. A number of studies have examined cost efficiency from this viewpoint, and the blended education model has been found to have excellent value relative to invested resources (e.g., Lewis & Orton 2006).

Cost efficiency can also be analyzed from the viewpoint of how efficiently education following the model can be organized. In this case, there is no need to compare the costs to those of traditional education, but the goal is instead to keep the costs of blended education low. Even though traditional classrooms are often already equipped with some of the required technology, the blended education model often requires additional hardware and software acquisitions. However, these are typically one-time expenses. In addition, the development of a blended education model naturally requires plenty of personnel resources in the implementation stage. Over the long term, however, regular practices and the amount of work they require have a larger role in organizing education in a cost efficient manner. The role of personnel costs can be reduced by means such as automating functions related to the practice as much as possible. A part of the present evaluative study focuses on assessing the cost efficiency of the examined blended education model precisely from the viewpoint of how efficiently the model has been implemented.

2.2.4 Participation in the video-based blended education model

In a blended education model, the role of contact teaching can change substantially. In some blended education solutions, the role of contact teaching is significantly reduced and replaced by materials that support distance learning, such as written online materials and online discussion or video lessons. Some solutions retain contact teaching, but introduce alternative ways to participate alongside it. In these solutions, participation in contact teaching can typically be replaced with participation via lecture videos.

The concept of participation takes a different meaning in an environment where taking part is possible through the use of videos. Participation using real-time videos is easy to regard as largely equivalent to attending contact teaching classes, since the participation happens simultaneously with contact teaching and follows the course schedule.

The system becomes slightly more multidimensional when students are offered video recordings of contact teaching situations. Enabling participation using on-demand lecture videos introduces temporal flexibility to the model. Furthermore, this allows students to participate in the teaching at their own pace, meaning they can participate in the education without having to adhere to the course schedule. It is even possible to participate by watching the lecture videos out of the original order. Other scheduled course events, such as practice tasks and mid-term exams, can in this case still be used to structure the schedule of participation.

When studying the impacts of videos on participation, studies have typically focused on the impacts that lecture videos have had on the presence of contact teaching. According to Gosper et al. (2008), as well as Traphagan et al. (2010), participation in contact teaching has diminished as a result of lecture videos. Chester et al. (2011), Foertsch et al. (2002), Holbrook and Dupont (2011), McCombs and Liu (2007), and Vajoczki et al. (2010) have reported similar findings. On the other hand, Von konsky et al. (2009) did not find the availability of recordings to have much impact on participation in contact teaching. A number of other studies have also noted similar results (Brotherton & Abowd 2004, Grabe & Christopherson 2008, Walls et al. 2010). Interesting result was achieved by Stockwell et al. (2015) who did found that blended learning courses arranged as flipped learning (utilizing pre-class videos) improved attendance at face-to-face classes. It is important to keep in mind here that there are various factors behind these research results, such as the kinds of videos that have been used, the contexts they have been used in, and their role from a pedagogic viewpoint.

2.2.5 Learning outcomes of the video-based blended education model

One of the three aforementioned key reasons for organizing blended education is improved pedagogical practices. Blended education is built on solid pedagogical theories and teaching approaches. It can be associated at least with the cognitive learning theory, constructivist learning theory, and socially-situated learning theory. Blended education enables learners to learn in various possible ways, such as problem-based and activity-based learning.

Blended education has been criticized for focusing on the teacher for creating the knowledge rather than on the student (Oliver & Trigwell 2005). To improve learning outcomes, blended education should focus on student-centered learning by applying, for example, constructivist theories in designing and implementing learning activities.

A large portion of teaching, especially at institutes of higher education, builds heavily on lecture-based transfer of information from lecturers to students. Distance teaching, on the other hand, typically presents students with

vast amounts of materials and information that they are expected to learn independently (Waddoups & Howell 2002). Blended education provides new opportunities to organize pedagogically versatile education. Blended education is considered to enable, e.g., more student-oriented and active learning strategies (Hartman, Dziuban & Moskal 2000, Morgan 2002, Collis, Bruijstens & van Veen 2003), bring authenticity to classroom teaching (Oliver & Trigwell 2005) and allow learning that takes place at a workplace to be blended into traditional lecture-based teaching (Collis et al. 2005). Blended education also enables the improvement of communal learning by mixing, e.g., traditional contact teaching and virtual learning environments (Wisher 2006, Kirkley & Kirkley 2006).

When the teaching takes place partially online, the teacher can use the resources for the classroom and for more individual guidance of the students. Blended education as its best also offers students time to process information at their own pace. Online environments and software tools make it possible to collect more data on how students are performing. Such data helps teachers to differentiate more effectively. Blended education enables teachers to provide students with a richer learning experience by utilizing technologies. It is also easier to offer alternative learning paths and modalities for students. This gives students more choice in what they are studying and how (Horn & Fisher 2017).

Dziuban and Moskal (2001) have found that many pedagogic techniques, such as reflective teaching practices, communal learning, independent studies and intensive writing, work better in online learning environments. Suggested benefits of the blended education model also include improved opportunities in interaction with actual experts of the subject taught and better chances for individual students to receive mentor guidance (Waddoups, Hatch & Butterworth 2003).

However, at the time of the research, the objective of the development of the blended education model was to improve the accessibility of teaching in a cost effective manner. At the same time, the aim was, of course, that the education model would not weaken the learning outcomes. The new possibilities of better pedagogy, as embodied by the blended education model, were not utilized during the research. The environment of this research was therefore not at the third, transformative blending level of the blended learning categories (Graham 2006) presented earlier. The third level allows radical pedagogic changes to be made.

Studying still becomes different, also in blended education models where the primary goal is not to achieve pedagogic changes, but to improve flexibility. The main differences are typically related to interaction. For instance, studying by watching videos usually means that opportunities for interaction are limited. A blended education model, on the other hand, provides many possible benefits for students. Various learners have various learning preferences. At best, the blended education model can offer multiple ways to participate in teaching. For example, video lessons allow students to study at their own pace outside the contact teaching environment, which many can find distracting. On-demand videos also allow students to study at the time they desire; for instance,

when they feel the most energetic. With videos, students can pace the learning to best suit them in other respects as well; e.g., by taking breaks when they feel like it. Furthermore, on-demand videos naturally make it possible to repeat difficult parts multiple times.

When evaluating the profitability of video-based blended education models, one useful criterion is to examine their results on learning outcomes. So far, there have been somewhat contradictory results in this regard. Some studies have compared blended education to contact teaching courses, and others to distance learning courses.

In many cases, the results have been favorable for blended education. In an extensive meta-analysis sponsored by the U.S. Department of Education in 2009, Means et al. (2009) examined the differences between online and contact teaching courses. Around 40% of distance learning courses allowed students to also participate in contact teaching, and could thus be considered blended education courses. The key discovery in this study was that courses that included online teaching produced better learning outcomes, on average, than contact teaching courses. In another similar meta-analysis, Means et al. (2013) came up with similar results. What is notable about these findings is that the difference in performance was significant when comparing blended learning to contact teaching, but negligible when comparing pure distance learning to contact teaching. The most common disciplines in the two aforementioned meta-analyses were medicine and nursing. Other subjects included in the study were IT, teacher training, mathematics, linguistics, scientific training, social sciences and economics. In 2017, Vo, Zhu & Diep (2017) conducted meta-analysis on the impact of blended learning on student performance measured by objective outcomes; namely, final course grades. The result confirms that across contexts and designs that can be slightly different, blended learning is a good alternative to traditional face-to-face. Taking disciplines into account as a moderator, the study suggests that blended learning can better facilitate student learning in STEM disciplines than that of non-STEM disciplines. Deschacht and Goeman (2015) found out in their research that blended learning improves examination results of academic adult learners. The study focused on business education curriculum. Stockwell et al. (2015) found that blended learning courses improved in examination performance. Courses in this study were arranged according to the flipped learning model utilizing pre-class videos. The study concluded that this mode of blended learning was particularly successful in Science education because it allowed teaching to shift away from the traditional textbook model. This way students were able to engage with scientific concepts on a deeper level. In their study of social science courses, Vajoczki et al. (2010) found notable improvement in grades on courses that made use of video podcasts. Traphagan et al. (2010) found that students who regularly watched lecture videos would achieve better examination scores. The videos were used to assist geography courses. However, when the impact of absences was taken into account, the study found no differences in performance. Griffin et al. (2009) found in a study of theirs that students who regularly watched lecture videos

with synchronized audio and lecture materials achieved better scores in multiple choice exams in comparison to students who studied using audio recordings and separate, non-synchronized lecture materials. Participants in the study were social science students, but the subject taught was one that was not included in their regular degree program. Dziuban et al. (2004) examined the differences between blended education courses and online courses from the viewpoint of student performance, and found that students taking blended learning courses exhibited somewhat better learning outcomes and were less likely to drop out of courses than students taking the same courses online. In an examination comparing contact teaching with blended learning, the blended education model was found to be at least as good – and in a number of cases even better – for learning outcomes. In their recent study, Dziuban et al. (2018) reported very similar results. Blending maintains or increases access for most student cohorts, producing improved success rates. They also noted that the blended modality is competitive and, in some cases, results in lower overall withdrawal rates than either fully online or face-to-face courses.

The studies were conducted at the University of Central Florida, but it does not elaborate on which subjects the blended and online courses were organized in. The instructor's role receives emphasis in a meta-analysis by Zhao et al. (2005), in which the researchers found that, similarly to contact teaching courses, distance courses also exhibited notable differences in regard to learning outcomes. The study showed that the presence of an instructor led to the best results in courses that involved technologically-assisted studying and contact teaching. The meta-analysis included results from various fields, such as social sciences, mathematics, medical science, literacy, humanities, business, law, engineering, computer science, teacher training and skills that do not fall into other categories. According to Dean et al. (2001), students of medicine achieved better grades when traditional contact teaching was augmented with online sessions. Von konsky et al. (2009), on the other hand, found in their study that recordings of lectures (provided as audio instead of video) had a positive impact on course pass rates, but had no impact on grades. The study was conducted among students of software engineering. Wieling and Hoffman (2010) compared law students who were given an opportunity to participate in contact teaching if they so preferred to students who had no such option, or at least had difficulties in participating in contact teaching. They discovered that when using contact teaching and videos, the degree of participation correlated positively with passing courses. According to the study, the positive impacts of participation using videos were less significant the more students took part in contact teaching. Zhang, Dang and Amer (2016) conducted a study involving a university-level introductory course in computer information systems that was organized using blended and flipped education approaches. The course was attended by almost a thousand students, representing various major subjects. The course utilized a variety of teaching methods, one of which was instructional videos. According to the results, most students considered the video tutorials to be the most useful teaching method, especially when studying practical topics.

The study in fact recommends the organizers of blended and flipped courses to utilize video tutorials as a significant component. Thai et al. (2017) examined various methods of teaching from the standpoint of learning outcomes. The subjects of their research were second-year university students who participated in the School of Education's course on invertebrates. According to the results, students who participated in a blended learning version of the course achieved better learning outcomes than those who attended the course in a traditional manner, or as distance education (Thai, De Wever & Valcke 2017). The study found no significant differences between the learning outcomes of pure contact teaching and pure distance learning solutions (Thai, De Wever & Valcke 2017). Suda et al. (2014) discovered, in a study conducted on students of pharmacology, that participants in the blended courses achieved better results compared to distance learning or contact teaching students. Ilioudi et al. (2013), on the other hand, studied secondary school-level mathematics-based self-education using various learning methods. Lecture videos proved to be a more successful option than written materials for self-studying. Lecture videos that showed the entire classroom also appeared to be more effective than videos that only featured audio and showed the lecturer's notes (Ilioudi, Giannakos & Chorianopoulos 2013). Wiese and Newton (2013) also found video recordings to have clear positive impacts on biology students' grades. They also make note of how there were less requests for clarification on difficult topics. McFarlin (2008) conducted a study on physiology students and observed a 10% improvement in grades from courses having a reduced amount of contact teaching and more lecture videos available than in traditional lecture-based courses (McFarlin 2008).

Some of the studies showed contradictory results from blended learning or no positive results at all. A study by Gosper et al. (2008) was participated in by students and teaching staff from a number of faculties from various universities. According to the results, students believed that lecture recordings helped them achieve better learning outcomes, whereas the teaching staff were not as convinced. Lecture videos were used in a fashion very similar to the education model in the present dissertation, i.e., the students themselves could choose how to utilize the videos and thus control the degree of blending. The studies of Jensen (2011) and O'Bannon et al. (2011) did not detect any significant improvements in academic performance as a result of using lecture videos. O'Bannon et al. studied teacher trainees and used audio podcasts as a form of blended teaching, whereas Jensen's study aimed to blend psychology studies with lecture videos. Congdon et al. (2009) studied video-based distance learning among pharmacy students and compared this to students participating in blended education. The study did not find conclusive differences in performance among students participating with the help of videos and those attending contact teaching. The research by Asarta and Schmidt (2017) was particularly interesting. They found that students who have received good grades on average in their previous studies perform better in blended learning than under traditional conditions. Respectively, students who have a low-grade point average per-

formed better in the traditional conditions. No significant impact was found when examining students whose grade point average was in the middle zone.

There were also some negative impactss, but to a lesser degree. According to Ross and Bell (2007), students who could participate in contact teaching and also watched on-demand videos scored lower in examinations the more they utilized the videos. On the other hand, students with access only to videos scored higher the more videos they watched. The results came from examining videos in relation to a quality control course in health care studies. A study by Reasons et al. (2005) compared health care and teacher training courses arranged as contact teaching, blended learning, and pure distance learning. The results indicated that contact teaching and blended learning courses produced weaker results than the distance learning course.

As can be seen, results can be contradictory, which is also evident in a review of literature by Kay in 2012, which examines the educational use of videos by looking at more than 50 peer-reviewed publications on the subject, published between 2002 and 2011 (Kay 2012). He discovered that there were almost as many reports of positive learning outcomes as there were neutral results. Worth noting is that no negative impacts were found in the review. It is also typical for studies to avoid commenting on the possible causes of weakened or improved learning outcomes. The results cannot be directly generalized from the research subjects to other education programs, but are rather highly dependent on the subject taught, the course level, manner of assessing learning in the course (examinations, practice tasks, multiple choice tests etc.), the available technological solutions, the teacher's expertise, the method of blending, the pedagogical practices, etc. The education model examined in this dissertation also has an important unique feature compared to most previous evaluation studies of blended education models. In the model analyzed here, students can choose the extent of blending for themselves based on their own preferences and circumstances. In other words, the school organization has not decided in advance what is being blended and to what degree.

2.3 Videos in education

Two factors have been especially important for the increase of educational use of videos. The proliferation of videos as a result of YouTube has had great impact – making watching videos online an everyday activity for almost everyone. The role of technologies that students already use in their daily lives is far more natural than the role of the entirely new technologies that are implemented solely for educational purposes. Another factor that has had a notable impact on the use of videos is the proliferation of broadband internet connections (Kay 2012).

Videos can be produced and used to make teaching more versatile in a variety of ways. For example, their length can range from short video clips to long lecture recordings. Lecture recordings can be real-time streams or on-demand

videos. Real-time videos can be fully interactive: there can be, for example, integrated text-based interaction channels alongside videos, or videos can be one-way channels without any interaction opportunities. Videos can be produced in contact teaching classes or studio environments or, for example, be recorded directly from the lecturer's computer using screen capture devices.

Zhang et al. (2006), among others, have examined the usefulness of different types of videos. They found that watching videos divided into smaller pieces that make watching and searching for them easier improved learning outcomes, whereas watching videos that cover entire lectures had no results on performance. The study found videos that included interactivity to be noticeably better for both learning outcomes and student satisfaction, compared to non-interactive videos. In Zhang's study, the students were from various university faculties, representing major subjects such as electrical engineering, communication and arts (Zhang et al. 2006). The topic of the examined course was internet search engines.

At best, the use of video lectures can provide students with more choices regarding studying methods, and thus better support various types of learners. With real-time videos, students can focus on studying at their own pace, while still having some kind of interaction channel with the lecturer. With the help of technological solutions, interaction can be made to resemble a contact teaching situation. By using on-demand videos, students can choose the time and place for studying even more flexibly than with real-time videos. They can study when, e.g., they feel the most energetic. With on-demand videos, students can break the learned topics down into suitable portions and pace their studies according to their needs. Pacing one's studies allows taking breaks in order to reflect on the learned topics and to write down notes or summaries. While watching on-demand videos, students can also rewind difficult sections as many times as they wish.

In his review of literature regarding streamed videos, Sturges (2011) found that videos can be utilized as three kinds of basic components: online lectures, video lecture libraries, as additional materials to supplement lecture-based teaching, and as supplementary materials, such as demonstrations and illustrations. Kay (2012), on the other hand, divides videos into four categories based on their purpose of use:

- Lecture-based videos are recordings of entire lessons, which students can watch instead of / after participating in contact teaching.
- Enhanced video presents the slides used as teaching materials with additional voice-over narration.
- Supplementary videos expand on the taught topics by offering supplementary materials. These can include e.g., real-world examples, summaries of lectures or book chapters, and supplementary video materials that expand or deepen learning. This category also includes demonstrative supplementary videos.

- Working examples are explanations of specific problems (such as mathematical ones) in video form, which students have to resolve during their courses.

Winnips et al. (2011) have suggested various benefits for so-called web lectures carried out using lecture videos:

- Repetition of contact teaching situations: Students can rewind difficult sections of lectures. The videos can also be used to prepare for exams.
- Substituting for absences: Students have access to course materials when they have been unable to attend contact teaching due to, e.g., scheduling issues or illness.
- Flexible studying: Organizers can hand out supplementary materials, such as video clips for, e.g., completing learning tasks; or use videos to provide additional information to support lectures. Students can receive this help regardless of time or place.
- Development of presentation skills: Lecturers and/or students can watch their own presentations on video in order to develop their presentation skills.
- Recycling of lectures: The lecture videos can be reused in other courses or with other groups of students.

Educational videos can also be classified based on, e.g., the segmentation of videos. Kay (2012) categorizes educational videos into non-segmented and segmented videos. Non-segmented educational videos cover an entire lecture, and they can be watched from beginning to end using traditional video controls (play, pause, rewind, fast forward). Segmented videos, on the other hand, are divided into smaller pieces, and can be searched for and watched according to the user's needs.

Kay (2012) also categorizes videos based on varying pedagogic viewpoints. He presents three such viewpoints for using videos, all of which can be found in the literature: receptive viewing, problem solving, and produced video. Receptive viewing is by far the most common type of video. It refers to a relatively passive way of viewing learning materials. This kind of viewing can involve rewinding videos or repeating important topics; but from a pedagogic viewpoint, the essential issue is the mediation of information to the student. Problem-solving videos are designed to explain and to teach students how to solve specific problems. These types of videos are commonly utilized in teaching mathematics. The final category is videos designed and produced by the students themselves. This engages them in learning by studying, cooperating, and developing educational videos of their own. The approach is still relatively rarely used.

The aforementioned classifications and methods of utilizing videos enable traditional contact teaching to be made more multiform. Additionally, lecture videos enable the realization of completely new teaching solutions, such as

flipped learning. Flipped learning (also referred to as flipped classrooms or flipped teaching) is an example of a teaching solution that has become widely popular over the past few years, and which lends itself well to video-based teaching (Bergmann & Sams 2012, Lage, Platt & Treglia 2000). The pioneers of flipped learning are Jonathan Bergmann and Aaron Sams, who created videos that students were asked to watch and make notes on. These notes were then used to discuss the topics in class (Bergmann & Sams 2009, Shrestha, Shakya & Gautam 2016). In flipped learning, traditional classroom activities such as lectures are facilitated for studying at home using videos, whereas activities that have typically been done at home – such as homework – are performed in class (Szafir & Mutlu 2013). Teaching can be realized, for instance, by having students watch lecture videos at home and do their "homework" in class together with other students and the teacher (e.g., Chen, Wang & Chen 2014). In flipped learning, the lecturer can focus on the students instead of teaching, and thus better observe, among other things, what kind of guidance individual students need (Johnson et al. 2014). Flipped learning is built on a student-oriented view of education, where the focus and responsibility to learn are shifted from the lecturer onto the student. In other words, the idea of flipped learning is to provide the actual teaching as self-studies and to utilize classroom time for learning by doing. Videos are naturally very well-suited for mediating this type of teaching, and thus have been an essential part of the method since its inception (Sohrabi & Iraj 2016). Other assets, such as audio recordings, online materials and other electronic learning materials, are also used to varying degrees.

Flipped Classroom is well suited for mathematical and scientific topics, and in those contexts it is also much used (Rahman et al. 2015, Stockwell et al. 2015). Some researches has shown that the learning outcome increase when flipped classroom is used instead of ordinary classroom education (Stone 2012). A survey from 2015 (College Faculty 2015) concluded that students learned better when some E-learning was added in their education. Also teachers reported that student grades improved, after the flipped classroom approach was implemented.

The blended learning solutions can be divided into passive and active applications. Flipped learning is a good example of active blended learning application, where as for example the use of a Learning Management System in face□to□face education represents the passive application (Cheolil, Hoan & Sunyoung 2016). However, it is important to note that blended learning and flipped learning are not synonymous (Zhang, Dang & Amer 2016). It is of course possible to organize education that is simultaneously flipped and blended, but to also focus on only one method.

In an extensive review of relevant literature, Kay (2012) pointed out several challenges related to video-based teaching. These include technological issues, students' preferences for contact teaching, awareness of alternative methods of studying, and the time required by video-based studying. The technological problems were most commonly related to file sizes being too large, slow download speeds, a lack of mobile devices, screen sizes, and not knowing how to use

the videos. According to Kay's (2012) observations, in some cases students had expressed a preference for contact teaching, stating that it is more engaging. Some also reported having more distractions at home than in a lecture hall, or having experienced that they could not ask questions when watching lecture videos. In some of the studies examined by Kay, students had found time management difficult; they did not have the time to watch videos at home, or watching a lecture video would take them as much as twice the amount of its actual length (Kay 2012).

3 RESEARCH METHODS

This section describes the research approach of this dissertation. More specifically, the section focuses on describing design science research framework and evaluation research as a part of it. Furthermore, section 3.3 describes the case study research that is in a central role in the individual studies that make up the analysis of this dissertation. Section 3.4 presents survey research as a data collection method. Section 3.5 focuses on the quality of the study on the theoretical level. The evaluation of the quality of this study can be found in section 6.3.

3.1 Research approach

The study described in this dissertation is an evaluation research based on the design science research method. The evaluation research is part of a larger research and development work where the principles of design science research have been applied to the persistent development of an artifact; an education model based on the blended learning for the master's degree program in mathematical information technology at Kokkola University Consortium Chydenius. This dissertation does not focus on evaluating theories and methods built on them, but rather the realization of the artifact. Thus, the target of the evaluation is the education model based on blended learning. The evaluation of matters such as processes related to the construction of the model, and the quality of ideas brought up in the early stages of development are left outside the investigation.

3.2 Design science research

According to Järvinen (2012), the purpose of research is to produce new information that is of scientific interest and has practical applications. Research can be based on basic research or applied research. Basic research examines what the world is like at the moment, whereas applied or constructive research

builds and evaluates new innovations based on the results of basic research. Another word for this is design science research (DSR).

The premise of design science research are problems appearing in specific target environments (Järvinen 2012). Design science research attempts to create models that serve people's needs, and are thus evaluated as based on their utilization. The theoretical basis for design science thinking was created by Simon (1969) in the late 1960s. Simon defined the examination of human-made artificial artifacts and the effects they have on the real world using the terms science of the artificial and design science. This new field of science was motivated by the idea that most of the things surrounding us are artificial rather than natural (Simon 1969, Dresch, Lacerda & Antunes Jr 2015). Simon saw design as the dot that connects pure natural science theory and practical applications. He considered practical experimentation to be an important part of studying computers and their real-world applications. Testing an artifact based on theory in a practical scenario is, in fact, the central idea of design science research (Simon 1969).

In other words, artifacts are designed for a specific purpose. March and Smith (1995) use the term artifact to refer to technical innovations. Järvinen (2012) has expanded this to cover all innovations that aim for practicality (including social and information-based ones). The designed artifact can consist of constructs, models, methods, or realizations (Hevner et al. 2004, Johannesson & Perjons 2014). The design function has a concrete goal: it is evaluated as based on whatever value or benefits it offers to its userbase (March & Smith 1995). One can then examine whether the goals set for a construct or an improvement have been met (Järvinen 2012).

According to the views of March and Smith (1995), design science research creates knowledge for the design and construction of artifacts. Van Aken (2004) states that design science research focusing on construction can also improve the performance of current systems. In any case, both construction and improvement are based on the same approach and lead to similar results (van Aken 2004). Both cases also call for the evaluation of usefulness of new innovations. In relation to design science research, evaluation refers to the development of applicable criteria and their comparison against the performance of artifacts (March & Smith 1995).

3.2.1 Design science research framework

Hevner et al. (2004) have introduced the information systems research framework (Figure 5), in which they organize research tasks into two phases: behavioral science research and design science research. Behavioral science research test or creates new theories, whereas design science research constructs/evaluates artifacts, as in the following definition by March & Smith (1995).

In the figure, the left side determines the environment that defines the problem area which the study targets, the so-called business needs. In practice, this means emergent organizational needs. The environment consists of people, organizations, and the technologies that are available to them (or are planned).

People's roles, characteristics and abilities shape their views regarding needs, which are evaluated in relation to strategies, structures, culture, as well as current processes, infrastructures and development possibilities. On the right side of the figure is the knowledge base that consists of the basic building blocks of research and development. The right side consists of knowledge that can be achieved through, e.g., literature written on the subject, research results and existing solutions. The methodologies are the prevailing standards that are used in the research. At the center of the figure is the research itself. At the top is research that creates and tests theories and, on the other hand, design science research that builds artifacts for recognized organizational needs. The evaluation is situated at the lower middle of the figure. The framework does not restrict how the evaluation should be completed.

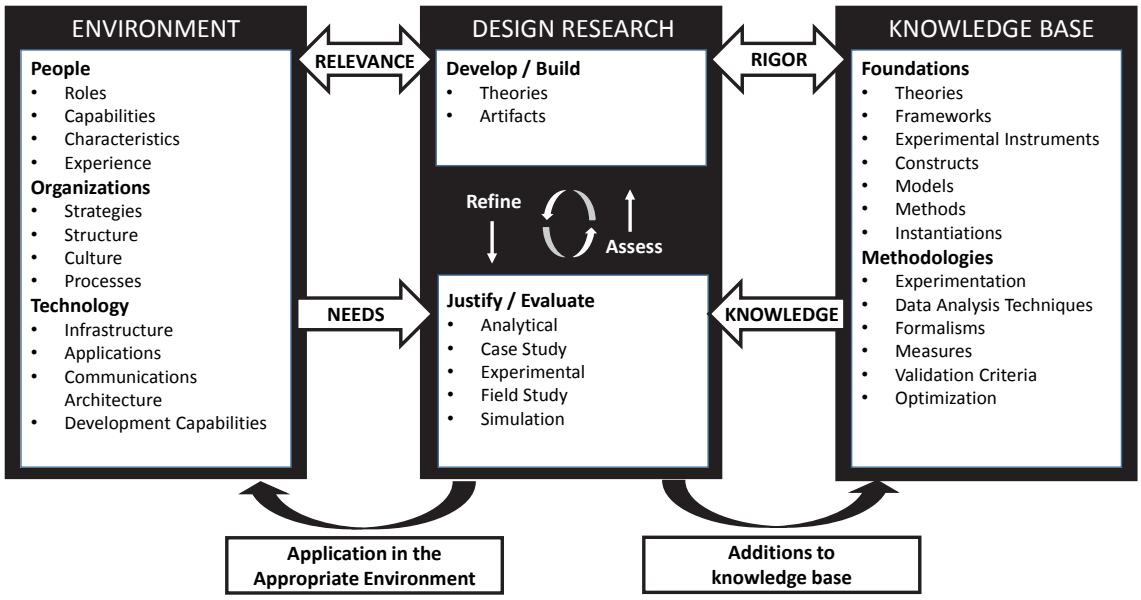

FIGURE 5 The information systems research framework (Hevner et al. 2004)

The artifact evaluated in this research, the blended education model, was created as part of a design science research that closely follows Hevner et al. framework. The correlation of the education model with Hevner et al. framework is depicted in figure 6. The environment of the study was the Kokkola University Consortium Chydenius as an organization, its master's degree program in mathematical information technology, the associated people, and the technological solutions used in the education. The needs for development, which are discussed in more detail in section 4, were based on practical experiences in this environment. On the right side of the figure is literary information related to the desired artifact, such as comparable studies and technological descriptions written elsewhere. Related to the knowledge base are also the research methods used in the evaluations contained in this dissertation (case studies), as well as various data processing methods (e.g., different classifications). The evaluation at the center of the figure was carried out by implementing the artifact in a real environment (education program) and evaluating it from various viewpoints as

case studies. Based on these evaluations from various viewpoints, the present study presents an overall look into the evaluation of the education model. Design science research is thus employed in producing a blended education model for the environment. Correspondingly, the present study produces a new example of a video-based blended education solution, as well as new scientific information about the use of this type of education model. Others designing similar models can later utilize this information as a knowledge base of their own design process.

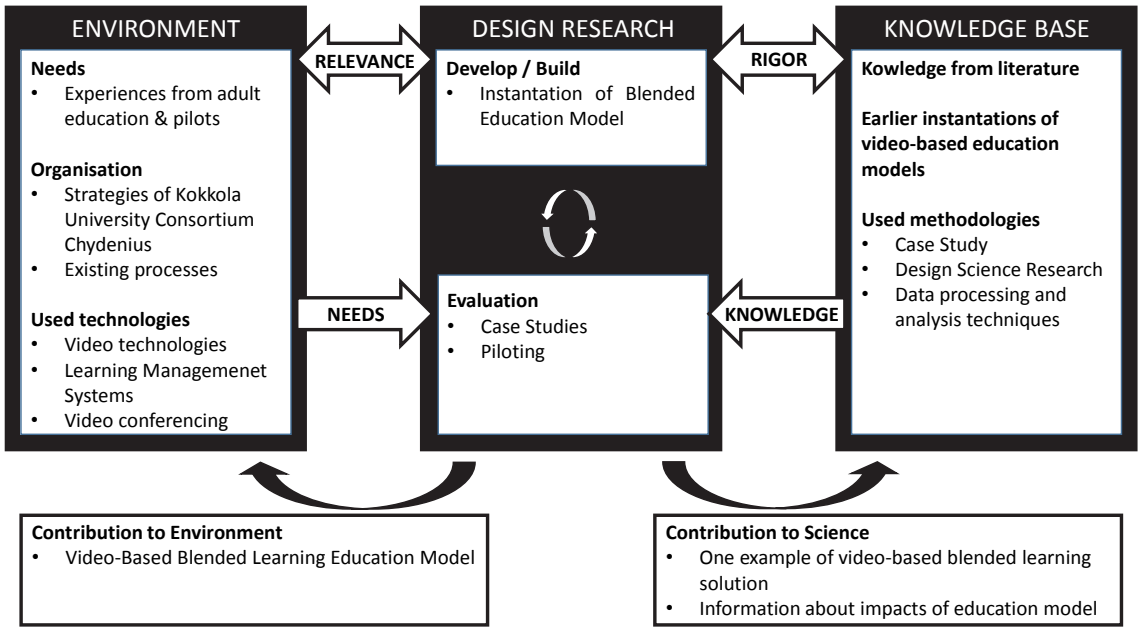

FIGURE 6 Correlation of the education model with Hevner et al. IS framework.

3.2.2 Design science research process

This evaluation study is a part of larger design science research project. There are multiple process models for DSR (Hevner et al. 2004, Peffers et al. 2006, Peffers et al. 2007, Takeda, Veerkamp & Yoshikawa 1990, Nunamaker Jr, Chen & Purdin 1990, March & Smith 1995, Wieringa 2014, Rossi & Sein 2003), though they are for the most part very similar. However, there are typically three core activities involved in the frameworks: construction, evaluation and identifying the problem (Offermann et al. 2009). One of the most common process models is by Peffers et al. (2007), which was formed by analyzing process models presented in earlier literature, making their model consistent with previous ones. Hevner et al. (2004) framework, which was introduced earlier, describes the essential elements of DSR. The model for the process and presentation of DSR introduced by Peffers et al. (2007) helps researchers conduct DSR in an efficient manner.

The process model by Peffers et al. (2007) consists of six activities, which are depicted in figure 7.

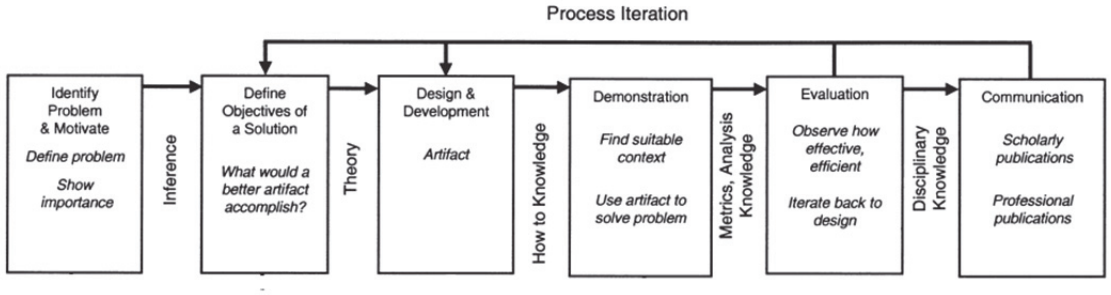

FIGURE 7 Design science research methodology process model (Peffers et al. 2007).

The first activities according to Peffers et al. (2007) are identifying the problem and presenting a motivation for research. The second activity is defining the objectives, i.e., setting goals as based on the problem. In this regard, it is important to understand which kinds of solutions are possible and which have already been presented. The third activity is design and development. At this stage, the artifact itself is created. The fourth activity consists of demonstrating the artifact's functionality by implementing it in a suitable test environment and by using it to address the problem. This can also include experimental use of the artifact, simulations, case studies and other applicable activities. The fifth activity, evaluation, consists of analyzing and measuring how well the artifact solves the previously identified problem. The objectives of the solution are compared to the results observed during the demonstration. There are many ways to perform the evaluation itself. As a result of the activity, the researchers can determine whether they must go back to the third activity in order to improve the efficiency of the artifact, or if they can continue into the final activity and leave further development for future projects. Finally, the sixth activity is communication. In this activity, the idea is to relay information about the artifact, as well as, e.g., the needs it addresses, its practicality, applicability and efficiency to other researchers and concerned parties.

The present evaluation research is a part of design science research, and follows the general process model introduced by Peffers et al. (2007). Correlation between the development work behind the education model and the previously described process model are illustrated in Figure 8. Demonstration of the artifact following its construction was realized by implementing the model in a master's degree program in mathematical information technology. Using case study methods, the publications included in this dissertation examine how the education model functions, as well as the impacts it has on the learning environment and users. In this dissertation, the developed education model is evaluated in comparison with these results. The publications included in the dissertation, conference presentations held based on them, and dissertation itself can be considered to be realizations of the final activity, which is communication with the scientific community and other parties. In other words, the present study focuses on the last three activities, though the final activity has also been realized outside the present work.

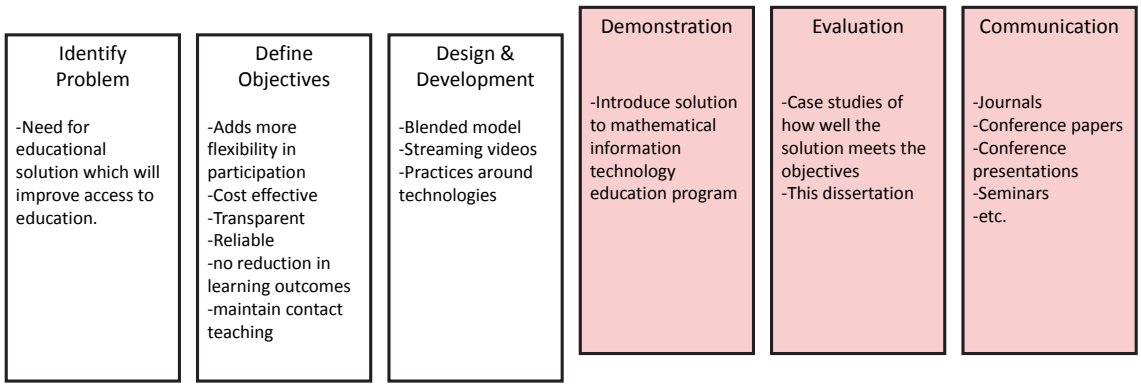

FIGURE 8 Correlation between the present study and the DSR process model presented by Peffers et al. (2007).

3.2.3 Evaluation in design science research

According to Hevner et al. (2004), the results of design science research are evaluated by implementing them in real-world scenarios in applicable environments. Evaluation also broadens the knowledge base that can then be used in later research. Evaluation can be done e.g., in the form of case studies, such as in the present dissertation.

March and Smith (1995) present an evaluation of realizations based on their efficiency and effectiveness on both the environment and the users. These criteria are very common and emphasize the benefits and side effects of innovation (Järvinen 2012). Järvinen (2012) notes that these evaluations highlight the planned effects, and complement the criteria with the unexpected results of realization discussed by Orlikowski (1996). These effects can be positive or negative. Other criteria for evaluation have also been suggested in the literature (e.g., Aier & Fischer 2011, Rosemann & Vessey 2008). Depending on the type of the evaluated artifact as well as the stage at which the evaluation is performed, other criteria may prove more useful for this purpose than others. Alongside the various criteria, it is important to remember that evaluation must always be performed in relation to the goals set for innovation.

Venable et al. (2016) present a number of classifications for evaluation related to design science research. They define two viewpoints from which artifacts can be evaluated. These are either the relevance of the artifact for its environment or the viewpoint based on the rigor it brings to the knowledge base. When observing literature related to evaluation, Venable et al. (2016) identified at least six different purposes for evaluation. The first of these is the natural need to evaluate how well an artifact meets the expectations with regard to its usefulness. Second, evaluation can be completed by assessing how well the theory could be utilized to produce a useful artifact. The third purpose of evaluation is to compare the new artifact with already existing solutions and thus produce information regarding whether the new artifact makes an improvement on the state of the art. In the fourth purpose, instead of focusing solely on the artifact's primary purpose, the benefits produced by the artifact are seen as a

complicated concept that consists of various criteria. Properties such as the artifact's perfection, consistency, accuracy, reliability of performance and other relevant quality criteria can be used as measures of quality (Hevner et al. 2004). The fifth purpose involves evaluating the artifact from the viewpoint of its so-called side effects, which can be either positive or negative. Finally, the sixth purpose of evaluation assesses either why an artifact works or why it does not.

Evaluations can be categorized into formative and summative evaluations based on the reasons for performing them (Venable, Pries-Heje & Baskerville 2016). Formative evaluations are performed in order to develop the subject of evaluation, while the focus of summative evaluation is on how the subject functions in a specific context. Summative evaluation provides information about which contexts the subject of evaluation can be applied to.

Venable et al. (2016) also classify evaluations based on when they are performed. Ex-ante evaluation is a form of predictive evaluation that aims to predict and gauge an artifact's future effects. This type of evaluation is performed before the artifact is designed or built. Ex-post evaluation examines an already implemented solution instead, from both economic and non-economic viewpoints.

Evaluations can also be classified as based on how they are carried out. Venable et al. (2016) divide evaluations into artificial and naturalistic variants. Artificial evaluation includes e.g., laboratory tests, simulations, criterion-based analyzes, theoretical arguments and mathematical reports. This kind of evaluation is scientifically more reliable, since the evaluations are easier to reproduce. Naturalistic evaluation examines the performance of a solution in its actual application environment, typically within an organization. Evaluation carried out in a naturalistic environment takes into account all the complexities resulting from human actions in a real-world scenario.

When developing evaluation criteria that are particularly suitable for assessing an education model, the aforementioned criteria can be furthermore complemented with ones related to gauging the quality of education. Numerous quality criteria have been developed for examining online teaching and especially distance teaching from slightly different viewpoints. The US foundation A Consortium of Institutions and Organizations Committed to Quality Online Education (Sloan-C), currently known as the Online Learning Consortium (OLC), has developed a quality system that is particularly applicable to online teaching. This quality assessment model consists of five properties that are essential to online learning: the efficiency of learning, student satisfaction, accessibility, organizer satisfaction and cost efficiency (Lorenzo & Moore 2002).

There have been multiple case studies devoted to evaluating the presently examined education model, all of which are included in this dissertation as partial publications. However, the evaluation performed in the present dissertation does not simply compile the evaluations from the publications but additionally attempts to form an overall assessment of the education model as based on the included evaluation. In this dissertation, the goal of evaluation has naturally been to find out how functional the artifact is in use. The benefit it provides is a

complicated concept, wherein the benefiting parties can be both students and the educational organization. From this point of view, the aforementioned fourth purpose of evaluating artifacts suggested by Venable et al. (2016), in which their usefulness is determined by other relevant measures of quality besides the primary purpose (accessibility), is applicable in this study. The present dissertation also evaluates the artifact in question by focusing on the fifth point by Venable et al. (2016), i.e., which side effects the artifact has on the role of contact teaching.

The evaluation has been actualized by applying it in practice in the IT master's degree program, making the process thus fall in line with the previously discussed concept of naturalistic evaluation as introduced by Venable et al. (2016). Furthermore, in accordance with the classification of Venable et al. (2016), the evaluation in question examines, above all, which benefits the artifact generates in its application environment. The nature of the evaluation is clearly ex-post evaluation, which has more summative characteristics than formative ones – even though the evaluation is not performed in multiple different environments. However, the evaluation provides a useful picture of the solution's functionality in an environment like the degree program examined.

The performed evaluation focuses on both technological solutions and the practices formed around them. Evaluation of practices and technologies cannot be separated when assessing the successfulness and functionality of the solution overall. The evaluation criteria are based on the aforementioned common criteria for evaluating the realization of an artifact and, to a certain extent, also the quality properties outlined by OLC. These criteria have been accommodated to be applicable to the topic of the study. The main subjects of evaluation in this study are the functionality of the education model and the impacts of the education model. The evaluation and the subjects of evaluation are discussed in more detail in section 5.1.

3.3 Case study research

Design science research can utilize various research strategies and data collection methods at various stages of work. The individual evaluative studies included in the present dissertation are case studies that utilize the most suitable data collection methods for their respective purposes, and process the data from likewise relevant viewpoints. The used data is presented in section 5.2. The purpose of the publications included in the dissertation has been to understand how the examined education model functions and which impacts it has within the context of the master's degree program in mathematical information technology. Accordingly, case study is an applicable research strategy here, enabling an assessment of impacts and functionality in a case-specific environment.

A case study focuses on a clearly outlined entity, such as a number of separate events, or an individual situation (Yin 2013). According to Yin (2013), case studies seek to answer the questions how and why, and thereby attempt to ex-

plain causes and effects as well as chains of events. Case studies in fact emphasize explanations over interpretations. Examining an entity of some sort is a fundamental characteristic of case studies. This type of study is especially suitable when the goal is to achieve a deep understanding of a subject's operation, essential composition, and interdependencies associated with it within a specific context.

The purpose of analyzing a case is to increase understanding of that particular topic. In other words, case studies do not attempt to produce generalizable information. However, certain regularities, mechanisms and processes related to the examined phenomenon can usually be identified in case studies. This makes it possible to consider what the results mean on a more general level, and how the results can be applied in other contexts.

The case study method has traditionally been used in psychology, sociology, political and business studies (Yin 2013), but it has also seen relatively widespread use in, e.g., studies on information systems. For example, Benbasat et al. (1987) have published a review of the use of case studies in research on information systems. According to Darke, Shanks and Broadbent (1998), case studies are useful when the subject of intrigue is the development and field use of information systems. They argue that case studies are a useful tool in understanding IT innovations and interaction between organizations. Case studies are also well-suited for evaluation research (Järvinen 2012), in which the research subjects are analyzed in their natural environments. The goal in this type of research is to describe the subject in detail by focusing on its characteristics in a systematic and truthful manner. Case studies often have to make compromises regarding the degree of realism and controllability (Runeson & Höst 2009). Since case studies are conducted in the research subject's natural environment, their degree of realism is higher. Correspondingly, this also often means that the degree of controllability is lower. A realistic situation is typically a complex sum of smaller factors, which makes it harder to understand what is happening. On the other hand, increasing control would diminish realism, which in turn can, at worst, lead to a situation where an important factor is ignored.

Case studies can be divided in accordance with the design of the research. Jensen & Rodgers (2001), describe the following classification:

- Snapshot case study: Detailed description of a single entity at a specific time
- Longitudinal case study: The entity is examined over a longer period of time
- Pre-Post case study: The entity is examined two times, between which there a major event has occurred. It is, therefore, a longitudinal design but also includes an assessment before implementation of the major event as well as follow-up assessment after implementation.
- Patchwork case study: Snapshot, longitudinal and Pre-Post designs are used for the same entity.

- Comparative studies of cases: Several entities are examined by comparing them in systematic way.

Publications **PI**, **PII**, **PIII**, **PIV** and **PVII** of this dissertation represent snapshot case studies. Publication **PV** is a pre-post case study. In **PVI**, both longitudinal design and snapshot design have been used.

Runeson and Höst (2009) suggest four different categories for case studies, based on the classification presented by Robson (2002). *Exploratory* case studies attempt to find out what is happening in a research environment and seek insights, ideas and hypotheses for future research. *Descriptive* case studies describe a situation or phenomenon in great detail. In this case, the generalizability of the said situation or phenomenon is not essential to the research. *Explanatory* case studies aim to explain a situation or problem, which is often, but not always, done by analyzing causalities. What can cause problems in explanatory case studies is the fact that they are usually conducted in real environments, where controlling various factors is difficult or outright impossible. *Improving* case studies aim to develop the subject of research from some aspect. This type of viewpoint resembles the methods of action research, and is typical on the field of software development.

The publications included in this dissertation attempt to employ a number of these viewpoints. Some of the studies aim to examine what happens in the educational program's environment when a blended education model is introduced (e.g., PI). Others describe the activities taking place in the environment, such as why students choose their preferred method of participation (**PIV**). Some studies focus on describing the impacts of the model (**PII**, **PIII**, **PV**, **PVI**, **PVII**) and, finally, some of the studies feature traits from the multiple types of publications mentioned above.

Case studies have been suggested to have five universal stages, which also apply unchanged to all empirical research (Runeson & Höst 2009). These stages are:

1. The case study design, in which the goals of the research are laid out and the research is planned.
2. Preparation for collecting the data, during which the data collection methods are defined.
3. Collecting evidence: realization of the data collection alongside the examined case.
4. Analysis of the collected data, and
5. Reporting.

Case studies can utilize various different methods of collecting and analyzing data (Yin 2013). From this point of view, the case study itself does not define the methods; they can be either quantitative or qualitative. The data can include, e.g., interview results, questionnaires and observations, existing documentation, various measuring results and statistics. Case studies can be carried out as

based on, e.g., an analysis of a wide assortment of archival materials, which can be supplemented with personal-level information if needed (Yin 2013).

On a methodological level, case studies closely resemble another method, action research. The purpose of action research is to affect or alter the environment of the research subject (Robson 2002). Case studies are, however, more observant in nature, whereas action research focuses on and actively contributes to change. According to Runeson and Höst (2009), when the researched topic focuses on the effects of changes, the methodology in use should still be classified as a case study.

3.4 Data Collection and Analysis

This study uses quantitative data. As mentioned earlier, there are many ways to collect quantitative data. The data for this research was mainly collected from existing sources. The data sources include media server log files, attendance records, the register of study credits, data from the classroom reservation system, and the video production error log. In addition, two surveys were used in the study. Details of the collected data are described in section 5.2. This section examines the underlying theory of the survey research and also shows how the quantitative material of this research has been collected and processed.

Survey research is a very common form of research and has long traditions (Robson 2002). Kelley et al. (2003) divide the survey into three categories according to their intended use. The classes are Descriptive Research, Analytical Studies and Evaluation Research. Descriptive Research is the most basic type of enquiry that aims to observe certain phenomena. Typically, the survey handles the situation at a certain point in time. The aim is to examine a situation by describing important factors associated with that situation, such as attitudes, experiences and/or knowledge. Analytical studies are intended to illuminate a specific problem through focused data analysis. These are typically longitudinal studies, and data is collected at more than one point in time. The aim is to illuminate the direction of observed associations this way. In Evaluation Research, data is collected to clarify the effects of a planned change.

Research questionnaires have three typical characterizations (Pinsonneault & Kraemer 1993). First, Survey's purpose is to produce quantitative data that describes, from a point of view, the subject being studied. The aim of the survey is to attempt to explain and compare the phenomenon (Hirsjärvi et al., 2009). The phenomenon studied in this study is a blended education model and its impacts. Second, the main way to gather information is to ask people about structured and predetermined questions. Third, information is usually collected from only a fraction of the study population, but is collected in such a manner as to be able to generalize the findings to the population.

In the survey research, all respondents are asked the same questions in the same order. Respondents are asked questions typically by means of a questionnaire form. The form can be used in very different types of surveys and meas-

urements, such as opinion polls and feedback measurements (Vehkalahti 2008). In this study, the term "survey" refers to those that are conducted to advance scientific knowledge.

The question types used in the survey research are determined by the purpose and research problem of the research. The survey can include both structured and open queries. In addition, there may be combinations of the same. In a structured question, the respondent has a choice of answers or a scale for which s/he chooses the most appropriate answer (Kananen 2008, Vehkalahti 2008, Kananen 2011). Scale questions can, for example, measure how strongly the respondent agrees with the given statement (Hirsjärvi et al., 2009). In open questions, the respondent can freely answer as s/he wishes without the ready answers. Open questions are aimed at spontaneous opinions from respondents (Vilkka 2007). Open questions are structured after data collection before material change to numerical form (Vilkka 2007). In the so-called semi-structured question, which is the combination of the above-mentioned question types, the respondent can comment on and supplement the answer to the structured question by an open question (Vehkalahti 2008).

The great advantage of the questionnaire is its effectiveness (Kelley et al., 2003). It is possible to get a lot of answers in the short term. The survey is a particularly suitable method when there are a lot of people surveyed. Surveys may, if necessary, be extensive, and the material will accumulate abundantly. Online surveys in particular can help researchers save both time and money. The survey research also produces data based on real-world observations (Kelley et al. 2003).

According to Hirsjärvi et al. (2009), the greatest weakness of a survey is its theoretical modesty and a certain kind of superficiality. In the context of the survey research, it is difficult to make sure that the questions are reasonable and the answers successful from the respondent's point of view. It is also virtually impossible to evaluate how serious the respondents have been in answering. Other weaknesses in specific to the survey include: uncertainty as to whether the respondents belong to the actual survey population and whether it had enough answers (Vehkalahti 2008, Kelley et al., 2003). When designing the questionnaire, it is also important to ensure that the questions measure the issues under investigation correctly (Vehkalahti 2008). The issues to be studied often have to be multi-dimensional and complex, so the layout of questions requires time and experience.

The data for survey research can be collected in a few ways. Common survey methods include postal questionnaires, face-to-face or telephone interviews and online questionnaires (Kelley et al. 2003, Hirsjärvi et al. 2009). In postal and online questionnaires, the questionnaires are typically sent to a large sample of people. These questionnaires are usually received without any previous contact between the researcher and respondent. The response rate in these types of queries is typically lower than if the query was made to a selected group by means of controlled, personalized contact. (Kelley et al., 2003, Hirsjärvi et al., 2009). In particular, online queries are popular today. The low response rate can be com-

pensated for by sending a query to a very large group. In an online survey, responses are typically stored directly in the database in electronic format. Thus, their further processing is very easy. In face-to-face interview and telephone interviews, the researcher meets the respondent personally. The researcher asks the questions and records the answers. The interaction is therefore two-way. The benefit of these collection methods is typically a high response rate. Kelley et al. (2003) states in their article that telephone interviews are easier to refuse than face-to-face interviews. Face-to-face or phone interviewing is more time-consuming than postal and online surveys.

Both surveys used in this research can be classified as evaluation research. The first survey was conducted as an online survey in 2009. The survey was carried out by sending an online form to all master's degree students through the LMS. The second survey was conducted as a telephone interview in 2010. All the students of the master's degree were interviewed. Both surveys contained structured questions. The majority of questions were multiple-choice questions with ready-made answer options. In addition, some of the questions contained a scale for answers. In scale-based questions, a five-step Likert scale (e.g. Robson 2002) was chosen as a scale. This means that the data obtained from these surveys were quantitative. The characteristic of collected data is described in more detail in section 5.2.

After the data collection, the data has to be analyzed. The purpose of analysis is to summarize data so that it is easily understood. The method of analysis used depends on the design of the survey. In this research, all the data was quantitative. Data was analyzed using statistical analysis methods. In some of the studies (PII, PIII, PIV, PVII), data classification methods were utilized. The aim of statistical analysis is to verify matters such as the amount of phenomena, their frequency, averages, deviations, distribution and arrangement into categories. In many of the studies, a quantitative approach allows the results to also be depicted graphically. If necessary, statistical tests (t-tests, Mann-Whitney U Tests and Kruskal-Wallis Test) were used to detect statistical significance. Statistical significances have been calculated in PI, PII and PVII. Statistical tests achieved significance values that indicate how high the risk is, suggesting that the resulting dependency may be due to coincidence. The significance value is also called the p value. The smaller the p value, the more significant – i.e., statistically more reliable – the result is. As a statistical significance level, this study has used the levels commonly used in statistical studies (Holopainen & Pulkkinen 2006):

- < 0.05 ($\alpha = 5\%$) is statistically almost significant
- < 0.01 ($\alpha = 1\%$) is statistically significant
- < 0.001 ($\alpha = 0.1\%$) is statistically very significant

3.5 Research evaluation

The quality of research refers to its validity, reliability and generalizability (Robson 2002), which together contribute to make the research credible and trustworthy. Validity means how effectively the employed measures and research methods measure what they are supposed to measure. The central concern regarding reliability is the repeatability of the research. This refers to whether the same results could be achieved if another researcher conducted the same study (e.g., Yin 2013). The purpose of reliability is, in other words, to minimize mistakes and deviations. Generalizability refers to how the research results can be generalized for wider utilization in the research subject's environment (Yin 2013).

3.5.1 Evaluation of case studies

Evaluating the validity of a case study can be done from three viewpoints, which are structural, internal and external validities. (Yin 2013, Hirsjärvi et al. 2009). Furthermore, case studies should be evaluated from the viewpoint of reliability (Yin 2013).

Of essential importance in regard to structural validity is the operationalization of the studied phenomenon and justifying the choices that are made. Structural validity evaluates how versatile the researcher's data collection has been and how the data has been outlined. It is thus essential for the researcher to decrease the amount of subjective choices while collecting the data. Case studies are often criticized precisely due to weak structural validity. Data is often found to be too limited, and there may be suspicions that its collection may have been motivated by subjective choices (Yin 2013). Structural validity can be reinforced by collecting data from as many sources as possible and by allowing other people who have participated in the study to examine the draft versions of the research report (Yin 2013).

Internal validity is primarily related to studies that seek to identify causalities. When evaluating causes and effects, researchers can make erroneous judgements due to, e.g., not having noted all factors that affect the events (Yin 2013). This naturally skews the research results. In other words, the adequate evaluation of causes and effects is essential for internal validity. Another, more concerning issue at the core of internal validity is that all conclusions not based on observations are unreliable (Yin 2013). Data must be carefully analyzed in order to achieve internal validity in research – and instead of deduction, the study must utilize methods that are proven effective.

External validity refers to how well the research results can be generalized against other cases (Yin 2013). According to critics, this is the biggest challenge for case studies, since an individual case does not necessarily produce generalizable results. In the context of case studies, generalizability could be ensured by e.g., repeating the study in various environments, or by attempting to guar-

antee that the subject of the research is a prototypical representative of its organization type (Yin 2013).

Accurate documentation of the research is an important consideration for the reliability of a case study (Yin 2013). The goal of reliability is to ensure that a study is reproducible in a way that yields similar results. The reliability of research can be improved with triangulation, which allows the same result to be achieved using different approaches. The point of this is to prove that the results are not random. Data triangulation uses various different methods to collect data from a number of sources. It also improves the aforementioned internal validity by offering evidence from multiple sources (Yin 2013). Researcher triangulation means that multiple researchers have cooperated in the collection and processing of data and the analysis of results. This is very useful in reducing the occurrence of outright errors as well as flawed actions or interpretations caused by subjective viewpoints. In other words, the internal validity of the research is strengthened. Theory triangulation refers to the utilization of different theoretical viewpoints in the analysis of results, whereas method triangulation means utilizing multiple data collection methods (Tuomi & Sarajärvi 2009, Eskola & Suoranta 1998). A researcher's own familiarity with the topic of research and the context in which the research is conducted are also considered factors that improve the credibility of a research (Miles & Huberman 1994).

3.5.2 Evaluation of design science research

In the present dissertation, the evaluation of the design science research project in question is partly made up of case studies. High-quality case studies contribute to the quality of design science research. The quality of design science research has also been analyzed in literature. DSR calls for the use of exact methods in the evaluation of artifacts (Hevner et al. 2004). This precision is achieved in the evaluation by efficiently utilizing the knowledge base, which provides needed theoretical bases and research methods. Arguments that question the quality of an artifact typically depend on the evaluation criteria that are employed (Hevner et al. 2004). In design science research, it is important for researchers to carefully review the employed evaluation criteria. Coming up with efficient ways of measuring is also an important part of research (Hevner et al. 2004). As one of the factors contributing to the quality of case studies, Hevner et al. (2004) bring up the testing and evaluation of artifacts in their intended use environments. This is an important consideration, especially when the artifact is a so-called human-computer solution, i.e., a solution that combines human and technological operations (Hevner et al. 2004).

When examining the generalizability of design science research, one needs to remember that DSR typically begins with a problem that has been identified in local practice. Because of this, researchers need to ensure that their work also contributes to a more general level than that of the target environment (Iivari 2015). The generalizability of design science research can be examined from multiple viewpoints. From the generalizability point of view, Iivari (2015) has presented two individual DSR strategies. The first strategy seeks to solve a

common problem that has no link to a specific practical situation. The other is based on an existing practical problem that is encountered in a real environment, and which the researcher attempts to solve with the artifact. Results of the first strategy can be easily generalized due to the common nature of the related problem. Problems that the second addresses are strongly linked to some specific context, meaning that their generalizability is more difficult to verify (Iivari 2015). Typically, generalization in such a case requires the solution to be demonstrated in other environments as well.

4 DESCRIPTION OF THE ARTIFACT

This section describes the artifact whose realization the dissertation evaluates. The artifact consists of the necessary technological solutions and the practices needed to utilize them. First in this section, the requirements this artifact is built to meet are described, and the starting point for the development work is outlined. These are essential for the evaluation study, since the realization of the artifact is evaluated in section 5 in relation to these needs and goals. After this, the section will look at the artifact's design research process. The artifact itself is presented in regard to the technologies and the practices enabling them to be used. Finally, the education model created as the realization of the artifact is introduced.

4.1 The need for and objectives of the development work

According to the DSR process model by Peffers et al. (2007) presented earlier (Figure 7), developing an artifact requires one to identify the needs for the project and to define its objectives. As stated in the framework for information systems (Figure 5) presented by Hevner et al. (2004), in design science research, the motivations for development work are often based on organizational needs or possibilities provided by new technologies. The needs for the education model examined here were primarily outlined as based on practical observations made regarding the master's degree program in mathematical information technology at Kokkola University Consortium Chydenius. Outlining the needs took place when the degree program was launched, i.e., at the turn of the millennium and the early 2000s.

All students in the degree program are working adults with families. Most notable challenges for these types of students are those regarding time allocation, which they must balance between work, family and studying. Furthermore, more than half of the students live more than an hour's drive away from where the contact teaching takes place. Unlike younger full-time students, the

adult students who live farther away cannot move onto the campus area due to their jobs and families. In addition, the students are primarily employed in the IT field, where work is often project-oriented and thus very demanding at times. In practice, this means that due to time constraints, the students have limited opportunities to participate in traditional contact teaching. Before the education model was implemented, this could be seen in the form of poor attendance rates in contact teaching.

With these considerations in mind, it was easy to see that there was a clear need for improving flexibility in regard to participation in the education. From the beginning, the central idea of the artifact's development process was to make the education offered more accessible. Improved accessibility would enable students to participate in classes and thus increase course pass rates. A number of additional objectives were set for the development process at the beginning, which were drawn from the needs of parties involved in the education model (the organization, lecturers, students etc.). It is important for students, and naturally also the educational organization, that improvements in accessibility and passing rates would not weaken grades or make studying more difficult. The solution needed to be usable from the students' point of view: in other words, one that is naturally suitable for studying. Furthermore, students needed to be able to count on the solution's operational reliability. From the organization's point of view, the developed education model also needed to be cost efficient.

The starting point for developing the artifact was to retain contact teaching. This was primarily to achieve continuity for lecturers and those students who were satisfied with traditional contact teaching. Furthermore, contact teaching classes functioned as a natural venue for the production of lecture videos. When the videos are produced from the lectures, the solution had to be realized in a way that would not disrupt teaching or distract attention away from the topic. In other words, the solution needed to be as transparent as possible for both lecturers and students.

To summarize, the objectives for developing the artifact were:

1. The solution must improve the accessibility of education and thus increase course pass rates
2. The video production must be cost efficient and operationally reliable
3. The video production must be transparent.

4.2 Design science research process

Before the development work was begun proper, starting premises, the correct technological solutions and knowledge of what kinds of solutions would be possible and sensible to realize in action were identified, as based on the second activity of the DSR process model introduced by Peffers et al. (2007). This stage of the work took place between 2002–2006. The researchers who participated in

the development work had been working in the training program for several years, meaning they were well-aware of the scope of associated problems. To increase their knowledge on the subject, the researchers studied development work completed elsewhere, equivalent solutions, and existing technologies. Know-how especially regarding video technology was brought into the training program. At the early stages of development, pilotings were conducted to search for suitable solutions and development areas.

Development of the artifact has been the result of years of work, which has continued even after this evaluation study. The research and development work has been projected in order to achieve very systematic way of working. The objectives of the development work were defined in great detail in relation to each project, mirroring them with the education model's stage of development at given moments, as well as the available technological solutions. Project-oriented development and research has also enabled searching for outside resources. The development projects have been funded by, e.g., EAKR, ESR, Tekes and ERASMUS.

The timeline of the development work's different stages is depicted in Figure 9. Between 2008–2012, the time the data was gathered, the artifact's realization as a part of the master's degree program in IT remained essentially the same. Naturally, technology has advanced during this period of time, and the production environment's components have been upgraded technically. However, the overall architecture and practices have remained unchanged from the standpoint of students and the video producer. The illustration also demonstrates how the exact lines between the various stages of development can be hard to define. An exception is the development phase following the data collection period (from 2012 onwards), in which the goals of the development work changed significantly from improving accessibility towards promoting grouping and interactivity.

Already at the early stages of development, it became clear that at best, the artifact would also enable arranging the whole education program as pure distance education. However, at that time it was not possible to cost-effectively implement a model that would enable this. Since the development emphasized the utilization of possibilities offered by technology as a part of education, the artifact has been developed in small steps alongside advancements in technology.

4.3 Description of the design artifact

The artifact consists of the technological architecture that was developed to fulfil the previously described requirements, and the practices that allow the utilization of technology built on it. The artifact relies heavily on lecture videos produced using video technologies. It was implemented in the master's degree program in mathematical information technology. Applicable pedagogic prac-

tices and a way of organizing education have been formed around the artifact, enabling its utilization.

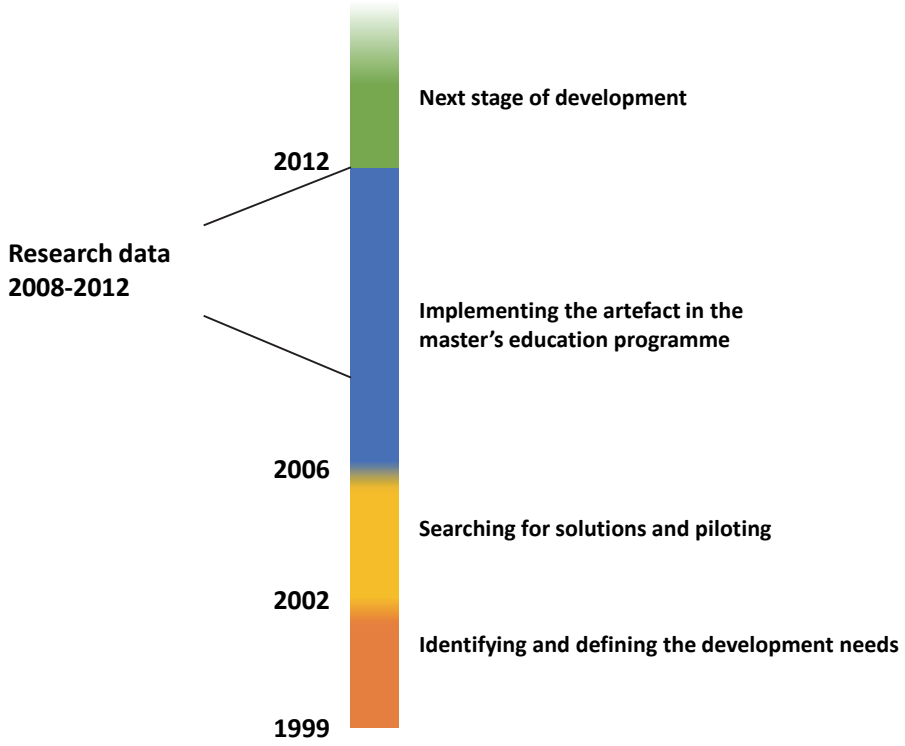

FIGURE 9 Development timeline of the education model

4.3.1 The technological architecture and associated practices

The development of technologies and infrastructures, such as the introduction of faster telecommunications, has enabled the realization of the education model using lecture videos that are streamed online. These developments have also made it possible to achieve lighter production and distribution processes. Furthermore, the streaming of videos online has also made real-time broadcasting possible.

From a technological standpoint, the basic idea of lecture video production is distributing image source signals to video production hardware before the signal is sent to the projector. Being able to capture presentation material on video from a data projector's image feed has been a significant development in regard to the cost efficiency of production, video quality, and the usability. The core feature of the video production hardware is the media selector, into which the classroom's image and audio feeds are directed. The media selector's image signal is directed through the required splitters and adapters to the recording and backup hardware, as well as the projector. The audio signals from media selector and speech from microphones is directed through the audio mixer into the recording and backup hardware. The simplified architecture of the recording system is illustrated in Figure 10.

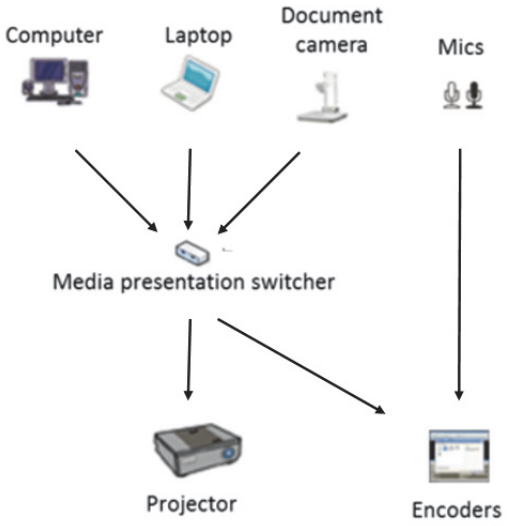

FIGURE 10 The hardware used in the recording system of the IT master's degree program

Document cameras are used in classrooms instead of whiteboards. This way, all materials shown by the lecturer in class are recorded on video in high quality. In practice, all the lecturer needs to do is to display the image they want to show using the projector. All conversations during class are also recorded on video. At the time of the research, there was no real-time two-way interaction between the lecturer and students who participate using videos. The interaction was realized asynchronously on LMS's course-specific discussion forums.

The one goal for technological development has been enabling automation. For this purpose, an application has been developed for handing the system's various functions. The educational organization can use the tool to time the recording of lectures. A large number of lectures can be timed at once. The same timer can be used to start/stop the recording, share real-time video, and transfer on-demand video to the media server for later viewing. Advanced automation of functions relating the use of technologies is essential for cost efficiency, and to a degree, the reliability and transparency of the education model. For instance, lecturers do not have to pay attention to starting the recording at the beginning of class, which naturally increases the reliability and transparency of the solution.

The lecture videos show all the teaching materials that are shown during class on a projector (Figures 11 and 12). Prioritizing the lecture materials over showing the lecturer was an intentional choice. Technical topics were considered to warrant the best possible visibility of lecture materials. In the case of the education model studied, the lecture videos are clearly lecture-based videos (see section 2.3); or, in other words, entire lecture videos that the students can watch instead of or after attending contact teaching. From a segmentation standpoint, the education model's lecture videos are non-segmented videos that contain the entire lecture.

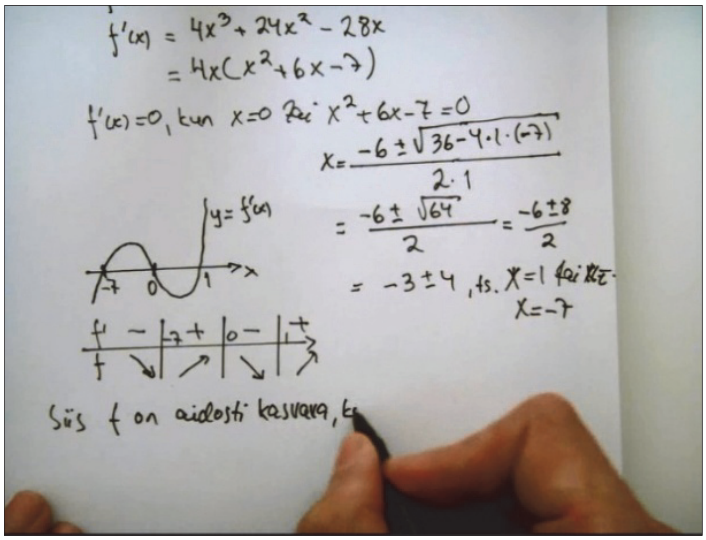

FIGURE 11 A capture from a lecture video, where the lecturer operates the document camera

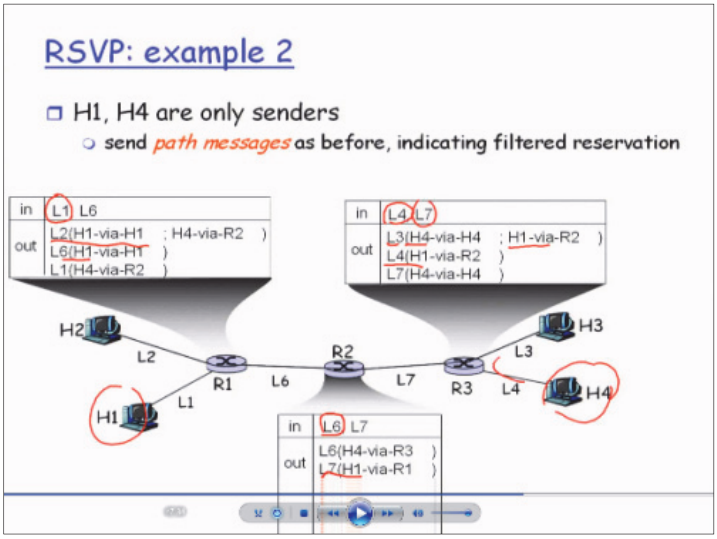

FIGURE 12 A capture from a lecture video, where the lecturer uses digital presentation material

For roughly a decade, almost all Finnish people have had access to internet connections also at home. For a long time, internet connections have also been available with such bandwidth that distribution of videos has been possible through a media server. This has made the distribution process significantly easier. In the solution developed, students can access real-time lecture videos through LMS using their user credentials. By utilizing LMS, access to specific videos has been restricted to students of a particular course only, which can be important for copyright reasons. Videos are produced with various options for picture quality, providing suitable alternatives for different devices or connec-

tion bandwidths. Better compatibility with various devices and the resulting improvement in accessibility were achieved by producing videos using the h.264 video format, in addition to Windows Media. This allows the videos to be viewed on a variety of mobile devices as well.

4.3.2 Realization in the mathematical information technology program

The realization of the artifact formed a blended education model implemented in the master's degree program in mathematical information technology. The evaluation made in this dissertation deals with this realization. In the education model, all teaching is continued to be provided as contact teaching as well as an adjunct to the lecture videos. The organization of the contact teaching is carried out basically in the same way as in the traditional classroom teaching based education model. However, all contact teaching situations in the education model are also recorded and made available online using real-time streaming technologies and on-demand videos. The artifact was intended to be realized in a way that would retain contact teaching, thus enabling the most versatile array of options for participation. Furthermore, contact teaching classes are natural opportunities for producing lecture videos.

All the contact teaching in the education program takes place on Fridays around noon and on Saturdays. These times have been determined after inquiring about the most suitable times from the students and the companies they work at. The idea behind the arrangements was to allow students with full-time jobs to have realistic opportunities to attend contact teaching. Following the students' wishes, the education is organized as intensive sessions, where one lecture can last 2–4 times that of a regular lecture, i.e., 3–6 hours at a time.

In practice, the production of lecture videos worked for the whole duration of the research by having the person responsible for the recording time the recordings for an entire weekend on Fridays using the automation tool that was specifically programmed for this purpose. The lecture videos became available to students during the day of the lecture. The distribution of videos is done automatically via LMS. The next working day from recording, the person responsible edited possible empty segments from the beginnings and ends of the automatically distributed videos when necessary. Other edits were made only in exceptional cases. Timing the recordings takes around one working hour per week on the average. Editing the videos takes around the same time per week. Students cannot download the videos, so they need an active internet connection to watch them. The lecture videos are available to the students throughout the course, allowing them to be used for revising learned topics.

Continuing to organize contact teaching retains the option for those students who would rather attend classes and who are able to do so. Students have multiple options for participating in the education program. These include traditional contact teaching, live-videos and on-demand videos. In all of these participation methods, students also have access to possible written course materials. Additionally, participation is even possible without videos or contact teaching, by studying using the written materials exclusively.

Retaining contact teaching alongside real-time videos means that students do not have to decide how they wish to participate in advance, but can choose the best alternative on a lecture-to-lecture basis depending on what best suits their situation at a given time. Students can attend some classes of the course in person and others remotely with the help of videos. In other words, the education follows the blended learning approach, wherein the students themselves decide the degree of blending. In accordance with the varying levels of blending (see section 2.2), students can blend their own studies at a course level by doing parts of a course remotely and other parts as contact teaching. They can also control this aspect at the level of the degree program by taking some courses entirely remotely and other as contact teaching. This range of options is a factor that separates the examined education model from other blended learning solutions. It also makes the model in question extremely flexible, both from the viewpoints of participation and support for different learning strategies. What is noteworthy about the model is that students can also choose to study entirely via contact teaching or distance learning respectively.

For the organization, the education model clearly represents blended learning on an institutional level (see section 2.2). The organization has intentionally sought a model where all studies would be available using both methods (contact teaching and distance education), as well as by combining them in various ways.

The technologies necessary for video recording were implemented transparently, meaning that they do not disturb students who attend contact teaching classes. Even though the classes are recorded on video, lecturers do not need to alter their own teaching methods to accommodate for this. Thanks to technological solutions, lecturers only need to know how to operate a document camera in place of an overhead projector. During the time period of the study, the real-time videos and on-demand videos did not involve interactivity, thus necessitating no procedures from the lecturer in this regard either. In other words, the new education model does not require any significant pedagogic changes to be made.

The lecture videos' central pedagogical concept is receptive watching (see section 2.3). However, some videos can be considered so-called problem-solving videos, especially when mathematical problems are presented. The primary objective of the artifact's development was to increase the accessibility of education and to provide distance learning students a mostly similar learning experience as their contact teaching colleagues, in accordance with the enabling blending (see section 2.2). In the education model, lecturers can make use of technologies and virtual learning environment in a way they see fit, meaning that some courses can be considered to represent enhancing blend.

5 EVALUATION

In accordance with the DSR process model introduced by Peffers et al. (2007), the artifact's operation is demonstrated after its realization in a suitable environment by using it to solve the defined problem. In this evaluation study, the artifact was examined in use in the master's degree program in mathematical information technology at Kokkola University Consortium Chydenius. An education model following the principles of blended education was created for use in the degree program based on the artifact. So, the artifact was implemented in a genuine educational environment. Piloting the artifact in an actual use environment is necessary and a natural part of the process, since besides the technologies used alongside the artifact, the practices formed around these are also an essential part of it. According to the DSR process model the functionality of the education model was examined by measuring how successfully it addresses the problem that was the starting point for the research, i.e., the accessibility of education. However, the benefits offered by the model are a complicated concept, requiring other relevant quality criteria in addition to the artifact's primary purpose to be used to determine its applicability. These criteria are described in more detail in section 5.1. The evaluation was performed by comparing the objectives set for the education solution during implementation with the observed results. These results were achieved in the case studies included as publications in this dissertation, in which evaluation had been done from various viewpoints. This introduction part of the dissertation provides a synthesis based on these publications and presents an overall evaluation of the education model.

The evaluation is applied to both the functionality of the technological solutions the education model is based on and the practices formed around these. When assessing the successfulness and functionality of the solution overall, both of these factors need to be evaluated concurrently. In other words, the focus of the evaluation is not on the usability or performance of the solution, but rather how well-suited the education model is for its intended purpose. The evaluation was performed "ex post": the stage when the artifact had already become familiar to the users and the learning phase was over.

The purpose of evaluating the education model was to determine the functionality of the model and its impacts from the viewpoints of the model's various participants, including students, lecturers, and the educational organization. In summary, the main subjects of evaluation were

1. the functionality of the education model, and
2. the impacts of the education model.

These were used as a basis for determining the criteria for evaluation, presented in section 5.1. The data used in the evaluation is presented in section 5.2. Sections 5.3 and 5.4 discuss the results of each main subject of evaluation. The evaluation was realized as separate case studies by implementing the model in the master's degree program in information technology.

5.1 Evaluation criteria

In order to increase the evaluation's reliability and comparability, the common evaluation criteria for the realization of artifacts discussed previously in section 3.2 are used by altering them to be applicable to the topic of the study. In many respects, the evaluation criteria also follow Sloan-C's criteria (Lorenzo & Moore 2002).

Development of the education model evaluated here was primarily headed by the educational organization. The solutions of the model were customized precisely for the education program in question. The development goals were determined by the organization. Because of this, the organization's satisfaction with the solution was not as important a criterion in this study than in the criteria used by Sloan-C, for instance. On the other hand, the model's transparency to the lecturer was one of the main goals for development work. One can think that the better this goal has been achieved, the less negative impacts are related to the education model from the point of view of the teaching staff.

The functionality of the created education model (section 5.3), as well as the impacts of the education model (section 5.4) are examined in the evaluation. Factors accounted for in the evaluation of the model's functionality were its cost efficiency, transparency, and operational reliability. The impacts of the education model were assessed by examining changes in accessibility of education, learning outcomes and the role of contact teaching. In practice, the intention of the development was to improve flexibility, and through this, course attendance and pass rates. However, flexibility was not to be increased at the cost of learning outcomes, but instead the goal was that the grades would not be weakened either. Furthermore, the evaluation examines changes to the role of contact teaching. The role of contact teaching was of course expected to change somewhat, though this impact was not specially desired. The subjects of evaluation and the associated criteria are presented in Table 2.

TABLE 2 The evaluation subjects and criteria

	Subject of evaluation	Criterion
Evaluation of functionality	Cost efficiency	Acquisition and operating costs of the solution
	Operational reliability	The ratio of successful video recordings compared to failed ones
	Transparency	Students' and lecturers' opinions on the transparency of the solution.
Evaluation of the impacts	Accessibility of education	Changes in participation rates compared to the situation before the model was implemented
	Learning outcomes	Changes in course grades and pass rates of students frequently utilizing technologies compared to those studying using traditional means
	Changes in the role of contact teaching	The significance of contact teaching in the video-based blended education model

- *Cost efficiency* is evaluated in relation to the available resources. The purpose of cost efficiency in the studies' blended education model was not to save money, but to realize a functional model with the least resources possible.
- *Operational reliability* is evaluated by comparing the amount of failed video recordings to successful ones. Furthermore, failed recordings are divided into fully and partially failed recordings. The goal was to reach the highest possible rate of success.
- *Transparency* refers to the technological solutions and their use not being disruptive for teaching. The goal was to create an education model that is transparent for both students and lecturers. Success in this regard can be gauged by asking students and lecturers about their experiences with the model.
- *Accessibility of education* is evaluated in order to analyze how well students can access the education. The evaluation focuses on whether the developed education model succeeded in providing more flexible ways of participation. Indicators of increased accessibility include changes in attendance rates and how big a role the videos play in participation.
- *Learning outcomes* are analyzed by examining course grades and pass rates. The evaluation compares the results of students who frequently utilize

technology to those who study using traditional means. Intended impacts of the increased flexibility are higher attendance rates, and as a result, better course pass rates. In regard to grades, the goal was for the new model not to have a negative impact on them.

– *Changes in the role of contact teaching* were not assigned with any particular objectives. However, it is important to keep track of these changes. Examining this phenomenon provides information about the significance of contact teaching, allowing educators to, e.g., justify its continued use or abandonment.

It is useful to acknowledge that the primary purpose of evaluations here has not been to seek guidelines for development work or to identify further development targets, but rather to verify that the development has made adequate progress in the area examined in the evaluation.

Individual evaluations have been carried out in case study format. Each case study has focused on one or more subjects of evaluation. The relation between the subjects of evaluation and the publications is described in Table 3. The introduction section of the present dissertation forms an overall evaluation of the artifact as based on these case studies.

TABLE 3 The relation between the studies and the evaluation subjects

	Subject of evaluation	PI	PII	PIII	PIV	PV	PVI	PVII
Evaluation of functionality	Cost efficiency					x	x	
	Operational reliability						x	
	Transparency						x	
Evaluation of the impacts	Accessibility of education	x		x	x	x		x
	Learning outcomes		x	x	x			x
	Changes in the role of contact teaching		x			x		x

5.2 The data

The studies attempt to examine, describe and explain various outlined entities with the use of information gained through different methods. All the studies match the characteristics of quantitative studies. The data used in them is quantitative, and consists of the following:

- Attendance records from contact teaching classes
- Log data from the media server
- Register of study credits
- Classroom reservation data
- Video production error log
- Student survey
- Student interview

The quantitative data was analyzed using statistical analysis methods. In addition to descriptive statistical analysis, some of the studies also utilize, e.g., data classification methods. The aim of statistical analysis is to verify matters such as the amount of phenomena, their frequency, distribution and arrangement into categories. The questions in interview and questionnaire were structured, and the data from these is also quantitative and analyzed statistically. The data used in the studies is described in more detail below.

Attendance records from contact teaching classes: All teaching in the master's degree program in information technology is organized as contact teaching. Attendance records, with students present at individual lectures noted down, were collected from contact teaching classes.

Media server log data: The media server used to distribute the videos offered versatile and extensive log data.

Register of study credits: The organizer's register of study credits provided information regarding individual students' course performance. The courses were graded with either a pass or fail, or on a scale of 0–5, with 0 meaning fail.

Classroom reservation data: Kokkola University Consortium Chydenius' electronic booking system provided information about the amount of media streaming events during specific time periods.

Video production error log: An error log that records all problems encountered during video production has been maintained. This data provided the numbers of errors in video production during specific periods of time.

Student questionnaire in 2009: During the spring of 2009 a questionnaire was directed, to the students of master studies in information technology. With the help of the questionnaire, we sought information about the factors affecting students' video viewing. A total of 35 students filled in the questionnaire, i.e., approximately 40% of the active masters students in information technology did return it completed. The results of the questionnaire were utilized in PII. The answers were filtered according to the group of students being examined in study. The questions were structured and the data from the questionnaire is quantitative.

Student interviews in 2010: All 67 active students in the master's degree program were interviewed in 2010. The results of the interviews were utilized in several studies (PIII-PVI). The answers were filtered according to the group of students being examined in each study. The questions of the interview were structured and the data from the interview is quantitative.

The publications included in the evaluation research are spread over a comparatively long period of time, between 2009–2014. Extensive data for the research was collected from the master's degree program in mathematical information technology during a lengthy period time, between 2008–2012. In addition, attendance records from 2005 were used as data from a time before the education model was implemented. The data used in individual case studies contains some degree of variation for students, depending on the year of the publication. The data has been expanded to cover more students and courses as new data has become available. The variability of the data does not, however, complicate the overall evaluation, since all students examined in the data represent typical participants of the education program in all essential respects. In conclusion, the data is representative of the mass of students enrolled in the degree program.

5.2.1 The use of the data in publications

The use of data by publication are presented below in Table 4.

TABLE 4 Data by publication

Data	PI	PII	PIII	PIV	PV	PVI	PVII
Attendance records		x	x	x	x	x	x
Log data	x	x	x	x	x	x	x
Register of study credits		x	x		x	x	x
Classroom reservation data						x	
Video production error log						x	
Student questionnaire 2009		x					
Student interviews 2010			x	x	x	x	

PI: The publication's data consists of log files indicating the viewing figures for lecture videos from the master's degree program in 2008. The data Includes 16 courses and 87 students. The log files were analyzed statistically.

PII: The publication's data consists of log files indicating the viewing figures for lecture videos from the master's degree program between 2008–2010. The data includes 25 courses and 85 students who accumulated a total of 342 course participations and 2552 participations in lectures. This information was complemented with attendance records from concurrent courses-based contact teaching situations, data of study credits and an online questionnaire sent to students in 2009 (n=35).

PIII: The study was conducted by analyzing log files of video views and attendance records from contact teaching. These were collected between 2008–2010 from courses organized as a part of the master's degree program in mathematical information technology. The data includes 22 courses, 74 students, 295 course participations and 2051 lecture participations. The data was analyzed statistically, and was expanded with the results from the structured interviews held in 2010 (n=67), as well as with information from register of study credits.

PIV: Data for this study consists of the results of the large-scale student questionnaire carried out as a structured interview in 2010 (n=67), as well as statistical information (log files and contact teaching attendance records) collected between 2008–2010 from the master's degree program in mathematical information technology. The data includes 25 courses, 56 students, 273 course participations and 2068 lecture participations.

PV: The data consists of the results of the student interview made in 2010 (n=67), and has been complemented with video viewing log files from the master's degree program, as well as contact teaching attendance records collected between 2005–2010. The data includes 10 courses and 34 students in 2005 and 13 courses and 58 students in 2010. In addition, data from the register of study credits was used.

PVI: The data comes from the classroom reservation system at the University Consortium Chydenius, the structured interview made to master's degree students in 2010 (n=67), the organizer's video production error log, the media server's log files, and attendance records from 2008–2011. The data includes 30 courses and 80 students who accumulated a total of 2,988 lecture participations. Video production log error data includes 709 streaming events.

PVII: The publication uses the media server's log files as data, and the attendance records from contact teaching collected from the master's degree program in mathematical information technology between 2008–2012. The data includes 38 courses, 77 students and a total of 500 course participations. In addition, the data was expanded with information from the register of study credits. All of the data was analyzed statistically.

5.3 Evaluation of functionality of the blended education model

One of the education model's main subjects of evaluation is its functionality. The viewpoints of all parties involved in the education model (students, lecturers, the organization) need to be taken into account when examining the aspect of functionality. An important consideration for the educational organization is cost efficiency. A cost efficient model allows it to be implemented to the full

extent of the degree program. From the students' standpoint, the model's operational reliability is especially important in environments where errors could at worst leave the student without access to the provided education. It is within the organization's interests to have students graduate with strong know-how in their field, which makes reliability an important factor also for them. Naturally, the model's operational reliability is also a matter of public image for the organizer. An important consideration from the viewpoints of students and lecturers is that the emphasized role of technologies in the education model does not disrupt studying or teaching. An essential objective here was, in fact, to construct a model that allows lecturers to teach just like they would traditional classes, and to also give students the choice between utilizing technologies to the extent it suits them or to ignore them. Due to these reasons, the evaluation focuses on the transparency of the model.

According to the results, the education model is highly functional in these regards. All of the subjects of evaluation have succeeded well in relation to the objectives set for them. In practice, lecturers can hold lectures in a classroom without having to manage the video recording in any way. Technical functionality can of course be developed further in many aspects, especially by increasing the level of automation. This would result in fewer failed recordings caused by user errors. As far as completely failed recordings go, the current situation is already at a level where only 0.5% of recordings fail. Increasing the degree of automation would naturally also have an impact on cost efficiency, which places significant emphasis on personnel costs.

5.3.1 Cost efficiency

In order to have the increased flexibility provide significant benefits for students, the flexible model must be able to cover an entire degree program. From the beginning of the development, one of the key conditions for achieving this degree of extensiveness was cost efficiency. The model's cost efficiency is analyzed in publications **PV** and **PVI**.

Cost efficiency has been studied from the point of view of how cost-effectively the blended education model has been implemented. In other words, the expenses have not been compared to the costs of organizing equivalent contact teaching courses. In the examined education model, all teaching is offered as contact teaching anyway, meaning that the purpose of the blended education model is not to replace contact teaching as a more cost efficient solution. For the educational organization, it is important that the blended learning solutions require as little extra resources as possible as an addition to contact teaching.

Development costs

The model's development costs consist of acquisitions as well as research and development costs. The required infrastructure necessitates acquisitions at the beginning and during development. These are one-off costs, and their size depends on, e.g., the materials' desired level of quality. The acquisition costs for the model developed for the master's degree program in mathematical infor-

mation technology at Kokkola University Consortium were also one-off. A considerable portion of the acquisitions would also have been made as a natural part of upgrading the school's facilities, even without the introduction of the new education model. Various commercial hardware and software solutions were utilized and combined with each other in order to actualize the developed system (**PVI**). From a financial standpoint, the development has progressed in small steps. There has not been a need for large, one-off investments, since additional components can easily be integrated into a system like this as the development advances (**PVI**). Developers of a self-made system can build needed accessories themselves or consider commercial alternatives, as long as these feature compatible interfaces that allow them to be integrated into the existing environment. In regard to cost efficiency, it is beneficial that the development has not committed to a single technological solution or hardware manufacturer, which allows further development decisions to be made with economic considerations in mind.

Over the years, significant research and development resources have been invested in the development of the new model. The intention has been to mostly do R&D in externally funded projects. The resource requirements of R&D have been high, mostly because the developed solutions and practices have been comparatively new and unique. Comparative education solutions were largely non-existent during the period of time the study focuses on. Emphasizing the resources used in the development of the education model itself is not essential when assessing the model's cost efficiency.

Operating costs

In this study, cost efficiency refers to the effectiveness of the operating costs of the video-based education model. From a cost-efficiency point of view, it is important to develop the practices related to video production processes, taking into account cost-effectiveness. Cost efficiency of operating the model is based on the automation of tasks, planning the teaching schedule in advance and managing devices remotely (**PV, PVI**).

The objective was to automate all facets of the model where doing so is sensible. Timing the recordings (starting and stopping) and transferring files to the media server are done using a timer programmed specifically for this purpose. Entire series of lectures can be timed at once (**PV**). In the examined environment, automation has been implemented to such an extent that only two man-hours had to be spent to arrange the video production and editing for all classes in the degree program that take place during the same weekend (**PV**). In practice, this means around 10–20 hours of teaching being recorded during a weekend. The time used for video production is divided in a 50/50 ratio between the setup (namely the timing) and editing the produced video material slightly (**PVI**). Annually, the time spent on video production in the master's degree program has been less than 100 man-hours (**PVI**).

The amount of work required in the recording process can be altered by staggering the teaching schedule. If classes are arranged into longer sessions,

for example only one or two meetings per week, the amount of production work is naturally different than if the teaching was spread across multiple days. In the master's degree program in information technology, teaching was mostly scheduled for Friday afternoons and evenings, and Saturdays during the daytime. This allowed for procedures related the video production to be performed at once, instead of splitting the work between multiple days.

The remote control functionality of devices has also been a significant factor in cost efficiency. With remote control, multiple functions have been possible to centralize on the workstation of the person in charge of the recording, or even to be operated from home when necessary. When making hardware acquisitions, the possibility of remote control needs to be taken into account.

If the focus is on personnel resources, cost efficiency can be affected considerably with the way the post-production process is handled. The solution chosen in the examined education model was to edit the videos afterwards as little as possible. Essentially, only empty segments from the beginnings and ends of videos were edited out. More extensive editing, such as adjusting sound levels, was only done in special cases if, for example, production errors had caused the volume to be too low or the sound was otherwise disrupted.

5.3.2 Operational reliability

As the videos form the core of the blended education model and contribute significantly to the accessibility of education for many students, the video production must be reliable. Factors affecting operational reliability include the reliability of both hardware and software, as well as the practices formed around them. Operational reliability is analyzed in detail in publication **PVI**.

The examined education model's operational reliability has in fact improved year after year as a result of experience with the technologies and associated practices. It is important that new hardware is always thoroughly tested outside the production environment before integration. Operational reliability and compatibility with existing configurations have thus been matters of consideration when choosing new hardware.

In order to reduce the effects of problem situations in video production, local recordings of lectures have also been saved, using a separate encoder in the classroom. The purpose of this has been to ensure the existence of a recording even in the event of network issues.

Hundreds of hours of lecture videos are produced annually in the master's degree program in mathematical information technology. Typically, up to 200 videos are produced each year. Table 5 describes the numbers and lengths of videos produced during the education program between 2008 and 2011, as well as the amount of errors in relation to the total number of recordings according to publication **PVI**.

TABLE 5 The quantities and lengths of lecture videos, number of documented failures, and percentages of failures in relation to all recordings between 2008 and 2011 (PVI).

	2008	2009	2010	2011
No. of lecture recordings	145	215	185	164
Duration/hr.	453	707	635	518
No. of complete failures	2 (1.4%)	2 (0.9%)	2 (1.1%)	1 (0.6%)
No. of partial failures	7 (4.8%)	5 (2.3%)	6 (3.2%)	4 (2.4%)

When looking at the total number of lecture videos, there are remarkably few complete recording failures. Complete failure means that lecture is strictly unavailable as real-time video or on-demand video. Between 2008 and 2010, the success rate was already as high as 99%, increasing to 99.4% in 2011, which corresponds to only one failed video recording per year (**PVI**). The causes of complete failures can be divided into three categories in the master's degree program (**PVI**):

- human error in timing
- a timed task failing to start (exact reason unclear)
- power outage

Unreliability resulting from human errors was successfully reduced by increasing the level of automation in the production. In addition, battery-packed devices were used in order to prevent failures resulting from power outages (**PVI**).

There were only slightly more partial failures, such as lectures failing to be streamed in real-time while recording, and distribution of on-demand video have succeeded as usual, or instances where a lecture had to be provided as a lower quality on-demand video created by the backup system (**PVI**). The study identified a number of different reasons for partial failures (**PVI**). Mostly these were the same as for complete failures, just on a smaller scale. Some of the reasons were, e.g., technical errors in the video production encoder (in which case the recording could still be saved as on-demand video) or a power outage that was short enough for the backup system to have recorded the lecture successfully.

The goal of operational reliability is of course a perfect success rate. Still, it is fair to say that the video production of education program has been highly reliable. Some of the individual failed productions have been compensated for by compiling a compensatory lecture video from lecture videos from previous times the course has been organized. In principle, the lecture videos are removed from the server after a course finishes. Depending on the lecturer, however, lecture videos have in some cases been stored until the next time the course has been organized. This has been the practice especially with lectures

taught by the degree program's own regular staff. Some lecturers have also requested copies of the videos after a course has finished.

5.3.3 Transparency

When operating alongside contact teaching, the production environment must be transparent, i.e., non-invasive for the teaching. Lecturers must be able to focus on teaching without being interrupted by the technology. It is desirable to have this apply to the students as well. The intention has been for the blended education model to have minimal presence in the contact teaching situation in classroom. Transparency is analyzed in detail in publication (**PVI**).

The classroom facilities at Kokkola University Consortium are designed with video production in mind. In practice, this means that the hardware required to produce videos can be found integrated into the classrooms. This integration has enabled the implementation of an automated system for switching the image source to complement the recording system (**PVI**). This functionality is essential for having all teaching materials used in class shown on the video. Procedures related to choosing the image source shown on a lecture video are precisely those that may disrupt contact teaching. In the solution examined here, the image source captured on video switches automatically as the lecturer uses a media selector tool to select the image source shown on the projector in class. In other words, all the lecturer needs to be able to do is to display the correct teaching materials in the classroom. This requirement is naturally not dependent of the existence of a recording system. Lecturers have been instructed in the use of the technological infrastructure found in the classrooms, such as the media selector, through written instructions and personal user training.

Another factor that increases the transparency of video production is posing as few restrictions as possible on the presentation materials and devices used by lecturers. In the solution examined in the present study, the recorded image source is captured from the signal between the media selector and the projector. This means that all materials that can be shown on the projector by the lecturer can also be recorded on video.

The lecturer also does not have to worry about starting or stopping the recording (**PVI**), as these procedures are timed by the support crew. The only thing that may require lecturers to change their working habits has to do with materials written by hand in the classroom (**PVI**). Recording text written on a whiteboard in adequate quality proved challenging in the piloting phase of the education model. That is why using whiteboards was substituted with using a document camera. This change has not been observed to cause problems among lecturers and there has been no negative feedback from the organization regarding the matter.

The production process is also transparent for students participating in contact teaching. This is greatly facilitated by the aforementioned fact that lecturers can focus on giving a lecture. According to previous research, students thought that recording of lectures or new teaching equipment used by the teacher (for example a document camera) do not interfere at all with the lec-

tures (Hakala & Myllymäki 2007). Also, the feedback that has been collected after each course has not elicited content stating that video recording is in any way disruptive to the students.

5.4 Evaluation of the impacts of the blended education model

The other main topic area of the education model's evaluation is its impacts. When assessing its impacts on people, all roles related to the education model should again be taken into account. The central goal and intended impact of the development was to increase the accessibility of teaching. This is an important consideration for the educational organization, which naturally hopes that students are able to study more efficiently and, as a result, graduate faster. Improving accessibility also opens up possibilities for the organizer to recruit students who otherwise could not participate in the degree program due to various reasons. For students, the education solution's positive impacts on accessibility are almost vitally important. Without improved accessibility, adult students' scheduling challenges make studying more difficult, or even impossible. Another focus area when evaluating the impacts of the education model is their impact on the operating environment. Above all, blended education models affect the role of contact teaching. These changes are also evaluated as part of this work.

According to the results, the goals set for the development regarding its impacts were achieved very successfully and were even above expectations. Accessibility was increased to a very high level, and in practice, teaching has been accessible whenever you have internet access. Improvements to accessibility also had positive impacts on learning outcomes. The research results indicate that from a learning standpoint, studying with videos is at least as equally effective as studying with contact teaching. However, the role of contact teaching has clearly undergone changes after the videos were implemented, and may continue to do so in the future. These forthcoming developments may require the role of contact teaching to be re-evaluated.

5.4.1 Accessibility of education

Increasing the accessibility of education in order to enable more methods of participation was a central development goal when the education was taken into the direction of blended learning. In the education model, students can freely choose their preferred studying method between contact teaching and real-time or on-demand video, on a lecture-to-lecture basis. The model's accessibility is examined in publications **PI**, **PIII**, **PIV**, **PV** and **PVII**.

It can be considered somewhat obvious that the videos themselves increase accessibility. In order to allow as many students as possible to take advantage of the improved accessibility, the selected solutions must be compatible with a variety of devices, and support mobility and slower internet connections. In the environment examined in the study, video production was first carried

out using the Windows Media format. Moving to the h.264 video format in addition to Windows Media greatly improved device independence and also enabled support for mobile devices. Bandwidth requirements of the videos produced in the research environment were always moderate, making teaching materials accessible even on slower connection speeds (**PV**).

Improvements to accessibility can also be measured by examining changes in the participation rates of education before and after the videos were implemented. Studying by using videos also includes participation using real-time or recorded videos. The total number of students participating using videos is itself revelatory in suggesting whether videos are an applicable solution for increasing accessibility, as well as how well students have been able to implement the videos in their studies.

In order to examine changes in participation rates, figures from 2005–2010 were looked at (**PV**). In 2005, all teaching in the degree program was organized as contact teaching. Video recording was tried only on two courses, which were excluded from the data from 2005. In 2010, all teaching was correspondingly offered as both real-time and on-demand video in addition to contact teaching. In 2005, less than one-tenth of the students resided more than 100 km away from the city they studied in, allowing good opportunities to participate in contact teaching in this regard. By 2010, as many as four out of ten students lived over 100 km away from campus. Increases in accessibility led to a clear change in the degree of participation during this period of time. The lecture-specific participation rate was by average 54% in 2005, whereas in 2010 it was 70% with all methods of participation taken into account (**PV**). In 2010, nearly three-quarters of lecture participations were conducted using videos (Figure 13) (**PV**). The improved degree of accessibility brought about by the videos and the resulting increase in participation rates were also highlighted in a study focusing on students' learning outcomes. Students who frequently made use of videos had higher participation rates than students who mainly relied on contact teaching (**PIII**).

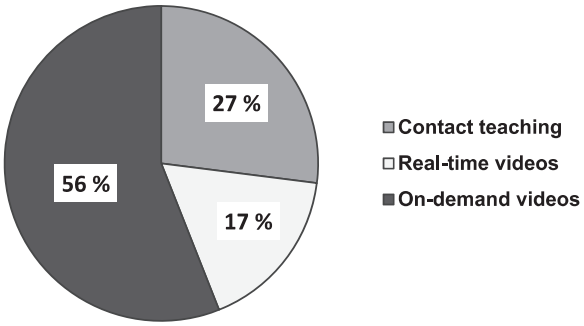

FIGURE 13 The relative share of different participation methods in 2010 (n=1101)(PV).

In the studies this dissertation is based on, the share of participation via videos was around two-thirds, depending on the set of data. Around half of the participations took place via on-demand videos, and an eighth with the help of real-time videos. Correspondingly, the share of participation based on contact teaching was roughly one-third at all times. Already in 2008, individual students watched more than seven hours of videos by average during each course (**PI**). These figures clearly indicate the significant role that videos have in participation in the degree program. When students were allowed to choose their preferred method of participation, the use of videos proliferated. Based on their wide degree of use, videos are arguably well-suited for educational purposes.

Besides usage statistics, students' opinions also support this conclusion. According to a wide-scale questionnaire study conducted in 2010, nearly all students agreed that lecture videos were useful for participation, focusing time allocation, revision, finishing course tasks and understanding new topics (**PV**). Only about one out of twenty students considered lecture videos to impede learning. However, according to the questionnaire's results, slightly over half of the students would prefer contact teaching; even though in practice, working adult students may not have the opportunity to attend such classes. According to the questionnaire results, participation using on-demand videos was the most suitable, schedule-wise, for nearly half the students, while only about one out of ten were able to make contact teaching classes fit their schedule (**PV**). From this standpoint, increasing accessibility has been very important. What was clear when examining the motivations for participating using lecture videos was that improved flexibility and the resulting increases in accessibility were an important motivating factor (**PIV**).

While performing the evaluations, it was observed that students who participate via different means also had varying preferences regarding methods of participation. According to the student interviews held in 2010, those who emphasize contact teaching consider it to be the best alternative for them (**PIV**). However, increased flexibility motivates students who primarily attend contact teaching to also utilize videos (**PIV**). It can be argued that even students who live near the campus need flexibility in their studies. Students who prefer distance learning generally think that videos can be used as a substitute for contact teaching (**PIV**). These are typically students who have less time to use for studying, due to their jobs. Furthermore, they are more likely than average to have a family and to consider physical distance to be a motivating factor for watching videos. Hybrid students, i.e., students who utilize a balance of contact teaching and videos, would often like to attend classes in person, and do not feel that participating via videos suits them as well as those who prefer distance learning. Even though hybrid students would prefer to participate in contact teaching, they cannot fit either attending classes or watching real-time videos into their schedule (**PIV**). For hybrid students, their manner of participation is above all determined by their schedule, not distance (**PIV**). In other words, the improved flexibility of videos is vitally important for hybrid students in particular, as well

as students who prefer distance learning. Without this flexibility, these students would find studying very difficult or even outright impossible.

Despite improved accessibility, most students still primarily participate in education following the pace of contact teaching situations, i.e., before the next class is held (**PVII**). This means that many of the students utilize the flexibility provided by the improved accessibility within a course's allotted time constraints.

5.4.2 Learning outcomes

One of the most important questions when evaluating the blended education model is its impacts on learning outcomes. At best, blended learning can combine the benefits of traditional contact teaching and distance learning. Conversely, blended learning in the worst case can be seen to combine the negative sides of these methods. The education model's impacts on learning outcomes have been examined in publications **PII**, **PIII**, **PIV** and **PVII**.

The idea behind improving student's opportunities to participate in education has been to allow them to better take courses and to have students graduate in time. In practice, this means that students are expected to pass courses more successfully, thanks to improved accessibility. However, the intention was not to have students pass courses more successfully at the cost of learning outcomes. In other words, the video-based practices were not intended to weaken grades.

Studying using videos is most different from contact teaching in terms of interactivity. During the research, the lecture videos' lack of a feedback channel for interaction between students and lecturers made interaction entirely one-way, and in this regard made it very different from the interaction offered by contact teaching. Viewers of real-time videos typically had no possibility to participate in the communication occurring in class. With on-demand videos, realizing interaction is even more challenging. Communication happening outside contact teaching was handled using an LMS, automatically making it quite asynchronous in nature.

Measuring learning outcomes is difficult, but one possible gauge is successfulness in passing the courses and thus progressing in one's studies. On the level of individual courses, performance and learning outcomes can be assessed with grades. A student's average grades can be used as a rough estimate of his or her performance in the degree program.

Learning outcomes were at first examined using very strict data categorization methods (**PII**). The study found that participation degrees and course passing rates were correlated, and that utilizing videos led to higher participation rates (**PII**). However, no correlation was observed between the degree of participation and grades. Secondly, students were categorized more loosely between those who favored contact teaching, those who favored distance learning and those who used a balanced combination of both. According to the results, participating in education using videos had a positive impact on passing courses (**PIII**). Students who utilized both contact teaching and videos equally partic-

ipated in education more than others, and also passed courses more successfully (**PIII**). The course pass rate of students who primarily watched videos was clearly higher than of those who primarily attended contact teaching, even though the degree of participation was largely similar between the groups (**PIII**). Results regarding course pass rates are presented in Figure 14.

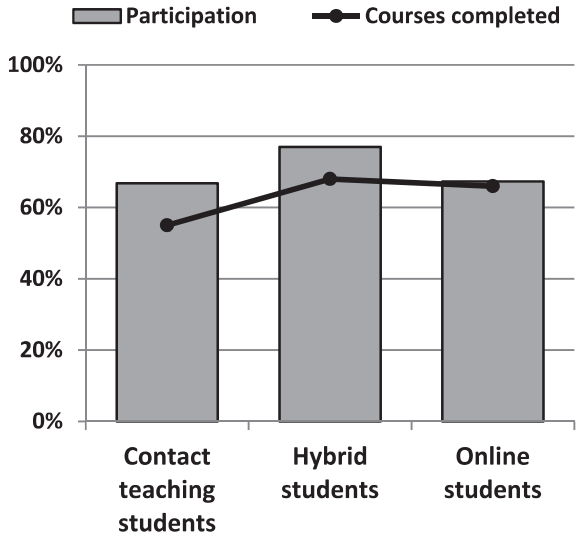

FIGURE 14 The average of participation rates (bars) and the averages of the shares of completed courses (graph) by student class. The data includes 74 students and 22 courses held between 2008 and 2010.

The analysis of this categorization also took grades into account. Comparisons between students who primarily either participated contact teaching or watched on-demand videos showed that those who watched videos received better grades on average (Figure 15) (**PIII**). As illustrated in the figure, students who utilized both modes of participation equally received slightly worse grades than others, regardless of the better participation rate. While examining students' motivations for choosing their particular mode of participation, it was found that students who made use of both methods equally would often have liked to attend contact teaching, but chose instead to watch videos from time to time due to practical reasons (**PIV**). In other words, they studied partly against their studying preferences. This may in part explain why they received lower grades than others. However, this does not seem to have much impact on their success in passing courses, as Figure 14 illustrates

Especially students who live further away and thus use videos more often received clearly better grades than those who lived near the campus and primarily attended contact teaching (**PIII**). This observation is illustrated in Figure 16, in which group A represents students living at maximum 50 km away to the campus and Group B those who live farther away.

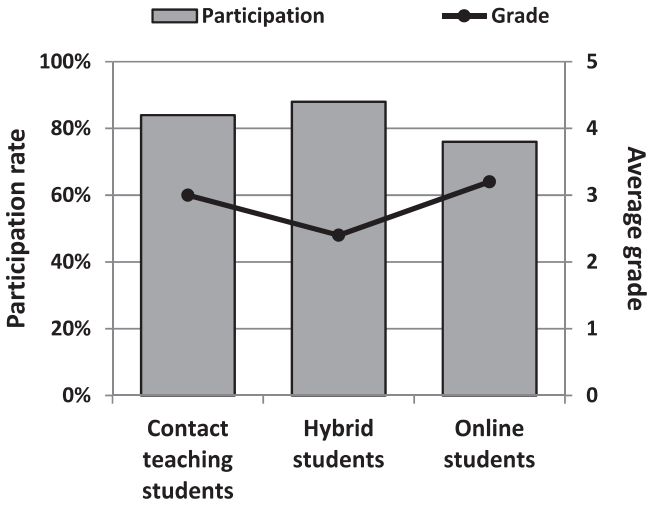

FIGURE 15 The average of participation rates (bars) and the average grades for the courses (graph) by student class. Assessment on a scale of 1–5. The data includes 65 students and 20 courses held between 2008 and 2010.

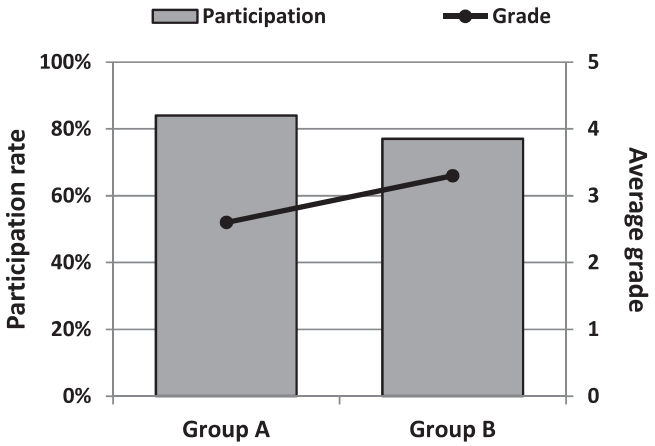

FIGURE 16 The average of participation rates (bars) and the average grades for the courses (graph) by students living near campus (Group A) and farther away from campus (Group B). Assessment on a scale of 1–5. The data includes 65 students and 20 courses held between 2008 and 2010.

The education model's impacts on learning outcomes were also evaluated in comparison with students' own expectations (**PIV**). According to a questionnaire for students, those who mainly studied by watching videos seemed more successful in reaching their study goals. Two-thirds of students who mainly studied by watching videos said their studies had progressed according to their own expectations. About half of the students who utilized a balance of contact teaching and videos shared this opinion, while only one-third of the students who mainly attended contact teaching had this view.

Another interesting result came from examining the times when students participated in course activities (**PVII**). Students who followed the pace of con-

tact teaching in watching lecture videos, i.e., primarily before the next lecture, achieved better learning outcomes in regard to course pass rates (Figure 17) and grades (Figure 18) than students who studied with delay (dictated their own pace without following the schedules and time allocations of contact teaching classes).

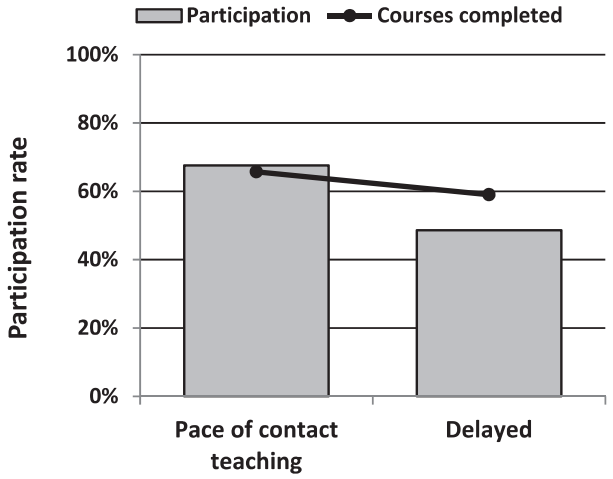

FIGURE 17 The average of participation rates (bars) and averages of shares of completed courses (graph) by students studying at the pace of contact teaching and students studying with delay (without following the schedules of contact teaching). The data includes 77 students and 38 courses held between 2008 and 2012.

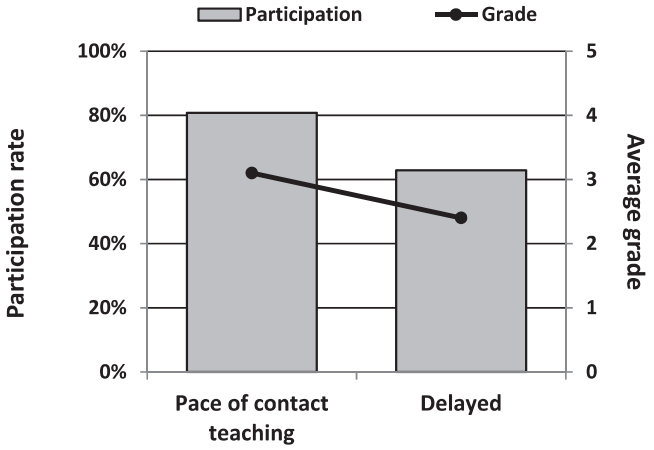

FIGURE 18 The average of participation rates (bars) and average grades for the courses (graph) by students studying at the pace of contact teaching and students studying with delay (without following the schedules of contact teaching). Assessment on a scale of 1–5. The data includes 57 students and 35 courses held between 2008 and 2012.

5.4.3 Changes in the role of contact teaching

Recording lectures has significantly changed the role of contact teaching, since there are currently other ways as well to participate in the instruction. Participation becomes a broader concept when it can happen outside class using real-time videos, and also at any time using on-demand video. Perhaps the most commonly asked question in this regard is how video lectures affect participation in contact teaching. The education model's transformative impacts on the role of contact teaching have been analyzed in publications **PII**, **PV** and **PVII**.

Retaining contact teaching alongside video lectures makes it possible that students do not have to decide their mode of participation in advance. They can instead choose the best alternative on a lecture-to-lecture basis, depending on what best fits their circumstances or study preferences at a given time. In other words, the education follows the blended education model, wherein the students themselves decide the degree of blending. It is also possible to attend contact teaching exclusively. The existence of contact teaching and the resulting free choice of one's mode of participation are central elements in the examined education model.

As previously stated, even though the overall participation rate has clearly increased thanks to the blended education model, participation in contact teaching has diminished. Between 2005 and 2010, there was a notable drop in the participation rate of contact teaching, from 54% to 27%. When assessing the importance of contact teaching, what needs to be remembered is that participation using real-time videos requires the existence of contact teaching. Depending on the set of data, the share of participations using real-time videos was slightly less than one fifth. Since around one-third of all participation was in contact teaching, it can be said that nearly half of the participation in the examined blended education model still take place simultaneously with, and by utilizing, contact teaching.

The majority of students in the degree program expressed a desire to attend contact teaching if there were no obstructions for doing so (**PV**). In practice, however, working adult students do not always have the opportunity to participate in contact teaching. In light of this, it is understandable that only one out of ten students considered contact teaching to be the most suitable form of participation for them, schedule-wise. Depending on the specific course and personal circumstances, even students who mostly studied by watching videos participated in contact teaching in some courses (**PII**). This of course supports the need for contact teaching.

Another reason for advocating for the continued existence of contact teaching is that it provides a natural environment for producing lecture videos. Without contact teaching classes, lecture videos would have to be recorded in a studio environment, which would introduce additional costs. Since the video production of studied education model is light-weight and inexpensive, new videos can be recorded each time a course is organized and then deleted afterwards. By allowing access to the videos only for students enrolled in the course,

and only for the duration of the course, many copyright issues typical for video production can be avoided.

When focusing on participation from a temporal standpoint, it was found that even though students extensively utilized the flexibility provided by the use of videos, they still attempted to follow the schedule of contact teaching (**PVII**). In practice, this means that even when using videos, students primarily attempt to watch the previous lecture video before the next lecture held. Four out of five students included in the study followed this practice. Thus, contact teaching appears to be beneficial even for students who frequently watch lecture videos. The study does not examine further why students use the videos in this manner. In any case, the time of participation seems to have an impact on grades and course pass rates, with those following the contact teaching schedule achieving better learning outcomes (**PVII**).

6 DISCUSSION

This section summarizes the results presented above. The section also discusses the meaning of the results, as well as how successfully the education model meets the goals that were set for it.

6.1 Functionality of the blended education model

The evaluation of the education model's functionality was performed by examining its cost efficiency, operational reliability and transparency. The evaluation concluded that the model's operational reliability, transparency and cost efficiency meet very well the goals set for them. Even though cost efficiency and operational reliability can almost always be improved further by increasing the degree of automation, the developed education model can be stated to be very functional overall.

As mentioned in Section 2.2.3, the costs of education following blended learning model can be compared to the costs of the earlier, traditional model of education or it can be analyzed from the viewpoint of how efficiently education following the model can be organized. In the environment studied, the objective of the blended education model was not to achieve savings in comparison to a traditional model but to keep the costs of blended education low. For this reason, cost efficiency was examined precisely by assessing how much additional resource the developed artifact, organized blended education model, required. This evaluation was performed from the viewpoint of the educational organization. The hardware and software acquisitions necessitated by the education model are one-off costs. The largest expense factor is the amount of work required by the new practices. Usage costs have in fact been an essential consideration in evaluating the education model's cost efficiency. The cost efficiency of use costs is most noticeable in the preparatory and post-production stages of video production, as these stages require the highest number of man-hours. Cost efficiency should additionally be accounted for in matters related to distri-

bution, quality control and possible backup systems. Although costs can be measured very precisely, determining cost efficiency is challenging, since it is always a subjective measure that is highly dependent on the available resources. Costs that may be reasonable to one organizer may be too high for another one. In the education model examined in this research, cost efficiency was improved by increasing the level of automation and by implementing functional practices. Thanks to automation, the production and distribution processes were made light enough to allow the production to cover the entire master's degree program. Around half a month's worth of man-hours are required annually from the organizer. It can be argued that the education model is functional in terms of cost efficiency and that its goals were successfully met, since the resources employed in its realization were adequate for organizing the education. However, the model's cost efficiency could yet be slightly increased by, for example, increasing automation to allow more recordings to be timed at once than is currently possible, or to even make it possible to time all recordings while the study program is being designed by directly connecting it to the booking system, thus resulting in no extra work. Noteworthy about cost efficiency is that this property is highly susceptible to changes that may occur when other parts of the system are developed. If cost efficiency is set as a priority, it needs to be taken into account during the development of new solutions.

In regard to operational reliability, the goal is always to achieve a technically flawless solution. In practice this means minimizing errors resulting from the organizer's own actions, and to a reach a situation where external failures, such as power outages, could be combated with a substitutive solution. Reliability of production is best achieved by taking the consideration into account during all stages of development. Implemented devices should be tested, and reliability should be one of the main concerns when choosing hardware. The formed practices must also be designed in a way that minimizes the possibility of human error. As the research results clearly indicated, a video-based education model can be realized with fairly few errors. In the model examined, the occurrence of errors has steadily decreased throughout the evaluation period. By the end of the examination period, the model has even reached a nearly error-free state, especially in regard to complete failures. However, even partial failures may be disruptive for students, since in these situations the lecture videos often become available to students later than planned, typically during the next working day. Still, from a reliability standpoint the education model can be said to be at an excellent level and to be very successful in fulfilling its objectives despite minor flaws. The model's operational reliability could still be improved by, e.g., increasing automation to reduce the chance of human error.

A goal of the examined education model was to have it require no particular actions from lecturers or students regarding video recording. Typical recording solutions may fail to achieve transparency if the lecturer must establish or close connections, operate technology, or, for example, ensure that the microphone is working properly. Lecturers may also have to adjust their teaching materials to be suitable for video recording. The goal of the examined education

model during the period of research was that lecturers could teach their classes just like normal, and that the organizer would ensure the teaching is recorded. The developed education model does not in fact require lecturers to account for any specific recording procedures. Lecturers have not given any negative feedback regarding teaching arrangements or their own stressfulness. While providing feedback at the end of courses, students have similarly had no complaints. The goals of the education model have thus been clearly fulfilled from the standpoint of transparency, which was achieved thanks to three main factors: the recording hardware was seamlessly integrated into classrooms, the image source is captured directly from the feed going into the projector, and the recording starts and stops automatically. Lecturers did not need to alter their way of teaching, though they were able to do so if they wanted. For instance, lecturers were able to come up with new pedagogic solutions that better take advantage of the technological environment and which also facilitate distance learning even better. If participation in the teaching in this education model begins to emphasize distance learning more in the future, what is needed are precisely these types of new pedagogic practices as well as the new technological solutions that support them.

6.2 The impacts of the blended education model

Overall, the objectives set for the education model regarding impacts were achieved very successfully, even positively surpassing expectations in some cases. From an accessibility standpoint, the impacts of implementing the examined education model were in line with what was hoped for, and the model's accessibility is now at a very high level. The model has also met and partly even exceeded expectations regarding learning outcomes. As for analyzing the role of contact teaching, there was no specific goal. That said, implementing the education model has clearly had an impact on the role of contact teaching, causing fewer students to attend these classes. If the same trend continues, there will inevitably be a need to re-evaluate the inclusion of contact teaching.

As stated in Section 2.2.1, blended education can be arranged from the point of view of flexibility for several reasons (Picciano & Seaman 2007). In the education model being studied, the main motivation for blending is avoiding scheduling conflicts. In the examined education model, teaching was available in video format if a student could not attend contact teaching. Lecture videos also offers opportunities for re-taking courses for students who have failed courses. The video distribution model supports all common devices, and lecture materials are accessible even on slower connection speeds and mobile devices. As stated in Section 2.2.1 mobile technology has the potential to increase accessibility in a blended learning. It can be said that the education offered in the blended education model is very easily accessible, regardless of time and place. The increase in accessibility can also be seen in the participation rates when examining participation before and after implementing the video system. Fur-

thermore, accessibility is achieved in the model using a solution that is suitable for studying. This becomes evident by examining the ways in which students participate in the education, with lecture videos playing a significant role. The study also found that students who primarily study using videos participated in the education as much or even more than those who primarily attended contact teaching.

As mentioned in the theoretical part of the work (see section 2.2.1) accessibility can be examined on multiple levels. It should be pointed out that at the time of the research, improved accessibility was achieved above all at the course level by using lecture videos. Courses typically started at a given time and lasted for a certain amount of time. Because the implementation of the courses, with the exception of participation in the lectures, was otherwise similar, the accessibility was not improve at all levels. Although a student could participate flexibly in lectures, s/he still has to complete the course's learning assignments and exams in the schedule required by the lecturer. Accessibility could thus be further enhanced by making courses available at any time during the academic year. The blended education model certainly promotes the implementation of such so-called non-stop courses. In this case, however, the pedagogical solutions of the course will change and the blended education model would no longer be transparent for the lecturers and students.

Because the one objective of the blended education model was to to keep the model as transparent as possible, the more versatile pedagogical solutions that blended learning makes possible, were virtually impossible to implement. Thus, when evaluating learning outcomes in this study, no attempt has been made to assess whether the blended model has brought better pedagogy. In regard to learning outcomes, the goal of the development was that the increase in flexibility would translate to higher course pass rates, but without compromising learning outcomes. According to the results, lecture videos increase accessibility, which enables higher participation rates, and in this way even improves learning outcomes. This is indicative of the fact that the evaluated model has been successful in achieving the aforementioned goal, and that its impacts have been positive. It seems that the central issue is not the method of participating in education, but rather the ability to participate at all.

As discussed in section 2.2 the main differences between blended education model and traditional education are typically related to interaction. Interaction collaboration and social presence are important if successful learning outcomes are wanted. On the other hand, it is known that the flexibility introduced by the embedded training model is important for students (Smyth et al., 2012, So 2009, Welker and Berardino 2005). In the education model studied, the students themselves decide on the degree of blending. Students can, according to their own needs, participate in the classroom or take advantage of the flexibility of the videos. This may partly be the reason for good learning outcomes too.

As mentioned in Section 2.2.5, earlier results related to learning outcomes have been contradictory. Perhaps the most similar results with the results of this study were achieved in the extensive meta-analyzes by Means et al. (2013)

and Means et al. (2009). They also found that blended learning courses produced better learning outcomes on the average than contact teaching courses, though the courses analyzed were partly different in the field of education from the subject of this study. Similar results were also found in several other studies (Thai, De Wever & Valcke 2017, Wiese & Newton 2013, Suda et al. 2014, Vajoczki et al. 2010, Griffin, Mitchell & Thompson 2009, Dziuban, Hartman & Moskal 2004). Some of the studies showed contradictory results (e.g., Jensen 2011, Congdon et al. 2009). Negative results were less common in earlier researches.

Successfully passing courses naturally also decreases the time needed to graduate, which is an important consideration for the educational organization. Worth noting, however, is that for hybrid students who utilized a balance of videos and contact teaching, the high rate of participation did have a positive impact on passing courses, but not on grades. Learning outcomes also seem to suffer if the flexibility provided by the lecture videos is used to postpone studying too close to the end of a course.

The purpose of evaluating the role of contact teaching was to determine how it has changed as a result of implementing the new education model. According to the results, participation in contact teaching has diminished, but there were still valid reasons for organizing contact teaching during the research period. As mentioned in section 2.2.4, in several earlier studies, similar changes in the role of the classroom teaching were also observed (e.g., Traphagan, Kucsera & Kishi 2010, Chester et al. 2011, Holbrook & Dupont 2011), though there were also reversed observations (e.g., Von Konsky, Ivins & Gribble 2009, Brotherton & Abowd 2004, Grabe & Christopherson 2008).

Among other things, contact teaching situations served as a natural place for producing videos. The results also showed a portion of students expressing a preference for participating in education via contact teaching, though in practice they were not always able to do so as adult students. However, even students who primarily studied with videos would occasionally attend contact teaching. From the organizer's point of view, it is important to note that contact teaching continues to have a significant role for a number of students, and that participation via real-time video also requires for it to be organized. After all, almost half of the participation in education occur simultaneously with contact teaching. If contact teaching were to be abandoned, a large portion of students would have to change the way they participate in education. However, it should be noted that if participation using videos becomes more common in the future, the continuation of contact teaching will need to be re-evaluated. The diminished role of contact teaching means fewer opportunities to have real-time verbal interaction in environments like the one examined here. This increases pressure to enable better interaction alongside participation using real-time videos.

When the aforementioned research results are compared with the development goals of the education model;

- the solution must improve the accessibility of education and thus increase course pass rates
- the video production must be cost efficient and reliable, and
- the video production must be transparent

it can be said that the objectives have been fulfilled. The evaluated video-based education model that follows the principles of blended learning enables the organization of education that is more accessible than in the earlier solutions. Evaluation of the artifact shows that from the viewpoints of students, lecturers and the educational organization, operating in a manner based on the model in the examined environment has been meaningful overall.

6.3 Research evaluation and limitations

This evaluative study is part of a larger design science research. The partial studies containing individual evaluations were carried out as case studies, meaning that the quality of the study is also evaluated from the viewpoints of both its quality as a case study and it being a representation of design science research. Theories related to the evaluation of quality are discussed in section 3.5.

In regard to the structural validity of a research, it is important to have adequately extensive data that has not been narrowed down subjectively. The case studies included in this dissertation have attempted to collected comprehensive sets of data. In practice, this means that the case studies were only carried out after there was enough data to examine. This, on the other hand, has resulted in the study being conducted over a long period of time. The purpose has been to include all students in the case study data, without selecting them subjectively. The data essentially includes all active students whose information has been available at a given time. However, because the realization of the education model was applied to a degree program that has fairly few students, in some cases it was necessary to dismiss data classifications where there would not have been enough data for some of the categories. In this regard, a wider set of data could have opened more possibilities for examination.

For the sake of internal validity, it is important not to draw unfounded conclusions from the results and to instead base deductions on direct observations as much as possible. This can be achieved by, e.g., analyzing the data carefully and by using analysis methods instead of deduction. The partial studies presented here have attempted to utilize statistical methods whenever applicable. The data in the case studies was quantitative. Processing the data has been statistical. Conclusions drawn from the results are typically based on statistical examination, which is useful for avoiding distorted interpretations of results caused by researchers' subjective views. The choice of statistical analysis methods was mainly dictated by the framework of the research and the quality of the data, not the phenomenon examined.

Gauging the generalizability of the individual case studies, i.e., their external validity, is arguably not meaningful in this study, since the case studies are part of larger design science research. The purpose of the case studies was to evaluate the examined environment without making any specific generalizations. The generalizability of the study is in fact discussed later in this section, mainly in relation to its generalizability as a design science research.

In order to improve the reliability of this study, the studies' terminology, theoretical framework, research environment, data collection methods, data, possible classifications and the processes of analysis were documented in adequate detail. Another factor contributing to the study's reliability is the data triangulation used in it. As is typical for design science research and case studies, the data for the study was collected from multiple sources to accumulate a richer and more reliable set of data. In other words, the study utilized various data, data collection methods, and classifications within the data. This is especially accurate when the study is examined as design science research, which is what the case studies represent. Doing so emphasizes how the results of the design science research are achieved by utilizing various kinds of data, data collection methods, and classifications. The data was collected carefully and the phone interviews were recorded, for example. Multiple researchers participated in the collection and processing of data and the analysis of the results. This so-called researcher triangulation is very useful in reducing the occurrences of outright errors, as well as flawed interpretations caused by subjective viewpoints.

A researcher's own familiarity with the topic of research also adds to the credibility of a study. Indicative of the author's own familiarity with the topic of the research is the fact that he himself has graduated from the master's degree program in question. Furthermore, he has worked in the program for over ten years in development and teaching tasks. During this time, the author has participated in numerous projects involving the development of educational technologies and associated practices. The author has participated in designing and realizing these projects, and worked in a number of them as part-time employee and project manager.

Using precise methods is important in evaluating the quality of design science research. A crucial task when evaluating an artifact is to define the evaluation criteria. Furthermore, the artifact must be evaluated in a purposeful environment. In this study, the evaluation of the artifact was carried out using the case study method, and the results of the evaluation were published in scientific peer-reviewed conferences or journals. The purpose of the peer-reviews was to verify the validity of the research. The evaluation criteria of the present study are based on internationally recognized quality criteria for evaluating the realization of artifacts and the quality of online teaching. These criteria have been accommodated to be applicable to the topic at hand, in order to increase the reliability and comparability of the research. The developed education model has been tested with actual students, lecturers and organization in a genuine educational environment for which the model was originally designed. However, it is not possible to control all variables when conducting case studies in this

type of environment, which naturally has an impact on a study's reproducibility and the generalizability of the results.

In summary, this research was based on theoretical background information, experience, and knowledge gained through piloting. The study utilized applicable research methods, the result of design was implemented in an applicable environment, and the evaluation criteria were formed as based on generally acknowledged criteria. The data used in the study was versatile, as were the methods of processing and analyzing the data.

6.3.1 Generalizability of the results

The education model evaluated here was developed from a very specific starting point for the purpose of solving challenges faced in an certain education program. In light of this, the examined artifact follows the classification strategy introduced by Iivari (2015), in which the goal is precisely to solve a problem appearing in a certain environment. This approach is not quite as common as another strategy described by Iivari, in which the objective is to resolve a general problem that is not necessarily related to any particular situation. Because of this, the study's results are above all highly relevant in practice, but more difficult to verify on a general level.

From the viewpoint of adult education, the challenges related to the education model examined here are very commonplace. The artifact can thus be considered to combat problems related to typical adult students' time allocation. Similar challenges are a relevant topic also in relation to master's degree programs, as students often begin their working careers while still studying. In this regard, the evaluated solution is not only suitable for the examined environment, but is also significant in a wider context.

Generalizability can also be examined from a technological standpoint. The developed technological solution is highly customized to fit the needs of the education program, e.g., in regard to pedagogic solutions (like a certain type of need for interaction) and technological solution (such as LMS). With these considerations in mind, the technological solutions presented and evaluated in this study can be generalized for application in similar education programs. The solution is also closely tied to the infrastructure provided by the local organization, such as its servers and the hardware integrated into the classrooms. In practice this means that the technological solution can be built by anyone, as long as the organization has the required know-how. However, it cannot be transferred to a different environment as is.

The generalizability of evaluation of functionality of the solution follows the same pattern; if the technological solution is constructed similarly to the one described in this study, the evaluation results regarding functionality can be generalized to apply to that environment. Then again, the evaluation results regarding the solution's impacts are largely case-specific, and in many respects cannot be generalized into a wider context.

The education model concerned, which is based on the versatile use of technologies, was used in a master's degree program in mathematical infor-

mation technology. The IT students participating in the study were probably better prepared to adopt the new technologies than average students from the viewpoints of technical know-how and possibly also hardware and infrastructure. When analyzing the generalizability of the impacts, attention should also be paid to the substance being taught and the teaching methods employed. For example, teaching technological and mathematical subjects may be significantly different from teaching humanities, and studying with the use of videos may not be suitable for all subjects. In many aspects, the education solution presented in this study was customized for Kokkola University Consortium Chydenius' master's degree program in mathematical information technology, for example, with regard to interaction solutions. Implementing the same solution into an environment that utilizes entirely different teaching methods may thus produce largely varied results regarding its impacts.

7 CONCLUSIONS AND FUTURE WORK

This dissertation is based on a development work that aimed to produce a new education model based on technologies and their associated practices for use in Kokkola University Consortium Chydenius' master's degree program in mathematical information technology. The goal of the solution was to increase the accessibility of teaching by offering students more flexible participation opportunities. The essential goal of this dissertation was to describe the achieved artifact as a whole and evaluate it.

The first research question in this study was "*Is the education model technically functional?*" The education model examined in this study proved to be cost efficient, transparent for lecturers and students and operationally very reliable. It is thus fair to say that the model is functional from the technological point of view. The second research question was "*What are the impacts of the education model?*". Results showed that it has positive impacts on the users of educational environment. The model enables significant improvements in the accessibility of education without affecting learning outcomes negatively. In fact, it can even improve them. Allowing students to choose their preferred way of participating in education results in vastly different ways to complete a degree program. Some students primarily attend contact teaching, while others may utilize videos extensively. Furthermore, a portion of students make use of a balance of both methods. However, in an environment like the one examined here, videos seem to have a particularly significant role.

As the research results show, it is possible to form an education solution based on both contact teaching and the use of videos that is meaningful for students, lecturers and the organizer of education alike. A carefully thought out, well-constructed technological environment, that takes its target audience's needs into account, can at best provide genuine additional value; it is not merely a substitute for contact teaching or a copy of it.

The solution in question seems in many respects to be representative of the direction that higher education is likely to follow in the next few years. However, the development targets and possibilities of the future development can already be identified in the examined education solution. When the accessi-

bility of an environment is at a good level, the focus of development in the future may shift more towards improving opportunities for interaction and for collaborative work. There is also need for pedagogic solutions that utilize the environment more efficiently.

In the future, a solution similar to the one examined here would also enable organizations to provide increasingly personalized education. This would mean that the current learning environment would be developed towards one in which each student could choose the studying methods that best suit him/her in regard to time allocation, knowledge acquisition and study preferences. Virtual environments do in fact offer completely new opportunities for supporting learning. For instance, versatile data related to study behavior can be collected and analyzed for utilization in addressing the needs of students, lecturers and educational organizations. These so-called learning analytics enable education to be better customized to suit each student's needs and studying behavior. In the future, the more versatile pedagogical opportunities offered by blended learning may also be utilized in teaching and thus further improve learning outcomes.

YHTEENVETO (FINNISH SUMMARY)

Videoihin perustuvan sulautetun koulutusmallin kehitys- ja arviointitutkimus

Kokkolan yliopistokeskus Chydeniuksessa järjestettävän tietotekniikan maisterikoulutusohjelman kaikki opiskelijat ovat aikuisia ja suurin osa perheellisiä ja työssäkäyviä. Tällaisilla opiskelijoilla ajankäyttöön liittyvät haasteet ovat merkittävä opiskelua haittaava tekijä. Opiskelijoiden on vaikea osallistua perinteisesti järjestettyyn koulutukseen. Haasteena tällaisessa koulutuksessa ei ole opiskelijoiden työllistyminen vaan opetuksen saavutettavuuden parantaminen.

Tämän väitöskirjatutkimuksen taustalla on ollut kehitystyö, jonka tarkoituksena on ollut muodostaa Kokkolan yliopistokeskus Chydeniuksen tietotekniikan maisterikoulutuksen yhteyteen teknologioihin ja niiden ympärille rakentuneisiin käytäntöihin perustuva uusi koulutusmalli. Ratkaisun tavoitteena on ollut lisätä opetuksen saavutettavuutta tarjoamalla opiskelijoille joustavampia osallistumismahdollisuuksia. Kehitetyssä koulutusmallissa joustavuus on toteutettu ennen kaikkea luentovideoiden avulla. Kehitystyö on tehty suunnittelutieteellisen tutkimuksen periaatteiden mukaisesti. Koulutusmallin keskiössä ovat luentovideoiden lisäksi niiden vaatimat tuotantolaitteistot ja teknologioiden ympärille muodostuneet käytänteet.

Tutkimuksen kohteena olevan koulutusratkaisun keskeisimpiä periaatteita on opiskelijalle tarjottava valinnan vapaus omista opetukseen osallistumisen tavoistaan. Koulutusohjelman opiskelijat voivat valita osallistumistapansa luentokohtaisesti kulloiseenkin elämäntilanteeseensa parhaiten sopivalla tavalla lähiopetuksen, reaaliaikaisen videon ja tallenteen välillä. Valinta voi perustua opiskelijan omiin opiskelumieltymyksiin tai esimerkiksi työn tai perhe-elämän asettamiin aikataulullisiin haasteisiin. Tällainen valinnan mahdollisuus tekee koulutuksesta hyvin uniikin. Opiskelijat siis itse päättävät omalta kohdaltaan opiskelunsa sulautumisen asteen. Opiskelijat voivat myös halutessaan opiskella täysin lähiopetuksessa tai täysin etäopiskelijoina. Ratkaisulla pyritään joustavuuden lisäksi tukemaan erilaisia oppijoita.

Väitöskirjan keskeisenä tavoitteena on ollut kuvata syntynyt koulutusmalli kokonaisuutena ja toteuttaa sen arviointi. Arviointia on tehty kahdesta näkökulmasta; koulutusmallin toimivuuden, kuten kustannustehokkuuden ja toimintavarmuuden näkökulmasta ja toisaalta koulutusmallin käyttäjäyhteisölle tuottaman arvon ja hyödyn näkökulmasta. Arvioinnin kohteena on siis ollut järjestelmän toimivuuden lisäksi sen vaikutukset. Arviointia on toteutettu erillisissä tapaustutkimuksissa, joilla on pyritty todentamaan riittävän pitkälle viety kehitystyö eri näkökulmista. Tapaustutkimukset on raportoitu väitöskirjan osana olevissa julkaisuissa. Tässä väitöskirjan johdanto-osassa on tehty synteesiä näiden osajulkaisujen arviointien pohjalta ja muodostetaan koko koulutusmallia koskeva kokonaisarviointi.

Toimivuuden arviointia toteutettiin tarkastelemalla koulutusmallin kustannustehokkuutta, toimintavarmuutta ja läpinäkyvyyttä. Koulutusmallin lä-

pinäkyvyys on arvioinnin mukaan erittäin hyvällä tasolla ja toimintavarmuus ja kustannustehokkuuskin hyvällä tasolla. Vaikkakin kustannustehokkuutta ja toimintavarmuutta voidaan kehittää lähes rajattomasti esimerkiksi lisäämällä automatisointia, voidaan yhteenvetona todeta muodostuneen koulutusmallin olevan toimivuuden näkökulmasta arvioituna varsin hyvin toimiva.

Kokonaisuutena tarkastellen koulutusmallille asetetut, vaikutuksiin liittyvät tavoitteet on myös saavutettu erittäin hyvin. Osittain positiiviset vaikutukset ovat jopa ylittäneet odotukset. Saavutettavuuden näkökulmasta tutkimuksen kohteena olevan koulutusmallin käyttöönoton vaikutukset ovat olleet toivotunlaiset. Saavutettavuus on kehittynyt koulutusmallissa erittäin hyvälle tasolle. Oppimistulosten osalta koulutusmallin kehitykselle asetetut tavoitteet ovat osittain jopa ylittyneet. Videoiden avulla tapahtuva opiskelu näyttäisi olevan oppimisen näkökulmasta vähintään yhtä toimiva ratkaisu kuin lähiopetuskin. Lähiopetuksen rooli on koulutusmallin käyttöönoton vaikutuksena selkeästi muuttunut ja osallistuminen sen avulla vähentynyt. Jos tämä trendi jatkuu samansuuntaisena, tulee lähiopetuksen olemassaolon uudelleenarviointi väistämättä eteen.

Tutkimuksen tulokset osoittavat, että lähiopetukseen ja videoihin perustuen voidaan muodostaa koulutusratkaisu, joka on mielekäs niin opiskelijan, luennoitsijan kuin koulutuksenjärjestäjänkin kannalta. Tutkimuksen kohteena oleva koulutusmalli on kustannustehokas, toimintavarma ja vaikutuksiltaan positiivinen. Sen avulla koulutuksen saavutettavuutta voidaan parantaa merkittävästi, ilman että oppimistulokset kärsivät. Tarkasti mietitty, oikein rakennettu, kohderyhmänsä tarpeet huomioiva teknologinen ympäristö on parhaimmillaan aidosti lisäarvoa tuova ratkaisu; ei vain korvike lähiopetukselle tai kopio siitä.

Tämän tutkimuksen kohteena oleva koulutusratkaisu näyttää olevan monilta osin sellainen, mihin suuntaan esimerkiksi korkeakoulutuksen järjestämisen yhteydessä ollaan menossa lähivuosina. Tulevaisuuden kehityskohteita ja mahdollisuuksia on kuitenkin jo selkeästi nähtävissä tutkimuksen kohteena olevassa koulutusratkaisussakin. Kun ympäristön saavutettavuus on hyvällä tasolla, niin tulevaisuudessa kehitystyön painopiste voi siirtyä entistä enemmän esimerkiksi vuorovaikutusmahdollisuuksien ja yhteistoiminnalliseen työskentelyyn liittyvien mahdollisuuksien parantamiseen sekä ympäristöä entistä paremmin hyödyntävien pedagogisten ratkaisujen kehittämiseen.

REFERENCES

Aier, S. & Fischer, C. 2011. Criteria of progress for information systems design theories. Information Systems and E-Business Management 9 (1), 133-172.

Allen, I. E. & Seaman, J. 2007. Online nation: Five years of growth in online learning. The Sloan Consortium.

Allen, I. E., Seaman, J. & Garrett, R. 2007. Blending in: The extent and promise of blended education in the United States. Sloan Consortium.

Anohina, A. 2005. Analysis of the terminology used in the field of virtual learning. Educational Technology & Society 8 (3), 91-102.

Asarta, C. J. & Schmidt, J. R. 2017. Comparing student performance in blended and traditional courses: Does prior academic achievement matter? The Internet and Higher Education 32, 29–38.

Becker, S. A., Cummins, M., Davis, A., Freeman, A., Hall, C. G. & Ananthanarayanan, V. 2017. NMC horizon report: 2017 higher education edition. Austin, Texas, USA:The New Media Consortium. 1-60.

Benbasat, I., Goldstein, D. K. & Mead, M. 1987. The case research strategy in studies of information systems. MIS quarterly , 369-386.

Bergmann, J. & Sams, A. 2012. Flip your classroom: Reach every student in every class every day. USA: International Society for Technology in Education.

Bergmann, J. & Sams, A. 2009. Remixing chemistry class: Two Colorado teachers make vodcasts of their lectures to free up class time for hands-on activities. Learning & Leading with Technology 36 (4), 22-27.

Betts, K., Hartman, K. & Oxholm, C. I. 2009. Re-examining & repositioning higher education: Twenty economic and demographic factors driving online and blended program enrollments. Journal of Asynchronous Learning Networks 13 (4), 3-23.

Bondarouk, T. & Ruël, H. 2010. Dynamics of e□learning: theoretical and practical perspectives. International journal of training and development 14 (3), 149-154.

Bonk, C. J. & Graham, C. R. 2006. The Handbook of Blended Learning: Global Perspectives, Local Designs. San Francisco, CA, USA: Pfeiffer Publishing.

Bonk, C. J., Olson, T. M., Wisher, R. A. & Orvis, K. L. 2002. Learning from focus groups: An examination of blended learning. International Journal of E-Learning & Distance Education 17 (3), 97-118.

Brotherton, J. A. & Abowd, G. D. 2004. Lessons learned from eClass: Assessing automated capture and access in the classroom. ACM Transactions on Computer-Human Interaction (TOCHI) 11 (2), 121-155.

Chen, Y., Wang, Y. & Chen, N. 2014. Is FLIP enough? Or should we use the FLIPPED model instead? Computers & Education 79, 16-27.

Cheolil, L., Hoan, C. Y. & Sunyoung, K. 2016. Partnerships and Innovation for Blended Learning at Seoul National University. Republic of Korea. Bangkok: UNESCO.

Chester, A., Buntine, A., Hammond, K. & Atkinson, L. 2011. Podcasting in education: Student attitudes, behaviour and self-efficacy. Journal of Educational Technology & Society 14 (2), 236.

Collis, B., Bianco, M., Margaryan, A. & Waring, B. 2005. Putting blended learning to work: a case study from a multinational oil company. Education, Communication & Information 5 (3), 233-250.

Collis, B., Bruijstens, H. & van Veen, J. K. 2003. Course redesign for blended learning: Modern optics for technical professionals. International Journal of Continuing Engineering Education and Life Long Learning 13 (1-2), 22-38.

Congdon, H. B., Nutter, D. A., Charneski, L. & Butko, P. 2009. Impact of hybrid delivery of education on student academic performance and the student experience. American Journal of Pharmaceutical Education 73 (7), 121.

Conrad, D. 2006. E-Learning and social change: An apparent contradiction. In M. F. Beaudoin (Ed.) Perspectives on higher education in the digital age.New York, NY, USA: Nova Science Publishers, 21-33.

Darke, P., Shanks, G. & Broadbent, M. 1998. Successfully completing case study research: combining rigour, relevance and pragmatism. Information systems journal 8 (4), 273-289.

Dean, P. J., Stahl, M. J., Sylwester, D. L. & Peat, J. A. 2001. Effectiveness of combined delivery modalities for distance learning and resident learning. Quarterly Review of Distance Education 2 (3), 247-254.

Deschacht, N. & Goeman, K. 2015. The effect of blended learning on course persistence and performance of adult learners: A difference-in-differences analysis. Computers & Education 87, 83–89.

Dresch, A., Lacerda, D. P. & Antunes Jr, J. 2015. Design science research: A Method for Science and Technology Advancement. Springer.

Dziuban, C. D. & Moskal, P. 2001. Emerging research issues in distributed learning. 7th Sloan-C International Conference on Asynchronous Learning Networks. Orlando, FL, USA: Sloan Consortium, 35.

Dziuban, C. D., Hartman, J. L. & Moskal, P. D. 2004. Blended learning. Research Bulletin 2004 (7), 1-12.

Dziuban, C.D, Graham, C. R., Moskal, P. D., Norberg, A. & Sicilia, N. 2018. Blended learning: the new normal and emerging technologies. International Journal of Educational Technology in Higher Education 15 (1), 1-16.

Eskola, J. & Suoranta, J. 1998. Johdatus laadulliseen tutkimukseen. Tampere, Finland: Vastapaino.

Faculty Focus. 2015. Flipped Classroom Trends: A Survey of College Faculty, Magna Publications, Inc., Madison, Wisconsin, USA

Foertsch, J., Moses, G., Strikwerda, J. & Litzkow, M. 2002. Reversing the lecture/homework paradigm using eTEACH® web□based streaming video software. Journal of Engineering Education 91 (3), 267-274.

Garner, R. & Rouse, E. 2016. Social presence -connecting pre-service teachers as learners using a blended learning model. Student Success 7 (1), 25-36.

Garrison, D. R. & Vaughan, N. D. 2008. Blended learning in higher education: Framework, principles, and guidelines. San Fancisco, CA, USA: Jossey-Bass.

Githens, R. P. 2006. Cautions: Implementing interpersonal interaction in workplace e-learning. TechTrends 50 (5), 21-27.

Gosper, M., Green, D., McNeill, M., Phillips, R., Preston, G. & Woo, K. 2008. The impact of web-based lecture technologies on current and future practices in learning and teaching.

Grabe, M. & Christopherson, K. 2008. Optional student use of online lecture resources: resource preferences, performance and lecture attendance. Journal of Computer Assisted Learning 24 (1), 1-10.

Graham, C. R. 2013. Emerging practice and research in blended learning. In M. G. Moore (Ed.) Handbookof distance education. (3rd edition) New York, NY, USA: Routledge, 333-350.

Graham, C. R. 2006. Blended learning systems: Definition, Current Trends, and Future Directions. In C. J. Bonk & C. R. Graham (Eds.) The handbook of blended learning: global perspectives, local designs.San Francisco, CA, USA: Pfeiffer, 3-21.

Graham, C. R., Allen, S. & Ure, D. 2005. Benefits and challenges of blended learning environments. In M. Khosrow-Pour (Ed.) Encyclopedia of Information Science and Technology. (1st edition) Hershey, PA, USA: IGI Global, 253-259.

Graham, C. R., Woodfield, W. & Harrison, J. B. 2013. A framework for institutional adoption and implementation of blended learning in higher education. The internet and higher education 18, 4-14.

Griffin, D. K., Mitchell, D. & Thompson, S. J. 2009. Podcasting by synchronising PowerPoint and voice: What are the pedagogical benefits? Computers & Education 53 (2), 532-539.

Gunasekaran, A., McNeil, R. D. & Shaul, D. 2002. E-learning: research and applications. Industrial and commercial training 34 (2), 44-53.

Hakala, I. & Myllymäki, M. 2007. Video lectures alongside with contact teaching. Proceedings of the 18th EAEEIE Annual Conference on Innovation in Education for Electrical and Information Engineering. Praha, Czech Rebublic.

Halverson, L. R., Graham, C. R., Spring, K. J. & Drysdale, J. S. 2012. An analysis of high impact scholarship and publication trends in blended learning. Distance Education 33 (3), 381-413.

Halverson, L. R., Graham, C. R., Spring, K. J., Drysdale, J. S. & Henrie, C. R. 2014. A thematic analysis of the most highly cited scholarship in the first decade of blended learning research. The Internet and Higher Education 20, 20-34.

Hartman, J., Dziuban, C. & Moskal, P. 2000. Faculty satisfaction in ALNs: A dependent or independent variable. Journal of Asynchronous Learning Networks 4 (3), 155-179.

Haythornthwaite, C. & Andrews, R. 2011. E-learning theory and practice. London, UK: Sage Publications.
Hevner, A. R., March, S. T., Park, J. & Ram, S. 2004. Design science in information systems research. MIS quarterly 28 (1), 75-105.
Hirsjärvi, S., Remes, P., Sajavaara, P. & Sinivuori, E. 2009. Tutki ja kirjoita. (15.th edition) Helsinki, Finland: Tammi.
Holbrook, J. & Dupont, C. 2011. Making the decision to provide enhanced podcasts to post-secondary science students. Journal of Science Education and Technology 20 (3), 233-245.
Holopainen, M. & Pulkkinen, P. 2006. Tilastolliset menetelmät. (1.–4. painos) Helsinki: WSOY.
Horn, M.B. & Fisher, J.F. 2017. New Faces of Blended Learning. Educational Leadership 74(6), 59-63.
Iivari, J. 2015. Distinguishing and contrasting two strategies for design science research. European Journal of Information Systems 24 (1), 107-115.
Ilioudi, C., Giannakos, M. N. & Chorianopoulos, K. 2013. Investigating differences among the commonly used video lecture styles. The Workshop on Analytics on Video-based Learning. Leuven, Belgium, 21.
Jensen, S. A. 2011. In-class versus online video lectures: Similar learning outcomes, but a preference for in-class. Teaching of Psychology 38 (4), 298-302.
Jensen, J. L. & Rodgers, R. 2001. Cumulating the Intellectual Gold of Case Study Research. Public administration review 61 (2), 235-246.
Johannesson, P. & Perjons, E. 2014. An Introduction to Design Science. Cham, Switzerland: Springer International Publishing.
Johnson, L., Adams-Becker, S., Estrada, V. & Freeman, A. 2014. The NMC Horizon Report: 2014 Higher Education Edition. Austin, Texas, USA.
Järvinen, P. 2012. On research methods. (4th edition) Tampere, Finland: Opinpaja Oy.
Kananen, J. 2008. Kvantti - Kvantitatiivinen tutkimus alusta loppuun. Jyväskylän ammattikorkeakoulu, Jyväskylä.
Kananen, J. 2011. Kvantti: Kvantitatiivisen opinnäytetyön kirjoittamisen opas. Jyväskylän ammattikorkeakoulu, Jyväskylä.
Kay, R. H. 2012. Exploring the use of video podcasts in education: A comprehensive review of the literature. Computers in Human Behavior 28 (3), 820-831.
Kelley, K., Clark, B., Brown, V. & Sitzia, J. 2003. Good practice in the conduct and reporting of survey research. International Journal for Quality in Health Care 15(3), 261–266.
Kirkley, J. R. & Kirkley, S. E. 2006. Expanding the boundaries of blended learning: Transforming learning with mixed and virtual reality technologies. In C. J. Bonk & C. R. Graham (Eds.) The Handbook of Blended Learning: Global Perspectives, Local Designs.San Francisco, CA, USA: Pfeiffer Publishing, 533-549.

Lage, M. J., Platt, G. J. & Treglia, M. 2000. Inverting the classroom: A gateway to creating an inclusive learning environment. The Journal of Economic Education 31 (1), 30-43.

Lai, C. & Liou, W. 2010. Implementation of E-Learning and Corporate Performance-An Empirical Investigation. International Journal of Advanced Corporate Learning 3 (1), 4-10.

Lewis, N. J. & Orton, P. Z. 2006. Blending learning for business impact. In C. J. Bonk & C. R. Graham (Eds.) The Handbook of Blended Learning: Global Perspectives, Local Designs.San Francisco, CA, USA: Pfeiffer Publishing, 61-75.

Littlejohn, A. & Pegler, C. 2007. Preparing for blended e-learning. New York, NY, USA: Routledge.

Löfström, E. & Nevgi, A. 2007. From strategic planning to meaningful learning: diverse perspectives on the development of web-based teaching and learning in higher education. British Journal of Educational Technology 38 (2), 312-324.

Lorenzo, G. & Moore, J. 2002. The Sloan consortium report to the nation: Five pillars of quality online education. Needham, MA, USA.

Lowenthal, P. R., Wilson, B. G. & Parrish, P. E. 2009. Context matters: A description and typology of the online learning landscape. Bloomington, IN, USA: Association for Educational Communications and Technology.

March, S. T. & Smith, G. F. 1995. Design and natural science research on information technology. Decision Support Systems 15 (4), 251-266.

Mayisela, T. 2013. The potential use of mobile technology: enhancing accessibility and communication in a blended learning course. South African Journal of Education 33 (1), 1-18.

McCombs, S. & Liu, Y. 2007. The efficacy of podcasting technology in instructional delivery. International Journal of Technology in Teaching and Learning 3 (2), 123-134.

McFarlin, B. K. 2008. Hybrid lecture-online format increases student grades in an undergraduate exercise physiology course at a large urban university. Advances in Physiology Education 32 (1), 86-91.

Means, B., Toyama, Y., Murphy, R. & Baki, M. 2013. The effectiveness of online and blended learning: A meta-analysis of the empirical literature. Teachers College Record 115 (3), 1-47.

Means, B., Toyama, Y., Murphy, R., Bakia, M. & Jones, K. 2009. Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. Washington, DC, USA.

Miles, M. B. & Huberman, A. M. 1994. Qualitative data analysis: An expanded sourcebook. Thousand Oaks, CA, USA: Sage Publications.

Morgan, K. R. 2002. Blended learning: A strategic action plan for a new campus. Seminole, FL: University of Central Florida .

Norberg, A., Dziuban, C. D. & Moskal, P. D. 2011. A time-based blended learning model. On the Horizon 19 (3), 207-216.

Nunamaker Jr, J. F., Chen, M. & Purdin, T. D. 1990. Systems development in information systems research. Journal of Management Information Systems 7 (3), 89-106.

O'Bannon, B. W., Lubke, J. K., Beard, J. L. & Britt, V. G. 2011. Using podcasts to replace lecture: Effects on student achievement. Computers & Education 57 (3), 1885-1892.

Offermann, P., Levina, O., Schönherr, M. & Bub, U. 2009. Outline of a design science research process. Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology. New York, NY, USA: ACM, 7.

Oliver, M. & Trigwell, K. 2005. Can 'blended learning'be redeemed? E-learning and Digital Media 2 (1), 17-26.

Orlikowski, W. J. 1996. Evolving with Notes: Organizational change around groupware technology. In C. U. Ciborra (Ed.) Groupware and Teamwork.New York, NY, USA: John Wiley & Sons, Inc., 23-59.

Parker J., Maor, D. & Herrington, J. 2013. Authentic online learning: Aligning learner needs, pedagogy and technology. Issues in Educational Research 23 (2), 227-241.

Peffers, K., Tuunanen, T., Gengler, C. E., Rossi, M., Hui, W., Virtanen, V. & Bragge, J. 2006. The design science research process: a model for producing and presenting information systems research. Proceedings of the first international conference on design science research in information systems and technology (DESRIST 2006). Claremont, CA, USA: , 83.

Peffers, K., Tuunanen, T., Rothenberger, M. A. & Chatterjee, S. 2007. A design science research methodology for information systems research. Journal of Management Information Systems 24 (3), 45-77.

Picciano, A. & Seaman, J. 2007. K–12 online learning: A survey of US school district administrators.Needham, MA: Sloan Consortium .

Pinsonneault, A. & Kraemer, K. 1993. Survey research methodology in management information systems: an assessment. Journal of management information systems 10(2), 75-105.

Procter, C. 2003. Proportion, Pedagogy and Processes: The Three P's of E-Learning. Proceeding of International Conference on Informatics Education & Research (ICIER).

Rahman, A. A., Mohamed, H., Aris, B. & Mohd Zaid, N. 2014. The Influences of Flipped Classroom: A Meta Analysis. 6th International Conference on Engineering Education. Berjaya Times Square, Kuala Lumpur.

Reasons, S. G., Valadares, K. & Slavkin, M. 2005. Questioning the hybrid model: Student outcomes in different course formats. Journal of Asynchronous Learning Networks 9 (1), 83-94.

Robson, C. 2002. Real world research: A resource for social scientists and practitioner-researchers (Second edition) Malden, USA: Blackwell Publishing.

Rosemann, M. & Vessey, I. 2008. Toward improving the relevance of information systems research to practice: the role of applicability checks. Mis Quarterly , 1-22.

Ross, B. & Gage, K. 2006. Global perspectives on blending learning. In C. J. Bonk & C. R. Graham (Eds.) The handbook of blended learning: global perspectives, local design.San Fransisco, CA, USA: Pfeiffer, 155-168.

Ross, T. K. & Bell, P. D. 2007. "No significant difference" only on the surface. International Journal of Instructional Technology and Distance Learning 4 (7), 3-13.

Rossi, M. & Sein, M. K. 2003. Design research workshop: a proactive research approach. Presentation delivered at IRIS 26, 9-12.

Runeson, P. & Höst, M. 2009. Guidelines for conducting and reporting case study research in software engineering. Empirical software engineering 14 (2), 131-164.

Servage, L. 2005. Strategizing for workplace e-learning: some critical considerations. Journal of Workplace Learning 17 (5/6), 304-317.

Sharpe, R., Benfield, G., Roberts, G. & Francis, R. 2006. The undergraduate experience of blended e-learning: a review of UK literature and practice.

Shea, P. 2007. Towards a conceptual framework for learning in blended environments. In A. G. Picciano & C. D. Dziuban (Eds.) Blended learning: Research perspectives.Needham, MA, USA: Sloan Consortium, 19-35.

Shrestha, B. K., Shrestha, R., Shakya M. 2017. Blended Learning in DWIT College: From Learners Perspective. Proceedings of the 4th International Conference on Information Technology for Development. Kathmandu, Nepal

Shrestha, B. K., Shakya, M. & Gautam, N. 2016. Flipped Class: New e-learning Object in Nepal and Perspective of Teachers. Proceedings of the third international IT conference on ICT for INTELLIGENT COMPUTING. Kathmandu: Nepal.

Simon, H. A. 1969. The sciences of the Artificial. Cambridge, MA, USA: MIT press.

Sims, D. E., Burke, S. C., Metcalf, D. S. & Salas, E. 2008. Based Guidelines for Designing Blended Learning. Ergonomics in Design 16 (1), 23-29.

Smyth, S., Houghton, C., Cooney, A. & Casey, D. 2012. Students' experiences of blended learning across a range of postgraduate programmes. Nurse Education Today 32 (4), 464–468.

So, H.J. 2009. Is blended learning a viable option in public health education? A case study of student satisfaction with a blended graduate course. Journal of Public Health Management Practice 15 (1), 59–66.

Sohrabi, B. & Iraj, H. 2016. Implementing flipped classroom using digital media: A comparison of two demographically different groups perceptions. Computers in Human Behavior 60, 514-524.

Spector, M. J., Merrill, D. M., van Merrienboer, J. & Driscoll, M. P. 2008. The Handbook of Research on Educational Communications and Technology. (3.th edition) New York, NY, USA: Routledge.

Stockwell, B. R., Stockwell, M. S., Cennamo, M. & Jiang, E. 2015. Blended Learning Improves Science Education. Cell 16 (5), 933–936.

Stone, B. 2012. Flip your classroom to increase active learning and student engagement. 28th Annual Conference on Distance Teaching & Learning. Madison, Wisconsin, USA.

Sturges, D. L. 2011. Effective Online Courses in Business Administration: Expanding course design to activate diverse learning styles. In C. Wankel & S. J. Law (Eds.) Streaming Media Delivery in Higher Education: Methods and Outcomes.Hershey, PA, USA: IGI Global, 237-246.

Suda, K. J., Sterling, J. M., Guirguis, A. B. & Mathur, S. K. 2014. Student perception and academic performance after implementation of a blended learning approach to a drug information and literature evaluation course. Currents in Pharmacy Teaching and Learning 6 (3), 367-372.

Szafir, D. & Mutlu, B. 2013. ARTFul: adaptive review technology for flipped learning. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. Paris, France: ACM, 1001.

Takeda, H., Veerkamp, P. & Yoshikawa, H. 1990. Modeling design process. AI magazine 11 (4), 37-48.

Thai, N. T. T., De Wever, B. & Valcke, M. 2017. The impact of a flipped classroom design on learning performance in higher education: Looking for the best "blend" of lectures and guiding questions with feedback. Computers & Education 107, 113-126.

Traphagan, T., Kucsera, J. V. & Kishi, K. 2010. Impact of class lecture webcasting on attendance and learning. Educational technology research and development 58 (1), 19-37.

Tuomi, J. & Sarajärvi, A. 2009. Laadullinen tutkimus ja sisällönanalyysi. (6.th edition) Helsinki, Finland: Tammi.

Vajoczki, S., Watt, S., Marquis, N. & Holshausen, K. 2010. Podcasts: Are they an effective tool to enhance student learning? A Case Study. Journal of Educational Multimedia and Hypermedia 19 (3), 349-362.

van Aken, J. E. 2004. Management research based on the paradigm of the design sciences: the quest for field-tested and grounded technological rules. Journal of management studies 41 (2), 219-246.

Vehkalahti, K. 2008. Kyselytutkimuksen mittarit ja menetelmät. Helsinki: Kustannusosakeyhtiö Tammi.

Venable, J., Pries-Heje, J. & Baskerville, R. 2016. FEDS: a framework for evaluation in design science research. European Journal of Information Systems 25 (1), 77-89.

Vilkka, H. 2007. Tutki ja mittaa–Määrällisen tutkimuksen perusteet. Helsinki: Tammi

Vo, H. M., Zhu, C. & Diep, N. A. 2017. The effect of blended learning on student performance at course-level in higher education: A meta-analysis. Studies in Educational Evaluation 53, 17-28.

Volery, T. & Lord, D. 2000. Critical success factors in online education. International journal of educational management 14 (5), 216-223.

Von Konsky, B. R., Ivins, J. & Gribble, S. J. 2009. Lecture attendance and web based lecture technologies: A comparison of student perceptions and usage patterns. Australasian journal of educational technology 25 (4), 581-595.

Waddoups, G. & Howell, S. 2002. Bringing Online Learning to Campus: The hybridization of teaching and learning at Brigham Young University. The International Review of Research in Open and Distributed Learning 2 (2).

Waddoups, G. L., Hatch, G. L. & Butterworth, S. 2003. Case 5: Blended Teaching and Learning in a First-Year Composition Course. Quarterly Review of Distance Education 4 (3), 271.

Walls, S. M., Kucsera, J. V., Walker, J. D., Acee, T. W., McVaugh, N. K. & Robinson, D. H. 2010. Podcasting in education: Are students as ready and eager as we think they are? Computers & Education 54 (2), 371-378.

Watson, J., Murin, A., Vashaw, L., Gemin, B. & Rapp, C. 2010. Keeping pace with K–12 online learning: An annual review of policy and practice. Evergreen, CO, USA.

Welker, J. & Berardino, L. 2005. Blended learning: understanding the middle ground between traditional classroom and fully online instruction. Journal of Educational Technology Systems 34 (1), 33–55.

Wieling, M. B. & Hofman, W. H. A. 2010. The impact of online video lecture recordings and automated feedback on student performance. Computers & Education 54 (4), 992-998.

Wieringa, R. J. 2014. Design Science Methodology for Information Systems and Software Engineering. Berlin, Germany: Springer-Verlag Berlin Heidelberg.

Wiese, C. & Newton, G. 2013. Use of Lecture Capture in Undergraduate Biological Science Education. Canadian Journal for the Scholarship of Teaching and Learning 4 (2), 4.

Willett, H. G. 2002. Not one or the other but both: hybrid course delivery using WebCT. The Electronic Library 20 (5), 413-419.

Winnips, J., Verheij, G. & Gommer, E. 2011. The Next Step for Use of Streaming Video in Higher Education: Didactic Models for Weblectures. In C. Wankel & S. J. Law (Eds.) Streaming Media Delivery in Higher Education: Methods and Outcomes.Hershey: PA: IGI Global, 39-60.

Wisher, R. A. 2006. Blended learning in military training. In C. J. Bonk & C. R. Graham (Eds.) The Handbook of Blended Learning: Global Perspectives, Local Designs .San Francisco, CA, USA: Pfeiffer Publishing, 519-532.

Yin, R. K. 2013. Case study research: Design and methods. Thousand Oaks, CA, USA: Sage publications.

Young, K. 2002. Is e-learning delivering ROI? Industrial and Commercial Training 34 (2), 54-61.

Zhang, D. & Nunamaker, J. F. 2003. Powering e-learning in the new millennium: an overview of e-learning and enabling technology. Information Systems Frontiers 5 (2), 207-218.

Zhang, Y., Dang, Y. & Amer, B. 2016. A Large-Scale Blended and Flipped Class: Class Design and Investigation of Factors Influencing Students' Intention to Learn. IEEE Transactions on Education 59 (4), 263-273.

Zhang, D., Zhou, L., Briggs, R. O. & Nunamaker, J. F. 2006. Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness. Information & Management 43 (1), 15-27.

Zhao, Y., Lei, J., Yan, B., Lai, C. & Tan, H. S. 2005. What makes the difference? A practical analysis of research on the effectiveness of distance education. Teachers College Record 107 (8), 1836-1884.

ORIGINAL PUBLICATIONS

I

THE EFFECT OF TIME AND PLACE DEPENDENCE WHEN UTILIZING VIDEO LECTURES

by

Ismo Hakala, Sanna Laine & Mikko Myllymäki, 2009

Proceedings of the 20th EAEEIE Annual Conference on Innovation in Education for Electrical and Information Engineering

The Effect of Time and Place Dependence When Utilizing Video Lectures

Ismo Hakala[#1], Sanna Laine[#2], Mikko Myllymäki[#3], Jari Penttilä[#4]

[#]*University of Jyväskylä, Kokkola University Consortium Chydenius*

P.O.Box 567, FIN-67701, Kokkola, Finland

[1]ismo.hakala@chydenius.fi

[2]sanna.laine@chydenius.fi

[3]mikko.myllymaki@chydenius.fi

[4]jari.penttila@chydenius.fi

***Abstract*— In many learning institutes, diversification of teaching with the help of various technologies has become an essential part of educational arrangements. With the increase in the use of networks for teaching purposes, the use of streaming videos is now one of the possibilities to be reckoned with in trying to increase flexibility in studies. Specially recorded on-demand videos provide the students with better chances to decide when, where and how to study. Information on how students use on-demand videos can be obtained, apart from student questionnaires, from the log files of a media server. These files offer an information source that, on the one hand, is diverse but, on the other, cumbersome and less used. This article examines, with the help of the log files of the media server, matters related to time and place dependence and the use of videos by the students. The investigation is based on the analysis of the log data entered about videos transmitted during the master's education programme in information technology in 2008.**

I. INTRODUCTION

The motivation behind the diversification in teaching has typically been the desire to make studying more flexible as regards time and place. In sparsely populated countries such as Finland, a student's long travel distance to the place of study can naturally be a significant limitation for participation in any face-to-face teaching arranged. Apart from geographical reasons, constant merging together of work and study can create problems for those wanting to participate in face-to-face teaching. Of all university students in Finland about 40% are studying part-time towards the end of their studies [4]. In the area of information technology making the transition to working life during the latter part of their studies is typically even more common. The limited opportunities that the students have for participating in the studies cause many temporary absences, which may significantly hamper course performance and on their part delay the students' graduation date. One solution to increase flexibility in studies is diversification of teaching with the help of video technologies. For example, video facilitated teaching that is offered in addition to face-to-face teaching and parallel with it can provide those students who live in places that are geographically distant with better chances for studying and, at the same time, ensure that the lectures are available also for temporarily absent students.

During the last few years there has been a strong increase in the use of teaching by video transmission in many Finnish universities. According to the background material of a survey [1] conducted in Finnish higher education institutes in 2008, of all 25 institutes surveyed 58% make use of real time streaming video and 80% utilize on-demand streaming video. By a streaming video we mean a video that need not be stored in the user's computer because the video can be viewed directly from the media server. Streaming technology also means savings in time and storage space, because viewing can start while the video is still downloading, and the video is not recorded by the receiver. By a real time video we mean a video which once shot is immediately coded and transmitted to the viewer. Thus we are dealing with an almost real time transmission from a recording instance where the lag prior to viewing is mainly due to coding required in order to transform the video into a format that can be transmitted. Therefore, viewing a real time video is bound to the moment of transmission and it cannot be forwarded or rewound. Real time transmissions thus offer the students a possibility to participate in teaching regardless of place. Lecture events that are transmitted real time can also be recorded and offered through a WWW based learning environment for the students to view as on-demand video. With the help of recorded on-demand videos, in addition to independence of place, independence of time is achieved. On-demand videos also allow the user to influence their viewing. They can be forwarded or rewound, or stopped where desired. This gives the student an opportunity to view the lectures in segments of a suitable length and in the order desired. It also makes it possible to repeat the lectures. Therefore, we may conclude that on-demand videos enhance the student's options to decide where, when and how to study.

From the viewpoint of the provider of the education, the students' freedom to decide where and when to study creates challenges of a novel type. Perhaps the most often asked question in this connection is how it will affect participation in face-to-face teaching. According to the statistics of a follow-up study over many years as presented in article [2], producing videos side by side with face-to-face teaching did not appear to reduce the numbers of those participating in lectures. On the other hand, our own experiences give some

978-1-4244-5386-3/09/$26.00 ©2009 IEEE

indications that participation in face-to-face teaching is decreasing. One of the reasons, in our case, may be geographical dispersion of students which is much wider than in the past. To unravel the reasons behind these types of developments, one of the information sources that could be used is the log files of the media server. The media server's log data provides a lot of useful information, for example, about the length of time the students viewed certain files, about the average viewing time of the videos and about the weekdays and timeslots during which those viewings took place. With the help of the log files it is also possible to find out how the students use videos: do the students view the videos directly or by forwarding and rewinding when looking for difficult segments?

This article examines, with the help of the media server's log file information, factors related to the use of videos by the students and time and place dependence. The media server's log files are an infrequently used information source in the analysis of questions related to the use of videos, which might be due to the laboriousness of their analysis. The material for the article originates from the log files of the media server that was used for the transmission of Master Studies in Mathematical Information Technology in 2008.

II. Description and handling of log files

In our master studies, the solution based on streaming videos was realized using the Windows Media Encoder software and equipment suited to the purpose. The equipment comprises a pc used for streaming, as required by the software, and recording equipment for image and sound. Video distribution is handled by the Windows Media Server. For viewing, the students need a viewing program, which is included with the Windows operating system, can be installed and updated as needed, and is free of charge. In addition, the students need an Internet connection (with the speed of at least 512 kbps), which 97% of the students had in 2007 according to an earlier survey [3].

The Windows Media Server that we use collects log data into 52 different record fields; thus, monitoring the use of videos can be done in a fairly comprehensive manner. The log file comprises information that is obtained from the server as well as from the clients. Table 1 shows the fields that are the most essential for this study.

TABLE I
An Example of Windows Media Server's Log File Fields.

date	c-starttime
time	x-duration
cs-user-name	c-status
cs-uri-stem	

When starting to create a connection, the server collects information into static fields, the contents of which then remain unchanged during the entire connection time. For example, the static fields *date* and *time* give precise information about the time instant of the event entered in the log. Also the values for the static *cs-user-name* and cs-*uri-stem* fields are obtained at the start of the connection creation. The *cs-uri-stem* field tells about the viewed on-demand file path from where real time video has been transmitted. Together with the *cs-user-name* field which contains the user identification of the student who viewed the video, *cs-uri-stem* allows one to examine other factors related to a student group's or an individual student's use of a particular video.

In addition to the information collected at the beginning of the connection creation, both the server and the client collect information during the entire length of the connection time, but the information collected by the client is transmitted to the log file on the server while the user is executing operations (forward, rewind, pause) on the media player or only at the end of the connection. During the connection, the server dynamically collects information into the *c-starttime* and *x-duration* fields, among others. These fields are updated during operations that the user executes. The *c-starttime* field contains a timestamp, which indicates the start point for client viewing on the streaming file. The duration between two operations (forward, rewind, pause, stop) effected by the user on the media player is entered into the x-duration field. With the help of these fields it is easy to examine the actions that the user has done while watching the videos. During the user operations the server updates the field values on the basis of the information it obtains from the client. It enters the information in its appropriate log row and at the same time starts to form a new log row. When storing the log row, the server announces that it has successfully formed connection with the c-status field's value. The values in the c-status field reveal whether the connection was a complete success or whether there were breaks and reconnections during the connection, or whether the viewing was terminated as a result of a connection breakdown or an internal error detected by the server. The c-status field also reveals possible viewing attempts that have failed due to missing viewing rights or a file requested.

III. Results of the log file analysis for master studies in 2008

For some years now, in the Master Studies in Mathematical Information Technology face-to-face teaching has been diversified by offering all face-to-face lecture teaching in real time and as recorded on-demand videos. The face-to-face teaching is arranged mainly for Friday afternoons and Saturdays. Almost all the students are working adults, the majority of whose employers support their employees' study by allowing them to adjust their work time or use it for study. The students live across a wide geographical area. Those living at the furthest distance are located 500 km away from the campus. A long travel distance to the place of learning together with simultaneous work and study are the most significant limitations placed on the students' participation in face-to-face teaching. Together they form the main incentive for increasing the flexibility of teaching with the help of video technology. Moreover, support for the students' different

learning methods has become an important factor in developing the use of videos for teaching.

The statistics presented in this paper are based on the log information of viewed lecture videos that were produced for the Master Studies in Mathematical Information Technology at the Kokkola University Consortium. In 2008 there were 16 course related videos that were viewed. In that year, 11 courses were lectured and recorded on video, but the log file contains, in addition, instances of five other courses, the videos for which were produced in 2007 but watched in 2008, for example, as a preparation for a repeat exam. During 2008 there were altogether 103 students who watched the videos, of which 69 were the students of the Master Studies in Mathematical Information Technology and 46 were the students of The Open University. In addition there were 18 active students of the Master Studies in Mathematical Information Technology who did not use video lectures at all. In the following study only the statistics created by the students (87) of the Master Studies in Mathematical Information Technology has been included.

A. The Effect of Time Dependence on Video Viewing

During 2008 the videos were viewed altogether 2356 times, of which number the share of on-demand lectures was 80% and the share of real time transmissions 20%. Of the students who viewed videos 94% (65 students) viewed on-demand videos and 61% (42 students) viewed real time transmissions. The share of real time transmissions shows that it is also important to offer a possibility to participate in teaching regardless of place but still simultaneously with face-to-face teaching. However, it seems the time and place independence of the on-demand videos and the possibility to repeat the lectures were, for the students, a better option than real time transmissions. In part the result was as expected, because the working students have only very limited opportunities to watch, for example, Friday afternoon's real time transmissions. Timewise, the time spent on watching the on-demand videos was approximately 1192 hours. On average, an individual student watched each course as on-demand video 12 times (approx. 7 hrs 30 min). These numbers indicate that the use of videos in studying has become a part of the activities of the master's students in information technology.

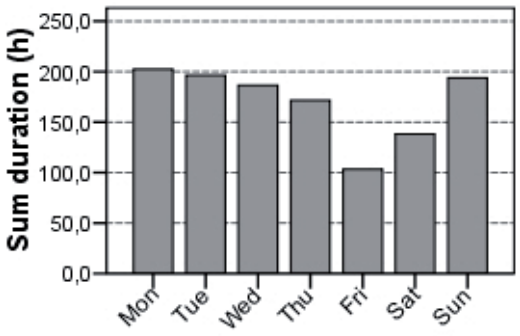

Fig. 1 The distribution of viewing time for on-demand video by weekdays.

The log file gives a clear picture of the distribution of viewing by weekdays. Figure 1 shows this distribution in relation to viewing time. The figure indicates that the videos are put to use in the beginning of the week and on Sundays. Face-to-face teaching is typically arranged for Fridays and Saturdays, therefore video viewing during those days is naturally less. Due to a practice in use, the lecture videos from previous Friday and Saturday were distributed through the media server to the students only the following Monday. This means that the student must watch the lectures during the beginning of the week, if he/she wants to watch the lecture videos before the next face-to-face teaching session. This partially explains the importance of the beginning of the week, but not that of Sunday, in video viewing.

On the other hand, the Figure 2 clearly shows that watching of lecture videos is concentrated for the two weeks following the lecture and after that, it becomes clear that the most popular viewing day is Sunday when the students have timewise the best opportunity to watch the videos. To comply with the requests from the students, we have developed the distribution of videos by making it more automated from the beginning of 2009. This has made it possible to provide the videos for the students already during the evening of recording. This aims to ensure that the students would be able to allocate time for the Sunday after the lecture for watching the lecture video.

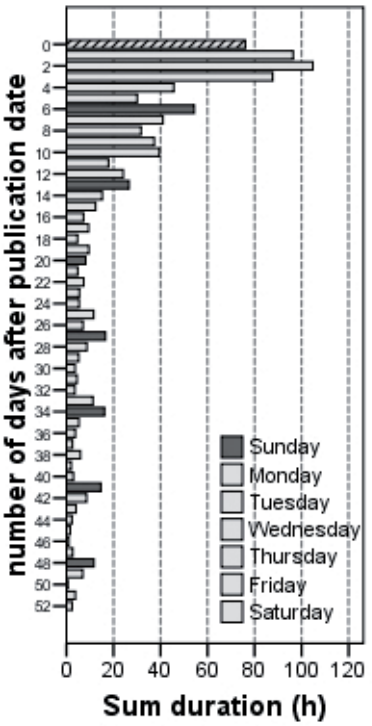

Fig. 2 Durations of viewing times for on-demand videos after their publication date.

If we observe the viewing time within a day (Figure 3) we can see that most viewing clearly happens between 4 pm and midnight. Judging by the times of viewing, it is obvious that

the master's students in information technology are adult working students constrained in their time use by their family but above all by their work life. Weekday data, nevertheless, indicate that viewing has taken place also during work time. To some extent, therefore, the students can use their work time for studying. If we focus on looking for differences between the weekdays and the weekend in our survey, we can see that video viewing during weekends is more evenly distributed over the whole day, the peak being reached between midday and 4 pm.

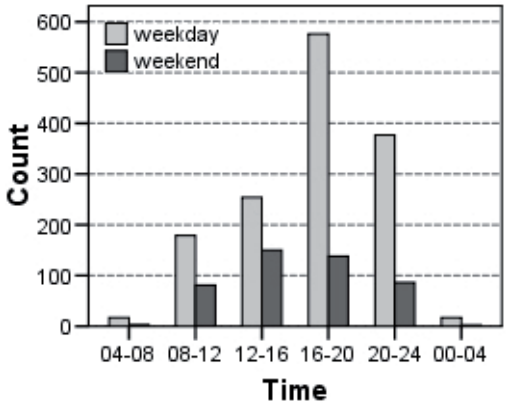

Fig. 3 Starting times for on-demand video study sessions during weekdays and weekends.

B. About Students' Video Viewing Practices

When we are investigating students' video viewing practices we concentrate on on-demand videos because when viewing real time videos users are not capable to move from one point to another on the time line or stop somewhere and later continued viewing the video. In our investigation on students' video viewing practices, we have defined 30 seconds as the minimum length of video viewing (the time between the start and the end of a video viewing) for the videos included in the students' study session. Any viewing times shorter than this have been regarded as being outside the actual study, and they have been classified as part of the forward and rewind displacement movements the student has executed on the timeline. The average duration of the study sessions was 38 minutes, and the average duration of the viewing times between displacements and pauses caused by the viewer was 8 mins 14 secs. On the other hand, if the displacements are counted as part of active viewing and only pauses are taken into account, we obtain an average duration of 10 mins 48 secs for the continuous unbroken viewing events. The average video viewing time may be thought as indicating the length of time appropriate for a video recording. In the present practice, the length of the videos and the lectures is the same. This is due to our desire to make it easy for the students going through the videos to find the parts where they might have experienced problems. If it were decided in the future to produce teaching events to be realized only in a video format without actual face-to-face teaching, it would be useful to keep in mind the information obtainable from the log data about average viewing times.

The behavior of the students viewing lecture videos can be observed by dividing the study sessions into different groups on the basis of the operations effected by the students watching the videos. One such classification is presented in article [2]. According to it, each individual student's study session is mapped to one of the five salvaging techniques.

A. StraightThrough: a study session plays media, but has no media jumps.
B. StartStop: a study session has no jumps, but the media played was paused and resumed.
C. SkipAhead: a study session has only forward jumps in the media
D. Relisten: a study session has only backward jumps in the media
E. Non-Sequential: a study session has both forward and backward jumps in the media.

This classification is created by observing, on the timeline, the relative locations of the consecutive viewings included in the study session and not only as related to the operations (forward, rewind, pause) effected by the student on the media player. For example, class C only includes study sessions where the start time of the last of two consecutive viewings belonging to the same session is genuinely later than the end time for the previous viewing. Figure 4 shows the classification of study sessions of the on-demand videos on the time line regarding displacements. As shown in Figure 4, video material produced in master's education programme is viewed mainly linearly with regard to time (69%) and moving backward is less frequently used. There are many factors that will have an impact on students' video viewing practices. Those kinds of factors are for example the content of the course, the students' learning styles and the motivation for utilizing videos.

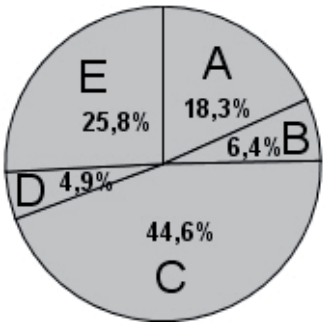

Fig. 4 Classification of study sessions of the on-demand videos.

C. The Effect of Place Dependence on Video Viewing

The students of the Master Studies in Mathematical Information Technology at Kokkola University Consortium live around a very wide area. It has been noted, during the latest student admissions, that the students more often than before live such a long way away that these distances alone can exert influence on the students' face-to-face teaching. We wanted to know if increase in the number of the students

living outside Kokkola and the long distances between the students and the campus area are affecting the students' activity in video viewing. For the study, the students are divided into two groups. The first group (Group A, 54 students) is made up of those students who watch the videos mainly in the town where the campus is located or within a distance of approximately 50km. The second group (Group B, 33 students) consists of students watching the videos more than 50 km away. In addition to this classification, in Table 2 the videos are grouped into all videos, real time videos, and on-demand videos. For each category, the average number of sessions and their duration per student during 2008 is considered.

TABLE II
THE EFFECT OF GEOGRAPHICAL DISTANCE ON VIEWING ACTIVITY.

		Group A	Group B
All	number of sessions / student	19,2	39,9
	duration in all (h) / student	13,6	33,9
On-demand	number of sessions / student	15,7	31,2
	duration in all (h) / student	9,6	20,4
Real time	number of sessions / student	3,5	8,7
	duration in all (h) / student	4,0	13,5

According to Table 2, all the factors considered about all videos (i.e. on-demand and real time videos together) in Group B achieved clearly higher values than in Group A. The results of the Mann-Whitney test show that the differences are statistically significant at 5 % significance level. Therefore, it seems that as the geographical distance increases to more than 50 km, viewing activity related to the teaching material (on-demand and real time videos together) is bound to grow. Also results related to the average number of sessions and their durations per student are found to be statistically significant at 5% significance level as far as the on-demand videos are concerned. However, in case of the real time videos, no statistical significance between the groups could be shown for these factors. This was partially due to the small number of real time video viewings.

As regards the effect of geographical distance on on-demand video viewing times, it is clear that those living further away watch videos more often on Saturdays and that the viewing times are distributed more evenly over the weekdays than is the case with those living near (Figure 5). The time of the day when the videos are viewed and geographical distance do not seem connected in any way. Neither is there any notable difference between Group A and Group B in the relative number of viewings between weekdays and weekends. On the other hand, if we have a look at the time spent on viewing, those living close by (Group A) spend 3 times more time in watching videos during the week than during the weekend, whereas for those living further away (Group B) the time they spend watching videos during the week is twice that during the weekend. The results of the Mann-Whitney test show that the difference between groups A and B in relation to weekend viewings is also statistically significant at 5 % significance level. Geographical location does not seem to have any effect on the time of the day when real time videos are watched. Regardless of the geographical location, on Fridays real time transmissions are viewed 3 times more often than on Saturdays.

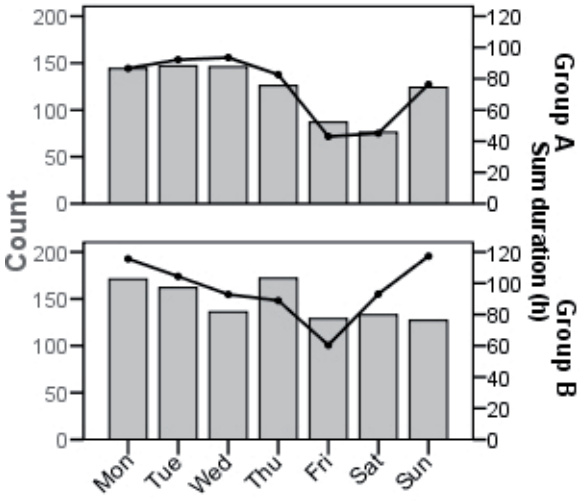

Fig. 5 The effect of geographical distance on distribution of viewing time for on-demand video by weekdays. The bars represent number of sessions and the line represents sum of durations.

Table 3 shows the lengths of average video viewing sessions classified by their geographical location. When defining the average length of viewing sessions, only students who had viewed the videos were taken into account. In case of all videos and especially in case of real time videos, the length of an average viewing session seems to have clearly increased for those living further away. It shows that while the difference is statistically significant at 1% significance level for real time videos no statistical significance could be shown for on-demand videos ($p \approx 0.18$, 1-tailed). In addition to the viewing sessions, we also examined how the differences in the average duration of the viewing times between the displacements and pauses effected by the viewer related to their geographical locations. Here also one could notice that the viewing times were slightly longer for those living further away (Group A 7mins 10sec and Group B 9mins 17sec).

TABLE III
THE EFFECT OF GEOGRAPHICAL DISTANCE ON THE DURATION OF THE STUDENTS' STUDY SESSION.

		Group A	Group B
All	average duration (mins) / study session	42,3	51,0
On-demand	average duration (mins) / study session	36,7	39,2
Real time	average duration (mins) / study session	67,7	93,3

Table 4, based on the classification above, shows the effect of geography on video viewing habits. Viewing habits differ mainly by linear viewing styles. Those living in a close proximity to the campus (in an urban area, Group A1, 40 students) and those living more than 50 km away utilized forwarding with on-demand videos more often, whereas those living outside an urban area but at least within 50 km (Group A2, 14 students) used that feature noticeably less. In this respect, the differences between these groups were statistically significant. Pausing and nonlinear video use were not dependent on geographical location.

TABLE IV
THE EFFECT OF GEOGRAPHICAL DISTANCE ON STUDENTS' VIDEO VIEWING PRACTICES

	Group A1	**Group A2**	**Group B**	**Total**
StraightThrough	13,5%	28,6%	19,0%	18,3%
StartStop	7,1%	6,9%	5,8%	6,4%
SkipAhead	47,7%	29,5%	46,1%	44,6%
Relisten	5,3%	7,4%	4,1%	4,9%
Non-Sequential	26,4%	27,6%	25,0%	25,8%

There are quite a few explanatory factors for the differences in the use of videos between students living at different distances from the campus. It is quite understandable that viewing activity increases with the increase of geographical distance, because the face-to-face teaching opportunities of those living further away are clearly more limited than of those living closer to the campus. This very same factor also explains why the student viewings focus stronger on weekends in case of the students living far away. Those living close to the campus and participating in face-to-face teaching do not have enough energy left for the weekends to utilize videos to such an extent as those living further away do.

Distance also has bearing on the motivation to watch videos. The students living in the proximity of the campus probably use videos more for revision, whereas for those living further away videos might, in addition, have become more and more a substitute for face-to-face teaching. This varying role of videos in students' education explains, among other things, the longer study sessions of those living farther away. When a video is used as a substitute for face-to-face teaching, it is necessary when viewing the video first time to dedicate a longer session for it. On the other hand, revising something seen before is possible in shorter sessions. It is natural also that once the motivation to watch videos has undergone a change from regarding them as face-to-face teaching substitutes to considering them as aids to revision, also the viewing habits will be affected. To find out more about the purpose of video use, it would be necessary to do a survey about students' motivations for video viewing.

IV. CONCLUSIONS

All teaching related to the master's education at Kokkola University Consortium is transmitted not only through face-to-face teaching but also as real time and on-demand video. The material collected from the log files indicates that today the use of videos as a study support among our students is already an established practice. Such widespread utilization of videos justifies our assertion that there are good reasons for collecting more accurate statistics about their use. Interpretation of log files is quite laborious and usually requires regrouping and joining of data stored in the server. Analysis of log files if carefully planned and realized provides us, however, with a possibility to examine the use of videos in a very wide ranging manner. At its best, this information can help the education organizer direct the development work towards right goals.

By examining log files, the organizer of education can obtain quite accurate information about the busiest video viewing times of the day, among other things. Useful knowledge about students' viewing habits and the effects of location on video viewing can also be obtained. When examining the data collected from the teaching related to the master's education, it was found that the video material is viewed mainly linearly with regard to time. From the viewpoint of video use, it seems clear that the geographical distance between students and the campus area is significant. This became particularly apparent when the viewing activity related to on-demand videos was considered. By examining the data provided by the log file, it could be stated, that for those living further away weekend is more prominent for video viewing activities and that their viewings are more evenly distributed on different weekdays than is the case with those living close to the campus. Geographical distance thus had its effect both on video viewing habits as well as on the lengths of study sessions. In future the usability of the results from the analyses of log data could be enhanced by combining the obtained information with information collected from other sources such as students' attendance lists or results of the mappings of learning styles.

REFERENCES

[1] Andberg, S. and Tuononen, K., "Videoviestintä suomalaisissa korkeakouluissa 2008", University of Helsinki - Educational Centre for ICT, 2009.

[2] Brotherton, J. and Abowd, G., "Lessons Learned From eClass: assessing Automated Capture and Access in the Classroom", *ACM Transactions on Computer-Human Interaction*, Vol.11, No. 2, June 2004, p. 121-155.

[3] Hakala, I. and Myllymäki, M., "Video lectures alongside with contact teaching", *Proceedings of the 18th EAEEIE Annual Conference on Innovation in Education for Electrical and Information Engineering*, Praha, Czech Rebublic, 2007.

[4] Kivinen, O. and Nurmi, J., "Työ, koulutus ja osaaminen. Yliopisto ja ammattikorkeakoulu yhdeksän maan eurooppalaisessa vertailussa.", University of Turku - Research Unit for the Sociology of Education, Report 72, 2008.

II

A BLENDED LEARNING SOLUTION AND THE IMPACTS ON ATTENDANCE AND LEARNING OUTCOMES

by

Ismo Hakala & Mikko Myllymäki, 2011

International Journal of Emerging Technologies in Learning, vol. 6, special issue, 42-49

A Blended Learning Solution and the Impacts on Attendance and Learning Outcomes

doi:10.3991/ijet.v6iS2.1658

I. Hakala, M. Myllymäki
University of Jyväskylä, Kokkola University Consortium Chydenius, Kokkola, Finland

***Abstract*—Blended learning based on lecture videos and face-to-face teaching provides good opportunities for students for participation in education, regardless of time or place. The article describes a blended learning solution that is based on face-to-face teaching and the use of streaming lecture videos as it has developed in connection with master studies in mathematical information technology. The particular focus of this article is on the use of lecture videos and the impacts of blended learning on participation in education and on learning outcomes. According to the results, lecture videos have become very popular among students. Moreover the use of lecture videos increases participation activeness, and the increase in participation has a positive impact on completion of courses. However, the use of lecture videos does not seem to have any clear-cut effect on grades obtained.**

***Index Terms*—blended learning; learning outcomes; lecture attendance; video lecture.**

I. INTRODUCTION

Due to rapid changes in work life, especially in the field of ICT, lifelong learning has an important role to play. In practice, lifelong learning means that the needs of the adult learner must also be met. Adult education brings with it novel challenges for education providers. Adult students often are integrated in work life. This is quite common, especially in the field of ICT. In addition to being employed, these students have often family responsibilities, and they are continuously forced to make compromises between participation in education and family life. Thus, the biggest problems that adult students and students who work and study have, are related to time use limitations. This is shown, above all, as difficulties in participating in the education arranged.

To improve the opportunities for participation in education, the education provider must seek new solutions to increase the flexibility of education. That means, first and foremost, enabling new, flexible ways of participation. One way to increase the ways to participate is to provide education by blending together face-to-face and e-learning methods.

E-Learning is an umbrella term, which can be widely defined to include all electronic technology used for learning purposes [1]. Today, almost all teaching in higher education institutes involves some use of electronic materials. The potential that technology has brought to us can be utilized also in face-to-face teaching, and often at least lecture transparencies are available in electronic form. More and more frequently there are complete courses or at least parts of courses that can be studied via the web. Ac-

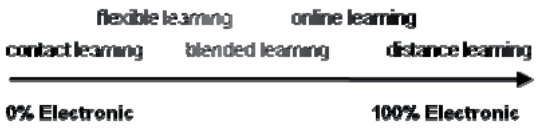

Figure 1. Spectrum of E-Learning [2]

cording to Procter [2], the spectrum of different E-Learning solutions can be shown as in Fig. 1. In the figure, the line represents the percentage share of teaching that is transferred electronically. The scale is flexible, and the terms often get their exact meaning only once they are being used.

The education model that is realized by combining face-to-face teaching and online learning is called the blended learning model [3]. The term "blended learning" thus describes learning with a mix of, for example, different location-bound activities (such as face-to-face classrooms), teaching that is not dependent on time or place (on-demand videos) and live E-Learning (real-time videos) [4]. Several slightly differing definitions for the blended learning model have been proposed (e.g., [3], [5], [6]). Indeed, it is hard to determine whether the term blended learning means face-to-face learning boosted by web technologies or online teaching made more efficient by face-to-face learning. It is also difficult to see what their mutual ratio should be so that the teaching could be referred to as blended [3].

In Master Studies in Mathematical Information Technology at the Kokkola University Consortium, the education provider does not force the courses to adapt to the contact learning, distance learning, online learning or blended learning model. The approach of the education provider is to offer education both in the form of face-to-face education and as online education implemented with the help of videos. The students in the education programme can freely choose the way to participate in education for each lecture. Solution that is based on face-to-face teaching and streaming lecture videos offers the students a full range of opportunities to participate in education regardless of time and place and in accordance with their own needs. To the student, education provided thus appears as a model of blended learning where the student can decide the degree of blending. The student can, if he/she so wishes, study solely through the face-to-face mode, but the student also has the choice to study solely through the distance mode.

According to some research participation in face-to-face education has a positive impact on course performance [7][8], and the provision of lecture videos might lure students away, without an acceptable reason, from face-to-

face education (example [9]). So it is a quite common belief that lecture videos have a negative influence on participation in face-to-face education and on learning [10][11]. One should keep in mind, nevertheless, that if participation in education is made more flexible, it also becomes more diverse. Thus, the strongest emphasis should not be put on the impact of lecture videos on participation in face-to-face education but rather on how the use of lecture videos affects participation as a whole and on the impact of video use on learning outcomes.

This study describes a blended learning solution as well as to examines the impacts of the use of the videos on participation in lectures and on study results. Based on the classifications of student's course participation, the article examines, in more detail, the impact of different participation modes on participation activity and learning outcomes. The article is extended and updated version of [13]. The results in this article are based on analyses of log data collected from transmissions of videos for 25 courses between 2008 and 2010, attendance statistics collected about face-to-face education, the register of study credits and on a survey [12] of master's students of information technology done in 2009.

The rest of this article is organized as follows: Section II reviews other related studies conducted elsewhere; Section III describes a blended learning solution for the Master Studies in Mathematical Information Technology, motivation for the use of blended learning and, briefly, the practice established for the production of videos; Chapter 4 classifies students and course participation on the basis of the amount of video use and, with the help of this, examines what the effects of the use of lecture videos on learning outcomes are. Finally, there are some conclusions.

II. RELATED WORK

When evaluating the impact of videos, it is important to observe the effects of video use on participation in education and on learning outcomes. However, research on lecture videos, for the most part, focuses on the ways videos are used or on the activeness in their use.

The impact of videos on participation in education has been examined especially from the viewpoint of participation in face-to-face education. Less attention has been paid to participation in education with the help of videos. Also in case of participation in face-to-face education the research results are conflicting. Some of the studies have found that videoing lectures has a negative effect on participation in face-to-face education (e.g., [10], [14]), but according to other studies there is hardly any effect (e.g., [9], [15], [16], [17]).

Neither have the learning outcomes in connection with the use of lecture videos been examined, to any great extent, in earlier studies. The results are contradictory and usually results cannot be directly projected from the topic of the investigation to other education programmes. According to the research by Gosper et al [14], students believed that lecture recordings had helped them in obtaining better learning outcomes. Dziuban et al [3] found that the learning outcomes in courses based on blended learning were somewhat better and cases of dropping out less frequent than in the corresponding online courses. When compared to face-to-face education, the blended model was found to be at least as good, in some cases even better. According to a study by Dean et. al. [18], students got better grades when online sessions were added to traditional teaching. Also according to Traphagan et al [10], students who use video lectures a lot obtain higher grades in exams.

On the other hand von Konsky et. al. [15], noticed in their research that the use of lecture recordings influenced completion of courses but had no influence on grades obtained. Wieling and Hofman [19] noticed that the amount of participation in face-to-face education and with the help of videos positively correlated with course performance. They found out that the greater the share of participation as face-to-face education the smaller was the positive effect of participation with the help of videos. Ross and Bell [20] investigated students who are able to participate in face-to-face education and view on-demand videos. They noticed that the more these students participate with the help of videos, the worse the grades they get. By contrast, they also investigated students who have only videos at their disposal and found out that the more they view the videos, the better the grades they obtain. Chiu et al [21] did not find any difference in course grades between those who took advantage of videos in their participation and those who did not

III. BLENDED LEARNING SOLUTION

There are approximately 100 students enrolled in Master Studies in Mathematical Information Technology at Kokkola University Consortium. All students in the programme are adults. For education providers, mature-age study brings with it novel challenges when compared with education directed to young students.

A. Challenges

Almost all the master's students are employed and most of them work in the field of ICT. Typical of this field is that the workload varies, and to maintain one's skills requires constant study. Working alongside study significantly limits the time that can be dedicated for study. To provide the working students with at least some kind of opportunity to participate in face-to-face education, if they so wish, face-to-face teaching is arranged to take place on Friday evenings and on Saturdays during daytime. To improve the participation opportunities for students who work, attempts are made to keep the courses concise. During a single weekend, typically 2-6 traditional lectures are given. Thus arranged, a course can be carried out in a few weekends. The problem with this is that absences of one weekend can mean, in the worst case, that the student cannot attend 15-50% of the course's face-to-face teaching.

For most adult students there is also one special issue to consider: almost all of them have a family to look after. Having a family sets more limitations for the time the student can dedicate for study. The students are thus forced to make compromises in their allocation of time between participation in education, on one hand, and work and family life, on the other.

Competition over students has lead to marketing of master's education in information technology consciously on a national level. The students of the study programme typically live around a wide geographical area. The distance from the places of the farthest living students to the campus area is approximately 500 km. Long distances

naturally make it more difficult for the students to participate in face-to-face teaching. It is quite significant also that the number of students living farther away is continuously increasing. Of the students accepted to the programme during the last few years only about 1/3 live so near the campus that the distance does not impede with their participation in education.

The limitations due to work, family life and long distances are shown, above all, as worsening opportunities to participate in the programme. Thus, there is a clear need to add flexibility to study participation. This has led to the provision of education being very strongly supported by solutions of educational technology.

B. *Adding Flexibility to Participation*

The education solution for the Master Studies in Mathematical Information Technology is based, above all, on the use of lecture videos created by streaming technology. The aim is to improve the opportunities of students to participate, with the help of videos, in education provided. The student can participate in education through the face-to-face mode or by watching a real-time transmission. Participation in education in this case would be in accordance with a course schedule designed beforehand. However, real-time videos free the student from dependency on the place of study. If a student wants to participate in education in accordance with some other schedule, he/she can view the teaching through on-demand video.

An important principle in the education solution is that students do not need to decide about their participation mode beforehand; they can choose to participate in each lecture the way that is the most suitable in their own particular circumstances. Thus, in one course the student can participate in education in many different ways by flexibly combining various alternatives. Moreover, the student can always, if he/she so wishes, revise earlier teaching sessions with the help of videos.

As a support for the studies, in addition to videos, a web based Learning Management System (LMS) is used. The system includes all the material that is related to the study and communications. Course-specific communication and distribution of materials that the course requires is also carried out through LMS. Therefore, the information needed can be accessed always by the student when connected to the Internet.

1) *Video Lectures*

The approach for adding flexibility to participation in education has been that it must be applicable to all teaching provision in the education programme, not only to some individual courses. All face-to-face teaching provided by the educational programme is offered as real-time video produced from face-to-face teaching situations. This has been made possible by automation, as far as possible, of the production of lecture videos During the production of a real-time video, the video is also recorded. This so-called on-demand video is offered to students for later viewing.

In connection with the videos produced for teaching information technology, the decision has been made to give priority to the visibility of lecture material. For this reason, a lecture video consists of sounds heard in the lecture theatre and of a picture of the electronic teaching material that the lecturer shows with the video projector in the teaching space. In addition to the computer and instead of using a traditional blackboard, the lecturers use a document camera, touch screen or smartboard. Thus all the teaching material used by them can be stored in the video. Good visibility of teaching material is also the focus of constant development work. Currently it is possible to produce these materials for HD standard. Fig. 2 shows an example of a lecture video where the lecturer uses a document camera. Fig. 3 shows an example of a lecture video where the lecturer uses a touch screen in the presentation of electronic lecture material.

2) *Use of Video Lectures*

The students get their links to real-time video and on-demand video recordings through the Learning Management System. In this way the links to videos can be accessed only by students who participate in the course concerned. On-demand videos can be viewed by the students already during the evening of the lecture day. The videos are on the media server; they cannot be stored on the student's own computer. Students log in with their own personal IDs to watch the videos. Research related to video use has been made possible by the use of the media server, prevention of storage and user IDs.

For some years now, the use of videos to diversify study has been an established practice in connection with the provision of education [12], [22]. The main principle is that the students have the opportunity to select between face-to-face education and video lectures as their lecture participation mode or combine both modes.

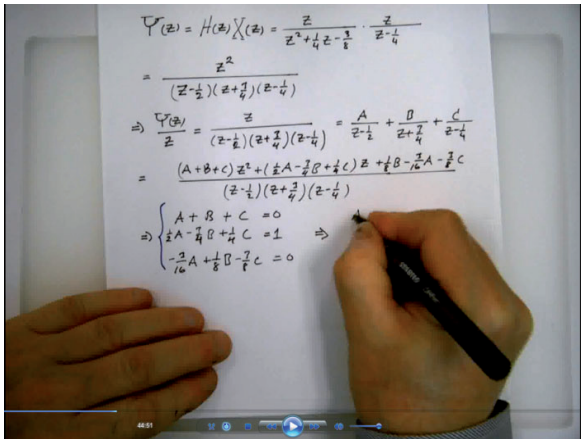

Figure 2. Example of a lecture video where the lecturer uses a document camera.

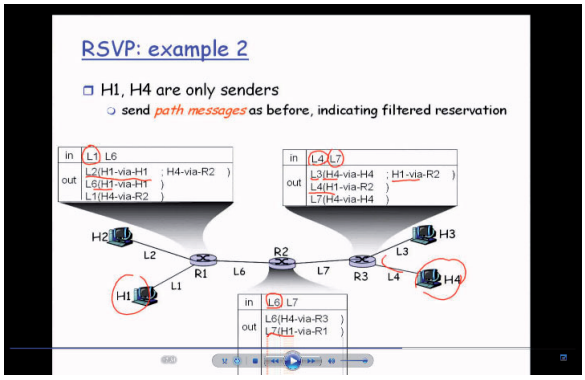

Figure 3. Example of a lecture video where the lecturer uses electronic material and a touch screen.

Fig. 4 shows the importance of the role that videos have in education when students can freely choose the way to participate for each lecture. Figure examines the portion of students' participation modes of all lecture participations in year 2010. In that year 74 % of all lecture participations took place with the help of videos and only one-fourth of the lecture participations occurred as face-to-face learning.

During 2010 there were 62 students who had watched real-time video or on-demand video. In practice, this includes all the students actively engaged in the programme. During 2010, lecture videos from 13 different courses were produced. The total viewing time for the real-time transmission of these courses amounted to 644 hours and for on-demand videos 2389 hours. In addition on-demand videos from previous year were viewed 193 hours. On average, 14 students viewed the recordings of one course and a single student watched the recording of one course for approximately 13,5 hours.

The use of videos is continuously increasing. This can be seen clearly highlighted in Fig. 5, which presents the amount of video viewing in hours during the period 2008-2010. The prediction is that growth will continue in the coming years when the use of lecture videos comes more and more familiar to students. Fig. 5 shows also that studying with the help of the real-time videos, which will happen simultaneously with the face-to-face teaching, have decreased in recent years. This reflects the fact that the role of face-to-face education is changing.

Since the videos have such a significant role, and because there are many students who have quite poor possibilities to participate in face-to-face teaching, the impact of videos on participation in education and on learning outcomes are examined more closely.

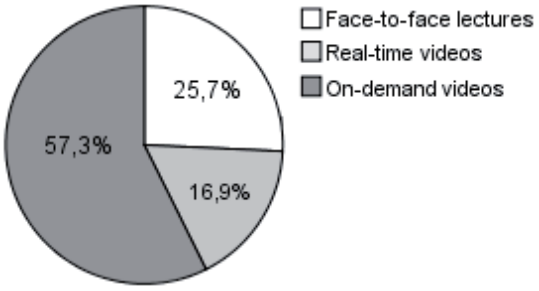

Figure 4. Relative shares of participation modes of all lecture participations (n=1252) for 11 courses from which statistics have been collected in 2010.

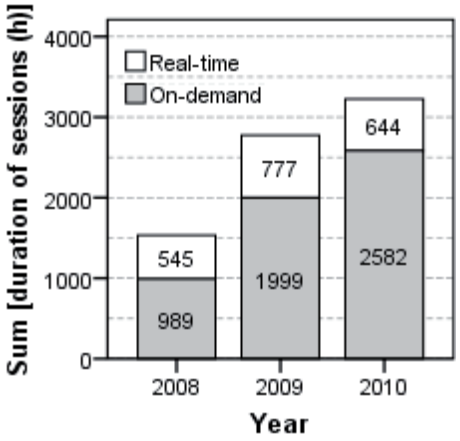

Figure 5. The amount of video viewing in hours per year based on the log data collected from transmissions of videos between 2008 and 2010

IV. IMPACTS ON ATTENDANCE AND LEARNING OUTCOMES

The media server used in video distribution stores information, in a comprehensive manner, from video viewing to log data [12]. The log data, in fact, provides good material for research related to videos. When necessary, log data can be complemented with other information. The results of the article are based on the log data of 25 courses held between 2008 and 2010. The study involved 75 students who accumulated a total of 342 course participations and 2552 participations in lectures. During this study, the log data has been complemented with the attendance statistics of face-to-face education, information in the register of study credits and with the results of the student survey [12] done in spring 2009.

The students of the Master Studies in Mathematical Information Technology have the opportunity to select between face-to-face education and video lectures as their lecture participation mode or combine both modes. Therefore, the student's participation mode in a course can be classified with the help of video lectures, based on the amount of participation, as shown in Fig. 6: as face-to-face participation, online-participation fully utilizing videos, or hybrid participation employing both of the participation modes.

A student was counted as a participant of a course if he/she participated at least in one lecture of the course by using any of the above participation modes. The classification could be done on the basis of the students' participation mode of all courses or as per course. The first one

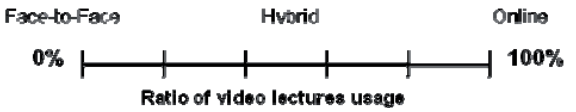

Figure 6. Classification of students' participation mode based on the amount of participation with the help of the video lectures.

is a classification of students and the second one is a course-specific classification. In this article both classifications are presented.

A. Classification of Students

First the students are classified on the basis of the participation mode on lectures of all 25 courses. The students are classified in three categories: as face-to-face students, online students, and hybrid students. These categories are defined as follows:

Category I (Face-to-face students): Face-to-face students, who always participate in courses in the face-to-face mode.

Category II (Hybrid students): Hybrid students, who participate in courses both in the face-to-face mode as well as with the help of lecture videos.

Category III (Online students): Online students, who always participate in courses with the help of lecture videos.

Table I considers participation in education for different student categories. Based on the table, 92% of the students

made use of lecture videos in study participation, and only 8% of the students always participated in face-to-face education. The opportunity, provided by lecture videos, to participate in a flexible way, increased also study participation. The participation percentages of both hybrid and online students during the study period were clearly above those of face-to-face students. The participation percentage of the latter group remained as low as 47%. This is clearly below the average participation percentage 67%.

The significant role of videos is partially explained by the results of the questionnaire that was directed to students in the spring of 2009 [12]. More than half of the students had the impression that lecture videos, together with other course material, facilitated their learning at least as well or even better than face-to-face teaching. About one-third of them thought that face-to-face teaching in some situations facilitates learning better than video lectures do. Only one-tenth were of the opinion that lecture videos cannot replace face-to-face teaching in any situation.

Table II shows the percentage of completed courses by student category. Based on the table, course completion by face-to-face students is clearly less than by hybrid students, and respectively, course completion by hybrid students is less than online students. For face-to-face students, only 42% of courses led to a grade that was approved. For hybrid and online students the corresponding percentages are 66% and 72%.

Fig. 7 shows the relation between course participation and completion. Based on the figure, face-to-face students participate considerably less in education and also complete clearly fewer courses than hybrid and online students who utilize lecture videos. On the other hand, hybrid students participate more in education but complete fewer courses than online students. However, according to t-tests the differences of participation and courses completed between hybrid students and online students are not statistically significant. Thus, the share percentage of completed courses seems to be dependent on the participation degree or the use of video lectures.

Fig. 8 focuses on the averages of the grades of only those students whose course studies were graded. Based on Fig. 7 and Fig. 8, the participation degree does not have any effect on grades. According to Fig. 8 face-to-face students have the best results and hybrid students the worst results, but the differences between categories are not statistically significant (Mann-Whitney U Tests). So, the results do not support the assumption that participation mode has some effect on grades.

B. Classification of Courses

Above, students' lecture participation for each course during the observation period was studied. The students can choose their participation mode as per lecture. Thus, a particular student can participate in one course as a face-to-face student and in another course as a distance student or a hybrid student. Thus, the importance of face-to-face and online participation in the classification presented above decreases and that of hybrid participation increases. A significant portion of hybrid students participated in some of the courses through the face-to-face mode only and in some of the courses only with the help of lecture videos. For this reason, the classification of students' course participation is also done as per course.

TABLE I.
CLASSIFICATION OF STUDENTS AND PARTICIPATION IN EDUCATION

	Students	Lecture participation
Face-to-face students	6 (8%)	47%
Hybrid students	39 (52%)	73%
Online students	30 (40%)	64%
Total	75	67%

TABLE II.
PERCENTAGE OF COURSES COMPLETED IN DIFFERENT STUDENT CATEGORIES

	Students	Completed	Not completed
Face-to-face students	6 (8%)	42%	58%
Hybrid students	39 (52%)	66%	34%
Online students	30 (40%)	72%	28%
Total	75		

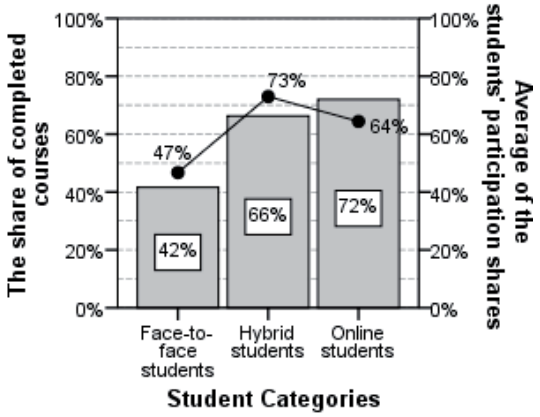

Figure 7. Average participation percentage (graph) and the share of courses completed (histogram) in different student categories. (n=75)

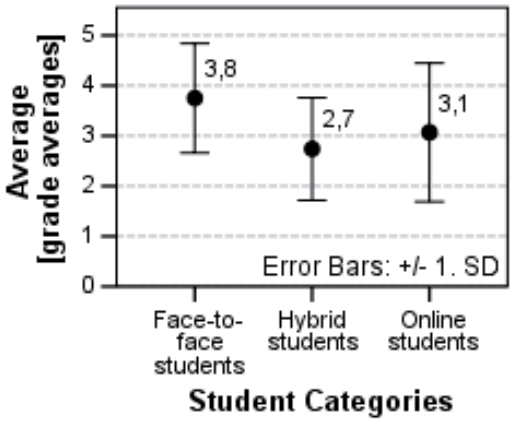

Figure 8. Grade averages and deviations (N=69) of the grades for completed courses. The courses are evaluated with 0-5 integral scale.

When classification concerns the student's course-specific participation mode, i.e., course participation mode, course participations by students and not the students themselves are classified. The students´ course participations are classified in three categories as face-to-face

participation, hybrid participation, and online participation, which are defined as follows.

Category I (Face-to-face participations): Course participations by students in which all the student's course participations have taken place through the face-to-face mode.

Category II (Hybrid participations): Course participations by students in which the student's course participations have taken place through the face-to-face mode as well as with the help of videos.

Category III (Online participations): Course participations by students in which all the student's course participations have taken place with the help of lecture videos.

As we examine all 25 course participations, we must keep in mind that the classification is no longer student-specific. A student can participate in one course purely through the face-to-face mode, in another course both with the help of lecture videos as well as through the face-to-face mode and in a third course solely with the help of lecture videos. In that case the student's course participations are, respectively, allocated to categories I, II and III.

Fig. 9 shows relationship between classification of students and the course-specific classification. According to the figure hybrid students constitute the main part of the face-to-face course participations. Similarly, nearly half of the online course participations are constituted by the hybrid students. Of the hybrid students, 20 participated in at least one course in the face-to-face study mode only and 26 participated at least in one course solely with the help of videos.

Table III shows the impact of course-specific classification on participation in education. Table III clearly shows the importance of lecture videos on participation in arranged education. Most of the course participations (84%) took place with the help of lecture videos, either as hybrid or online participation, and more than half (51%) of the course participations took place solely with the help of lecture videos. In addition, three out of four students participated at least in one course solely with the help of videos.

Table III shows that lecture participation was clearly most common (83%) in the hybrid participation category. Lecture participation percentages were good also in the face-to-face participation category and in the online participation category. Participation degrees were close to each other in these two categories.

Table III is clearer than Table I in presenting the importance of face-to-face teaching to students. According to Table I, only 8% of the students participated in face-to-face teaching. However, according to Table III, 35% of the students participated in at least one course in the face-to-face study mode only. Also the percentage of lecture attendance in Table III is substantially greater than in Table I.

The results can be interpreted as meaning that many students made an effort to participate, with the help of face-to-face teaching, in those courses in which they had the possibility to participate while keeping within the schedule. This is also reflected in Fig. 9, which shows that course participations by hybrid students was 75% of all face-to-face course participations. The desire to participate was also shown in the results of the student questionnaire [12], according to which, more than 70% would have liked to participate in face-to-face education on Fridays and Saturdays if there had been no time-related problems concerning participation.

Table IV divides the students' course participations, by categories, to those that led to course completion and those that did not. According to the table, the completion percentages are same (62%) for the online participation category and for face-to-face participation category. However, the hybrid category students have the greatest chance of completing a course with their clearly superior course completion probability (79%).

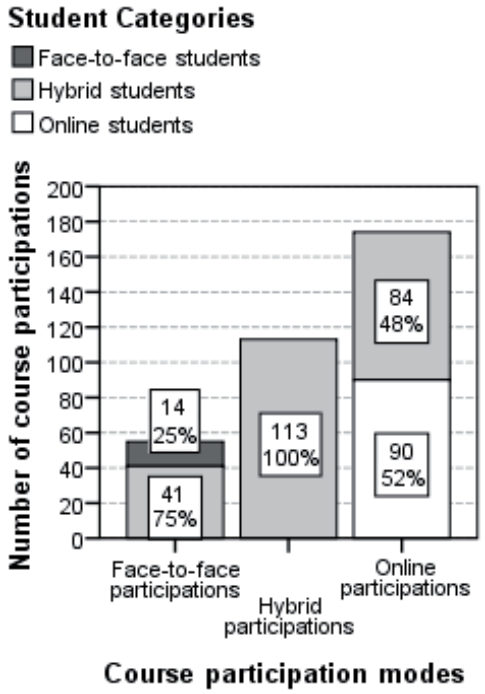

Figure 9. Relationship between classification of students and the course-specific classification.

TABLE III.
COURSE-SPECIFIC CLASSIFICATION AND PARTICIPATION IN EDUCATION

	Number	Students	Lecture participation
Face-to-face participations	55 (16%)	26 (35%)	67%
Hybrid participations	113 (33%)	38 (51%)	83%
Online participations	174 (51%)	56 (75%)	66%
Total	342		

TABLE IV.
PERCENTAGE OF COURSES COMPLETED IN DIFFERENT LECTURE PARTICIPATION CATEGORIES

	Completed	Not completed	Total
Face-to-face participations	34 (62%)	21 (38%)	55 (100%)
Hybrid participations	89 (79%)	24 (21%)	113 (100%)
Online participations	107 (62%)	67 (38%)	174 (100%)
Total	230 (67%)	112 (33%)	342 (100%)

Videos enable more flexible participation in education, and this is reflected also in course completions. Fig. 10 considers the effect of participation on course completion. According to the figure, the percentage of completed courses is dependent on the participation degree.

Fig. 11 considers the effect of participation on course completion. In the figure, the hybrid participations are further divided into five different categories on the basis of video use:]0,20[, [20,40[, … , [80,100[. For example, [20,40[indicates students' course participations in which [20%, 40%[of those participations have taken place with the help of videos and the rest of them as face-to-face education. The figure shows that the percentage of the completed courses is, above all, dependent on the participation percentage and not on the relative share of participations that have taken place with the help of videos. For example, those course participations in which videos were used in [40%, 80%[lecture sessions did not lead to course completion as well as did participations in which videos were used either more often or less often.

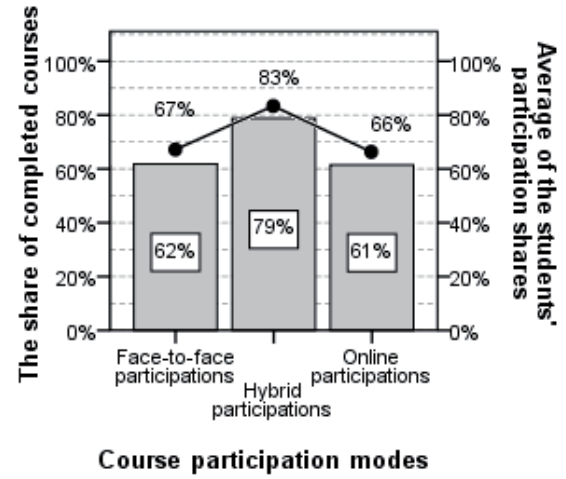

Figure 10. Average participation percentage (graph) and the percentage of courses completed (histogram) for different course participation modes.

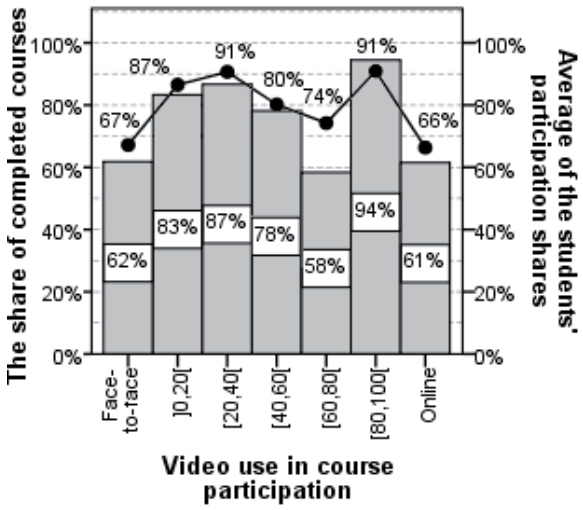

Figure 11. Average participation percentage (graph) and the percentage of courses completed (histogram) for different course participation modes.

Even though the participation degree explains completion of courses, nevertheless, even according to this classification, it does not seem to correlate with the grades obtained in the courses. This becomes apparent in Fig. 11-13. Fig. 12 and Fig. 13 show the averages of the grades for different course participation modes. According to Fig. 12 and Fig .13, the grades for hybrid participation category are not as good as other categories. However, the differences between categories are not statistically significant (Mann-Whitney U Tests and Kruskal-Wallis Test).

V. CONCLUSION

Increase in adult education and the challenges it has brought with it put providers of education under pressure to find flexible ways to arrange teaching. A much used method is mix together face-to-face teaching and online teaching. The blended learning model has been implemented already for many years in face-to-face teaching and videos produced about it in Master Studies in Mathematical Information Technology at Kokkola University Consortium. In the model, students themselves decide how much to utilize the videos.

In the results of this article, the importance of videos in the participation of education provided was strongly emphasized. Three out of four students participated at least in one course wholly with the help of videos and almost all students utilized videos to a certain extent in their partici-

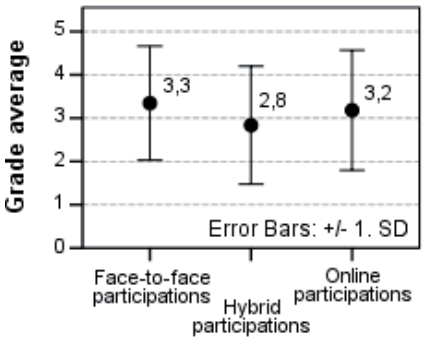

Figure 12. Grade averages and deviations (N=127) of the grades for completed courses. The courses are evaluated with 0-5 integral scale.

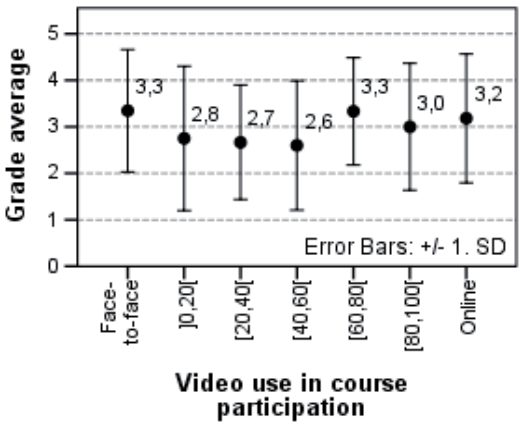

Figure 13. Grade averages and deviations (N=127) of the grades for completed courses. The courses are evaluated with 0-5 integral scale.

pation in education. The number of hybrid students, i.e. those students who use a different ways to participate to education, was high. The use of videos has increased substantially in recent years and the trend seems to be such that an increasing number of participations will take place with the help of the videos in the future.

Although the role of videos in participation for arranged education is strong, organizing face-to-face teaching is still well justified. According to the student classification, students who generally participate with the help of face-to-face education in all of the courses are a minority. However, with the course-specific classification it can be observed that more than every third student participates purely through face-to-face education in some individual courses. This seems to indicate that students often adapt their study in accordance either with the course or with their life situation. It also seems that many of the students might not have just one single mode to participate in the education provided.

The utility of the blended learning solution can be evaluated not only by participation in education but also in relation to learning outcomes. This article considered learning outcomes by focusing on the effect of the solution on course completions and grades. According to the results, use of lecture videos facilitates participation in a course. Similarly, it seems that the increased participation brought about by videos has a positive effect on course completion. Thus, provision of videos can be seen to demonstrate an indirect positive effect on learning outcomes. On the other hand, the use of lecture videos does not seem to have any effect on grades obtained.

The significant and increasing role of the lecture videos and a large number of hybrid students suggests that another kind of student classification could be useful. Therefore, the effects of video usage on learning outcomes have already been studied with the help of the classification that takes hybrid student better into account [23]. It is still a challenge to create a complete picture of the impacts of a blended learning solution realized with the help of videos. For example, one must be able to verify somehow the effects, on learning outcomes, of repeated use of videos. For this reason, further research on this field would be well justified.

REFERENCES

[1] C. Maguire and J. Zhang, "Blended learning in the development context: Experience with GDLN in Asia-Pacific", Tokyo Development Learning Center; Japan/ World Bank Distance Learning Partnership Project, 2007.

[2] C. Procter, "Proportion, pedagogy, and processes: The three p's of elearning", Proceedings of the International Academy for Information Management Annual Conference, Barcelona, 2002.

[3] C. D. Dziuban, J. L. Hartman, and P. D. Moskal, "Blended learning*", EDUCAUSE Center for Applied Research, Research Bulletin*, vol. 2004, no. 7, 2004.

[4] G. Harriman, "What is blended learning?", E-Learning Resources, http://www.grayharriman.com/blended_learning.htm, 2004

[5] C. J. Bonk and C. R. Graham, *Handbook of blended learning. Global perspectives, local designs*. San Francisco, CA: Pfeiffer Publishing. 2006.

[6] A. Littlejohn and C. Pegler, *Preparing for Blended E-Learning.* New York, NY: Taylor & Francis, 2007.

[7] S. E. Gump, "The cost of cutting class: Attendance as a predictor of student success", *College Teaching,* vol. 53, no. 1, pp. 21–26, 2005. doi:10.3200/CTCH.53.1.21-26

[8] L. Stanca, "The effects of attendance on academic performance: Panel data evidence for introductory microeconomics", *Journal of Economic Education,* vol. 37, no. 3, pp. 251–266, 2006. doi:10.3200/JECE.37.3.251-266

[9] J. A. Brotherton, and G. D. Abowd, "Lessons learned from eClass: Assessing automated capture and access in the classroom", *ACM Transactions on Computer-Human Interaction (TOCHI)*, vol. 11, no. 2, pp. 121-155, 2004. doi:10.1145/1005361.1005362

[10] T. Traphagan, J. V. Kucsera and K. Kishi, "'Impact of class lecture webcasting on attendance and learning", *Educational Technology Research and Development* , vol. 58, no.1, pp.19-37, 2009. doi:10.1007/s11423-009-9128-7

[11] S. Chang, "Academic perceptions of the use of Lectopia: A University of Melbourne example", Proceedings of the Australasian Society for Computers in Learning in Tertiary Education, Singapore, 2007.

[12] M. Myllymäki, I. Hakala and S. Laine, "The motivation for video viewing in blended learning", Proceedings of the International Technology, Education and Development Conference, Valencia, Spain, 2010.

[13] I. Hakala and M. Myllymäki, "Blended Learning in Master Studies in Mathematical Information Technology: Impacts on Attendance and Learning Outcomes", Proceedings of the 2nd IEEE EDUCON conference, Amman, Jordan, 2011.

[14] M. Gosper, D. Green, M. McNeil, R. Phillips, G. Preston and K. Woo, "The impact of web-based lecture technologies on current and future practices in learning and teaching", Australian Learning and Teaching Council, Sydney, 2008.

[15] B. R. von Konsky, J. Ivins and S. J. Gribble, "Lecture attendance and web based lecture technologies: A comparison of student perceptions and usage patterns", *Australasian Journal of Educational Technology*, vol. 25, no. 4, pp. 581-595, 2009.

[16] M. Grabe and K. Christopherson, "Optional student use of online lecture resources: resource preferences, performance and lecture attendance", *Computer Assisted Learning,* vol. 24, no.1, pp. 1-10, 2008. doi:10.1111/j.1365-2729.2007.00228.x

[17] S. M. Walls, J. V. Kucsera, J. D. Walker, T. W. Acee, N. K. McVaugh and D. H. Robinson, "Podcasting in education: Are students as ready and eager as we think they are?", *Computers & Education,* vol. 54, issue 2, pp. 371-378, 2010. doi:10.1016/j.compedu.2009.08.018

[18] P. Dean, M. Stahl, D. Sylwester and J. Pear, "Effectiveness of combined delivery modalities for distance learning and resident learning", *Quarterly Review Of Distance Education*, vol. 2, no. 3, pp. 247-254, 2001.

[19] M. Wieling and W. Hofman, "The impact of online video lecture recordings and automated feedback on student performance." *Computers & Education,* vol. 54, no. 4, pp. 992-998, 2010. doi:10.1016/j.compedu.2009.10.002

[20] T. K. Ross and P. D. Bell, "No significant difference, only on the surface", *International Journal of Instructional Technology and Distance Learning,* vol. 4, no. 7, pp. 3–13, 2007.

[21] C. F. Chiu, G. C. Lee and J. H. Yang, "A comparative study of post-class lecture video viewing", Proceedings of 5th IASTED international conference on Web-based education, Puerto Vallarta, Mexico, 2006.

[22] I. Hakala, S. Laine, M. Myllymäki and J. Penttilä, "The effect of time and place dependence when utilizing video lectures", Proceedings of the 20th EAEEIE Annual Conference on Innovation in Education for Electrical and Information Engineering, Valencia, Spain, 2009.

[23] I. Hakala and M. Myllymäki, "The use of lecture videos: attendance and student performance", to appear in Proceedings of the 14th International Conference on Computers and Advanced Technology in Education, Cambridge, United Kingdom, 2011.

AUTHORS

I. Hakala and **M. Myllymäki** are with University of Jyväskylä, Kokkola University Consortium Chydenius, Kokkola, Finland.

This article is an extended version of a paper presented at the IEEE EDUCON20211 Conference, held from April 4th-6th, 2011, in Amman, Jordan. Received April 20th, 2011. Published as resubmitted by the authors May 2nd, 2011.

[22] I. Hakala, S. Laine, M. Myllymäki and J. Penttilä, "The effect of time and place dependence when utilizing video lectures", Proceedings of the 20th EAEEIE Annual Conference on Innovation in Education for Electrical and Information Engineering, Valencia, Spain, 2009.

[23] I. Hakala and M. Myllymäki, "The use of lecture videos: attendance and student performance", to appear in Proceedings of the 14th International Conference on Computers and Advanced Technology in Education, Cambridge, United Kingdom, 2011.

III

THE USE OF LECTURE VIDEOS: ATTENDANCE AND STUDENT PERFORMANCE

by

Ismo Hakala & Mikko Myllymäki, 2011

In V. Uskov (Ed.), Proceeding of the 14th International Conference on Computers and Advanced Technology in Education

THE USE OF LECTURE VIDEOS: ATTENDANCE AND STUDENT PERFORMANCE

Ismo Hakala, Mikko Myllymäki
University of Jyväskylä, Kokkola University Consortium Chydenius
P.O.Box 567, FIN-67701, Kokkola, Finland
ismo.hakala@chydenius.fi, mikko.myllymaki@chydenius.fi

ABSTRACT
Lecture videos produced of face-to-face teaching are often successfully used to add more flexibility to teaching. As far as location is concerned, real-time videos enable flexible participation in education, and on-demand videos also make it more flexible timewise. This allows substitution of absences and makes distance study possible. This paper considers the effects of lecture videos on participation in education and on learning outcomes. These learning outcomes are examined with the help of course completions and grades obtained. In addition, it is examined whether there are differences related to learning outcomes between those for whom the distance is not a barrier for participating in face-to-face education and those who live far from the campus. Based on the results obtained, lecture videos have a positive impact on participation in education and on learning outcomes. Use of lecture videos improves completion rate, which naturally shortens completion times. In addition to the effect on completion percentage, the use of videos has a positive impact also on grades.

KEY WORDS
lecture videos; learning outcomes; attendance

1. INTRODUCTION

Utilization of educational technologies in the provision of education brings with it many kinds of benefits. Above all, educational technologies enable construction of flexible educational solutions that take into account students' individual needs. Lecture videos realized with the help of video technologies are particularly well suited for diversifying teaching as they allow one to participate in education regardless of time and place.

Use of lecture recordings in connection with higher education is quite diverse [12]. Clearly, the main objective in some of the usages is to increase flexibility. This applies, for example, to situations where lecture videos are produced to enable distance study or as a substitute in case of absences. When video technologies are utilized in education, the student can participate in lectures through face-to-face teaching or by watching a real-time transmission. Participation in education in this case would be in real time, in accordance with a course schedule designed beforehand. If a student wants to participate in education, following some other schedule, he/she can view the teaching in a delayed mode through on-demand video. Moreover, the objective in providing lecture videos might actually be to improve students' performance. However, at the same time as flexibility is to be increased, attention must be paid to how the use of videos will affect learning outcomes. At least negative impacts should be avoided.

It is a very widespread belief that lecture videos have a negative influence on participation in face-to-face education and, thus, are detrimental to learning [12][2]. Research indicates that participation in face-to-face education has a positive impact on course performance [7][11] and that the provision of lecture videos might lure students away, without an acceptable reason, from face-to-face education [1]. One should keep in mind, nevertheless, that if participation in education is made more flexible, it also becomes more diverse. Thus, the strongest emphasis should not be put on the impact of lecture videos on participation in face-to-face education but rather on how the use of lecture videos affects participation as a whole and on the impact of video use on learning outcomes. Only this information is really meaningful when we think about the advantages and disadvantages of the use of videos. In theory, the use of lecture videos may even be considered as improving students' performance because with the help of them we can increase motivation and commitment and facilitate information processing [12]. Theories related to learning with the help of multimedia [9] also support this idea.

The aim of this research is to examine whether the improvement in participation opportunities brought about by lecture videos is reflected in learning outcomes. Learning outcomes are examined from the viewpoint of course completions and grades obtained. Lecture videos play a very different role for students living near the campus area and for students living far from the campus. For this reason the research focuses on examining the role of video use in participation and its effects on learning in relation to the distance of the students' place of residence from the place of study.

The survey was conducted by analysing video viewing log data and attendance statistics for face-to-face education. The data for the survey were collected from 22 courses arranged in connection with the Master Studies in Mathematical Information Technology at Kokkola University Consortium. In addition, the material has been

supplemented with data from the register of study credits as well as with the results of a student survey in 2010.

2. RELATED WORK

When examining the impact of lecture videos on participation, research generally has focused on the impacts of lecture recordings on face-to-face education attendances. According to both Gosper et al [5] and Traphagan et al [12], participation in face-to-face education had declined as a result of introduction of lecture recordings. On the other hand, Von konsky et al [13] did not find anything indicating that recordings would have had any noticeable effect on participation in face-to-face education.

Chiu et al [3] did not find any difference in course grades between those who took advantage of videos in their participation and those who did not. According to the research by Gosper et al [5], students believed that lecture recordings had helped them in obtaining better learning outcomes. However, the teaching staff were not as convinced about the matter. On the other hand, it has been noticed that the use of recordings has a positive impact on course performance [13], [4]. Audio recordings instead of lecture videos were used in these two investigations. Also according to Traphagan et al [12], students who use video lectures a lot obtain higher grades in exams.

Some of the research has investigated students who have the opportunity to participate in face-to-face education as they wish and those who do not or for whom participation is difficult at the very least. Wieling and Hofman [14] noticed that the amount of participation in face-to-face education and with the help of videos positively correlated with course performance. According to that research, the greater the share of participation as face-to-face education, the smaller was the positive effect of participation with the help of videos. According to Ross and Bell [10], for students who are able to participate in face-to-face education and view on-demand videos, the more they participate with the help of videos, the worse the grades they get. By contrast, for students who have only videos at their disposal, the more they view the videos, the better the grades they obtain.

As it can be seen, the results are somewhat contradictory. Also, the results cannot be directly projected from the topic of the investigation to other education programmes. This provides a good justification for our research. Moreover, there hasn't been much research on the significance of the distance between a student's place of residence and the campus on participation with the help of videos and on learning outcomes achieved with them. This research differs from many others also in the sense that some of the students who are used as material for this research live so far that it is difficult for them to participate in face-to-face education. Thus, the selection of participation mode is not only determined by one's learning style or general interest in participation.

3. STUDY DESIGN

This article examines the role of lecture videos in participation in education and the impacts of this kind of participation on learning outcomes. The examination of those impacts is done by focusing on course completions, on one hand, and on obtained grades from courses where the results have been assessed, on the other. In addition, it is examined whether there are differences in this respect between those living near the campus and those living far from it.

The data for the research was collected from 22 courses of the Master Studies in Mathematical Information Technology at Kokkola University Consortium between 2008 and 2010. The teaching of all the courses used as material was arranged as face-to-face teaching. In accordance with the students' wishes, the programme was made as intensive as possible; thus, the duration of a single lecture equaled 3-4 traditional lectures. In addition to the face-to-face teaching, all teaching was offered through the web where it was implemented as real-time and on-demand video employing the streaming technology. The students were not required to decide about their participation mode beforehand; for each lecture session they could choose the mode that suited best for their own life situation. Thus, in each course the student could participate in education in many different ways by flexibly combining various alternatives. Moreover, the student could always, if he/she so wished, revise earlier teaching sessions with the help of videos.

The aim of the lecture videos used in the courses was to prioritize, maximally, the visibility of lecture materials. A lecture video consisted of sounds heard in the lecture theatre and of a picture of the teaching material that the lecturer showed with the video projector in the teaching space. Instead of using a traditional blackboard, a document camera, touch screen or smartboard were used during the lectures. In addition to the lecture videos, a web-based Learning Management System was used for the courses. The students could get through that system, in a written format, all the lecture material used in the course. The videos were on the media server; they couldn't be stored on the student's own computer. Students logged in on the server with their own personal IDs to view the videos.

Altogether 74 students participated in courses that were used as material. The number of course participations accumulated by the students during the investigation was 295 while the number of lecture participations during the same time period was 2051. All the students were adult students, most of whom study alongside work and have a family. In addition, more than a half of the students live far from the location where the face-to-face education takes place. The distance from the

places of the farthest living students to the campus area is approximately 500 km.

The material consists of attendance data collected from face-to-face teaching situations, log data of viewing of lecture videos, and information from the register of study credits. A student was counted as a participant of a course if he/she participated at least in one of the course lectures, either through face-to-face education or with the help of a lecture video. The courses were assessed using either a pass/fail scale or a whole number scale from 0 to 5 where 0 indicates fail. The material has been analysed statistically, and it has been supplemented in 2010 with the results of a structured interview that targeted students.

To examine the impacts of the use of lecture videos, the students were divided into three classes based on the use of videos, as follows:

Class 1: The student belongs to class [0, 1/3[, if the average share of his/her participations with the help of videos in all lecture participations is between 0-33.3%.

Class 2: The student belongs to class [1/3, 2/3[, if the average share of his/her participations with the help of videos in all lecture participations is between 33.4-66.6%.

Class 3: The student belongs to class [2/3, 1], if the average share of his/her participations with the help of videos in all lecture participations is between 66.7-100%.

To investigate the effect of distance, the students were divided, in addition, to two groups based on how far from the campus they live. The first group (Group A) consisted of students who live at a distance of 50 km at most from the campus area. The second group (Group B) consisted of students who live at a distance of more than 50 km from the campus.

4. RESULTS

4. 1 The Impact of Video Use on Learning

Figure 1, based on the server's log data, examines the portion of students' participation modes of all lecture participations. Slightly over a half of the lecture participations took place with the help of on-demand videos, and about one-seventh of them with the help of real-time video. Only one-third of all lecture participations occurred as face-to-face learning.

The results obtained from the video server's log data related to face-to-face education and real-time video, as shown above, agree nicely with the results of student interviews. Based on the survey, 33% of the students participate in lectures mainly through face-to-face education, 12% with the help of real-time video, 33% with the help of on-demand video, 19% through a combination of videos and face-to-face education and 3% by mastering other study material.

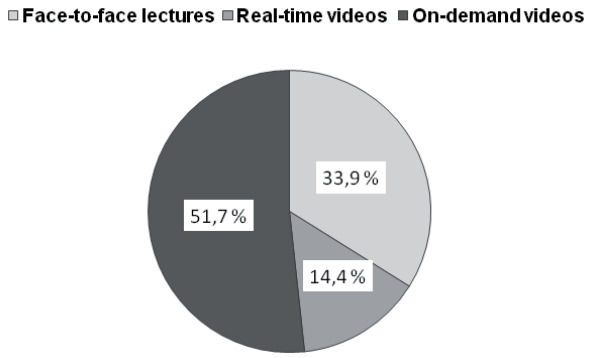

Figure 1. Relative shares of participation modes of all lecture participations (n=2051)

The large share occupied by the use of on-demand videos might be explained by the fact that most of the students who in the interview declared that they would participate in the education by combining videos and face-to-face education, nevertheless used videos to participate in education. This viewpoint is supported by the answers the students gave when asked about the participation mode that would suit best in their schedule. Participation with the help of on-demand videos suited best to 51% of the students, while participation in face-to-face education suited best only to 10%.

In spite of the substantial video usage, almost a half of the participation (48%) in education takes place in real time, at a temporal pace determined by face-to-face education. This seems to indicate that there is willingness to participate in face-to-face education. The results of the student survey also support this view quite well. Based on the survey, 54% of the students would prefer face-to-face education as the participation mode, 24% would prefer videos and 22% would prefer a combination of videos and face-to-face education.

To examine the impacts of lecture videos, the students were divided into three classes, based on the amount of video use, as follows: The students belonging to Class [0, 1/3[are said to be participating in education *with an emphasis on face-to-face education* and, correspondingly, the students belonging to Class [2/3, 1] are said to be participating in education *with an emphasis on videos*. The students belonging to Class [1/3, 2/3[are said to be participating in education *equitably, utilizing both face-to-face learning and videos*. One should keep in mind that, according to this classification, the student can utilize videos in each class in connection with the participation in education. Figure 2 shows how the students are divided into three classes as presented above.

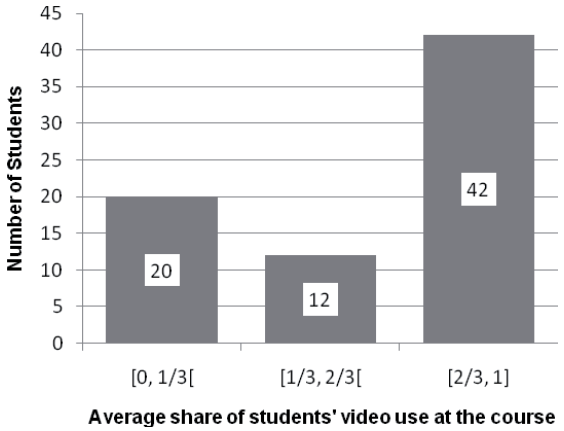

Figure 2. The number of students in different classes (n=74)

Altogether there were 74 students included in the survey. Of these, 57% participated in education with the help of videos at least two times out of three, which tells something about the popularity of participation with the help of videos. It is clearly shown that almost one-third participated in education with an emphasis on face-to-face learning, and approximately one-sixth participated in education utilizing equitably both face-to-face learning and videos.

Figure 3 shows participation in education (bars) and the proportion of courses completed (graph) by student class. Each bar is additionally divided into two parts by the proportions of participation mode. Of the participation modes, face-to-face learning (light gray) is lower down and participation with the help of videos (dark gray) is higher up in this figure.

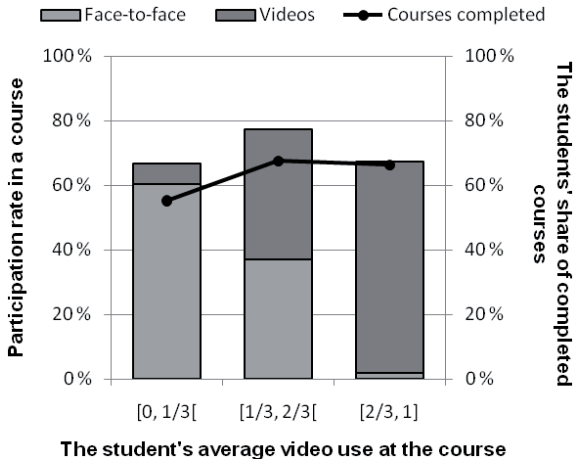

Figure 3. Students' participation in education (bars) and the proportion of courses completed (graph) by student class. Each class's lecture participations are additionally divided into sections by participation mode (bar division) (n=74)

Of the students' lecture participations that had an emphasis on face-to-face education, 91% took place as face-to-face learning, and of those with an emphasis on videos 97% took place with the help of videos. For those who utilized face-to-face education and videos in equal amounts, the share of face-to-face education was 48% and that of videos 52%.

During the observation period the average rate of lecture participation among the students was 69%. Based on the classification, clearly the students who participate in education in a balanced way, utilizing both face-to-face learning and videos, have the best participation rate (77%). Also the rate of completion (68%) among them is the best. There is no significant difference between those who participate in education with an emphasis on face-to-face education and those with an emphasis on videos (66.8% and 67.3%). On the other hand, those participating with an emphasis on videos are clearly better in completing the courses (66%) than those with an emphasis on face-to-face education (55%).

Figure 4 shows the relation between the rate of participation in education (bars) and grades (graph) in different student classes. The figure shows only the completed and graded courses and the students who participated in them (n=65). Due to this, the participation rates of the student classes are greater than in Figure 3. The average lecture participation rate is 80%. In addition to the participation rate, also the share of video use has increased slightly among those who put an emphasis on face-to-face education in their studies (14%) and among those studying equally with the help of face-to-face education as well as videos (60%). The portion of videos among those who put an emphasis on videos in their studies remains the same (97%).

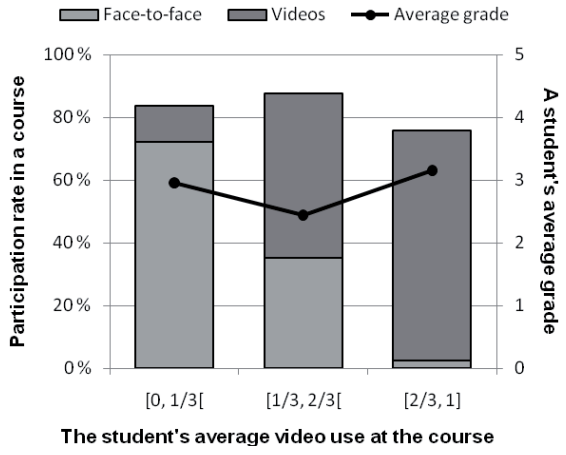

Figure 4. Participation in education by students for the courses completed (bars) and the average grades for the courses (graph) by study class (n=65). Assessment on a scale of 1-5

The students who utilized face-to-face education and the help of videos in their participation equally had their course participation rate higher (88%) than that of those who studied with an emphasis on face-to-face education (84%) or on videos (76%). In spite of the best participation rate, the average grade (2.4) was clearly worse than that for those who participated with an emphasis on videos (3.2%) or for those who participated

with an emphasis on face-to-face education (3.0). On the other hand, when we examine the averages for those who studied with an emphasis on face-to-face education and videos, it can be seen that the grade averages for those who studied with an emphasis on videos was better in spite of their worse participation rate.

Figure 5 shows slightly more accurately the effect of participation rate on grades. In the figure, the students' course participations have been classified into six separate classes in accordance with the grades. Here one student's course participations can thus be in several different classes. Based on the figure, the participation rate (49%) for those who received the grade of fail was clearly worse than for those who obtained the grade of approved (grades 1-5; 80%).

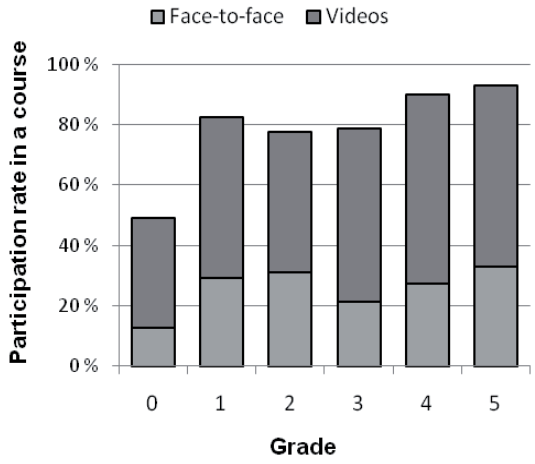

Figure 5. Students' participation in all the courses by grade. In the assessment, which has the scale from 0 to 5, 0 indicates a course failed and 1-5 corresponds to a course approved (n=269)

The average participation rate with the help of videos among those who received an approved grade was 66%. For those who received a grade of 3, participation with the help of videos was clearly the most common mode, the rate being 73%. For those who obtained a grade of 1 or 2, participation with the help of videos was 62%, which is clearly below the average rate. By contrast, those who received a grade of 4 or 5 had a rate of 67%, which is slightly above the average rate.

Based on Figures 3,4 and 5, one can state that participation with the help of videos has a positive effect both to participation in education as well as to the learning outcomes examined. It seems that the increase in the participation rate that is made possible by videos also has a positive effect on grades. Thus, it can be stated that the effect of the use of videos is clearly more positive than negative. As far as course completions are concerned, the results are in line with research done earlier [13]. Grade wise, the results agree with some of the research done earlier [4] [12].

4.2 The Effect of the Student's Place of Residence on the Impact of Video Use on Learning

To investigate the effect of distance, the students were divided into those who live near the campus (group A, nA=33) and those living farther away from the campus (group B, nB=41). Figure 6 shows the proportion of lecture participation modes in relation to all lectures for students living near as well as for those living farther away.

Figure 6 clearly shows the effect of the distance between the place of study and the place of residence on participation modes. However, there is no difference between the participation rates for groups A and B (68.9% and 68.7%) Based on the figure, those living near the place of study participate in education with an emphasis on face-to-face learning. In their case, it is clear that more than a half of all lecture participations occur as face-to-face learning. By contrast, for the B group members only 10% of all lecture participations take place as face-to-face learning, and most of the participations occur with the help of on-demand videos (74%). This supports the view presented above, i.e., students would be willing to participate in face-to-face education were it possible.

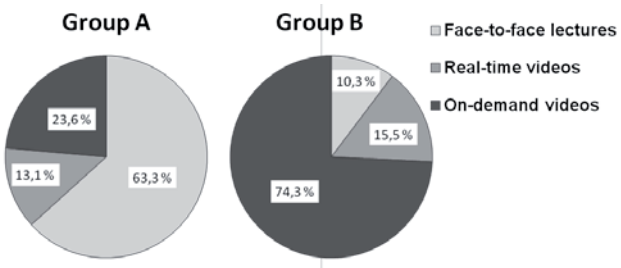

Figure 6. Relative shares of participation modes of all lecture participations for groups A and B

Figure 7 shows the differences between participation rates and course completions for student groups A and B. The participation rates for the student groups are approximately the same, but for those who live farther away from the campus and participate in education with an emphasis on videos the course completion rate is slightly better (65%) than for those who live near and study with an emphasis on face-to-face learning.

Figure 8 shows the differences between the student groups in relation to participation in graded courses that were completed and the grades obtained. As far as the courses completed are concerned, the participation rate for students living near (84%) is clearly higher than that for the students living farther away (77%). For students living near, face-to-face learning was the most common (61%) lecture participation mode; by contrast, for students living farther away participation with the help of videos was the main participation mode (93%). On the other hand, the average of the grades (3.3) for students living farther away is clearly better than those living near the campus (2.6).

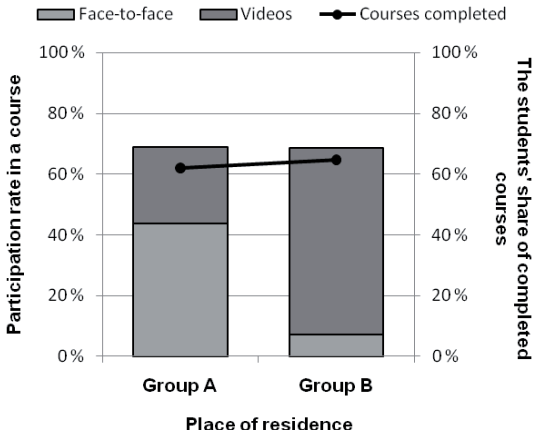

Figure 7. Participation in education for group A and group B students (bars) and the portion of courses completed (graph) (nA=33, nB=41)

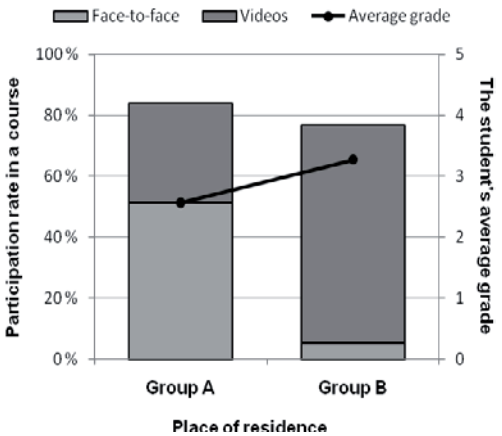

Figure 8. Participation in education by group A and group B students for the courses completed (bars) and the average grades for the courses (graph) (nA=27, nB=38). Assessment on the scale from 1 to 5

Figure 9 shows the effect of participation rate on performance and on grades for group A and group B. In the figure, the students' course participations have been classified into six separate classes in accordance with the grades. For both of the groups, the participation rate has a clear effect on course completion. Also the effect of participation rate on grades is exactly alike for both groups.

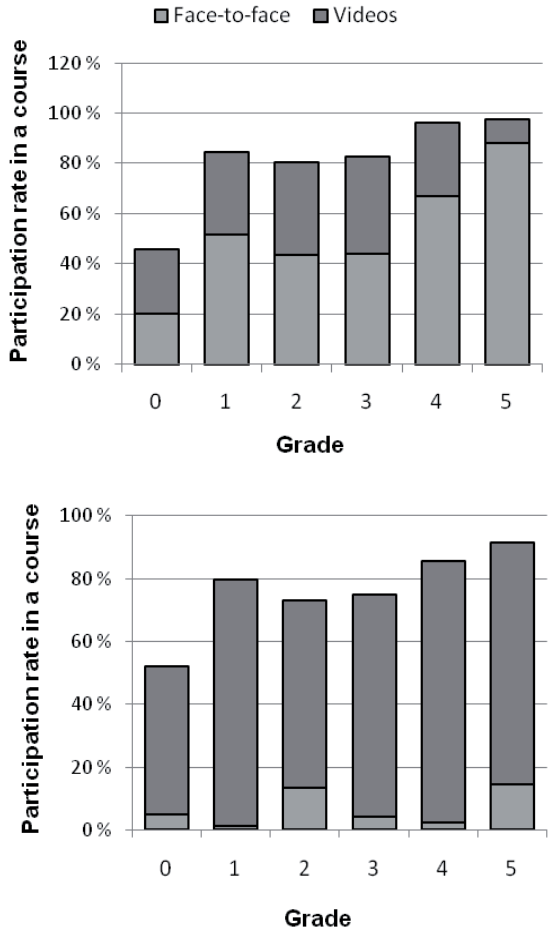

Figure 9. Participation, by grade, of group A (above) and group B (below) students in education on all the courses. In the assessment, which has the scale from 0 to 5, 0 indicates a course failed and 1-5 corresponds to a course approved (n=269). (nA=126, nB=143)

Based on Figures 7 and 8, it is possible to say that geographical distance has a clear effect on students' lecture participation modes. Students who live farther away participate in education with an emphasis on videos and those living near participate with an emphasis on face-to-face education. Those living farther away also cope with the courses slightly better than those living near and, moreover, obtain clearly better grades. Based on Figure 9, it is possible to say that in both groups the participation rate has effect on the grades obtained. As far as group A is concerned, the increase in the participation in face-to-face education seems to positively affect grades, especially with grades 4 and 5. This, for its part, lends support to results obtained earlier [10][14]. For group B, while the role of videos does not seem to correlate with the grade, it is important for all grades. In this, the result contradicts earlier research [10][14].

5. CONCLUSION

It is possible, with the help of lectures carried out with the help of real-time and on-demand videos in connection with face-to-face education, to introduce significant flexibilities to participation in education and to enable lecture revision. These flexibilities are important for almost all students but, especially for students who live farther away from the campus it is often the prerequisite for being able to study. This article examined the effect of videos on students' participation in education and on learning outcomes.

Participation with the help of videos was the clear favorite as a participation mode in education. Distance was the factor that increased most the participation in face-to-face education. For those living farther away from the campus, participation with the help of videos was the main participation mode in education. On the other hand, also two of five students living near participated in education with the help of videos. Based on a student survey, this was found to be due to factors mainly related to time use.

When the learning outcomes are examined with the help of completion performance and grades, it is found that participation with the help of videos had a positive effect also on the learning outcomes. The students who participated in education mostly with the help of videos, completed their courses slightly more frequently than the students who mainly participated in face-to-face education. Participation with the help of videos also had a positive effect on grades. Especially for students living farther away, who put an emphasis on participation in education with the help of videos, the course grades were clearly better than for students who lived near the campus and who put an emphasis more on face-to-face education.

Even if the use of videos has, to a some extent, reduced the participation in face-to-face education, it was found that, as a whole, lecture videos had positive effects on participation in education and on learning outcomes. Completion of courses with good grades also shortens the time needed for graduation. This is very important from the viewpoint of the education provider. This holds true especially when the increase in the completion percentage was not obtained at the expense of grades.

Our future objective is to examine the role of different learning styles in teaching, in participation mode and in learning outcomes achieved with different participation modes. In addition, we want to investigate, in more detail, the effects of video use for revision.

REFERENCES

[1] J. A. Brotherton & G. D. Abowd, Lessons learned from eClass: Assessing automated capture and access in the classroom, *ACM Transactions on Computer-Human Interaction, 11*(2), 2004, 121-155.

[2] S. Chang, Academic perceptions of the use of Lectopia: A University of Melbourne example, *Proc. Australasian Society for Computers in Learning in Tertiary Education*, Singapore, 2007, 135-144.

[3] C. F. Chiu, G. C. Lee & J. H. Yang, A comparative study of post-class lecture video viewing, *Proc. 5th IASTED international conference on Web-based education*, Puerto Vallarta, 2006, 126–130.

[4] P. Dean, M. Stahl, D. Sylwester & J. Pear, Effectiveness of combined delivery modalities for distance learning and resident learning, *Quarterly Review Of Distance Education, 2*(3), 2001, 247-254.

[5] M. Gosper, D. Green, M. McNeil, R. Phillips, G. Preston & K. Woo, *The impact of web-based lecture technologies on current and future practices in learning and teaching* (Australian Learning and Teaching Council, Sydney, 2008).

[6] M. Grabe & K. Christopherson, Optional student use of online lecture resources: resource preferences, performance and lecture attendance, *Journal of Computer Assisted Learning, 24*(1), 2008, 1-10.

[7] S. E. Gump, The cost of cutting class: Attendance as a predictor of student success, *College Teaching, 53*(1), 2005, 21–26.

[8] O. Kivinen & J. Nurmi, *Työ, koulutus ja osaaminen. Yliopisto ja ammattikorkeakoulu yhdeksän maan eurooppalaisessa vertailussa* (University of Turku - Research Unit for the Sociology of Education, Report 72, 2008).

[9] R. E. Mayer, *Multi-media learning* (Cambridge University Press, Cambridge, 2001).

[10] T. K. Ross & P. D. Bell, "No significant difference" only on the surface, *International Journal of Instructional Technology and Distance Learning, 4*(7), 2007, 3–13.

[11] L. Stanca, The effects of attendance on academic performance: Panel data evidence for introductory microeconomics, *Journal of Economic Education, 37*(3), 2006, 251–266.

[12] T. Traphagan, J. V. Kucsera & K. Kishi, Impact of class lecture webcasting on attendance and learning, *Educational Technology Research and Development, 58*(1), 2009, 19-37.

[13] B. R. von Konsky, J. Ivins & S. J. Gribble, Lecture attendance and web based lecture technologies: A comparison of student perceptions and usage patterns, *Australasian Journal of Educational Technology, 25*(4), 2009, 581-595.

[14] M. Wieling & W. Hofman, The impact of online video lecture recordings and automated feedback on student performance. *Computers & Education, 54*(4), 2010, 992-998.

IV

CHOOSING A STUDY MODE IN BLENDED LEARNING

by

Mikko Myllymäki & Ismo Hakala, 2012

In Goldweber, & Goelman (Eds.), Proceedings of the 17th Annual Conference on Innovation & Technology in Computer Science Education, 291-296

https://doi.org/10.1145/2325296.2325365

Choosing a Study Mode in Blended Learning

ABSTRACT

Education providers aim to meet today's education requirements by employing, among other things, education technology solutions that increase flexibility. This has also happened with the master's level mathematical information technology degree directed to adults. In the degree program, lecture videos brought in together with face-to-face teaching provide good opportunities for flexible educational arrangements. Education with the help of videos can be arranged in such a way that students themselves will be able to choose their study mode in accordance with their needs. When students themselves can choose their study modes, many different ways to take advantage of the flexibility provided are created. It seems that students with different participation styles achieve the aims for their study progress in different ways. The purpose of this paper is to profile students with different study modes, the profiling being based on a structured questionnaire. In this way we try to find out what are the factors that affect the study mode. Our investigation focuses on both the effect of internal factors, such as motivation, and the effect of external factors, such as distance and time limitations, in the choice of a study method.

Categories and Subject Descriptors

K.3.1 [**Computers and Education**]: Computer Uses in Education—*Distance learning*; K.3.2 [**Computers and Education**]: Computer and Information Science Education—*Computer science education*

General Terms

Experimentation, Human Factors

Keywords

study mode, student profile, blended learning, lecture video

1. INTRODUCTION

Education providers face a challenging task in attempting to meet the requirements that, for example, life-long learning and rapidly changing work life set for education. Work alongside study and education directed to adults force the education providers to adapt their own teaching to make it suitable for these purposes. Flexibility in study participation has, in fact, become the central element in education arrangements. Appropriate utilization of education technologies plays the key role in increasing flexibility. Diversification of traditional face-to-face teaching with the help of educational technologies enables arranging education in a form of so-called blended learning. Blended learning combines the traditional face-to-face study and online learning [4]. Realized in this way, education can be offered to students in a flexible manner regardless of time and place.

An educational technology solution that suits exceedingly well for the task of increasing flexibility is that of lecture videos made with streaming technology. These kinds of videos make it possible for the student to follow teaching in a face-to-face setting in real time and in a place better suited for students. With the help of on-demand videos the student is given the opportunity to participate in study when it is convenient to do so. Use of lecture videos is indeed a very popular solution that is becoming more and more widespread for diversifying education in higher education institutes [1, 9].

Blended learning realized with lecture videos brings about many kinds of changes to traditional study. The concept of study participation expands when it is possible to participate, in addition to a lecture room, in other places and even in other times. It has been proposed in earlier research that provision of lecture videos might have negative effects on face-to-face study participation [5, 9], or no effect at all [11]. On the other hand, it has been seen also that the flexibility brought about lecture videos on the whole could increase study participation, as long as study participation with videos is taken into account [7].

Participation with the help of lecture videos also differs in many ways from participation in face-to-face groups. Interaction changes its form, and the sense of cohesion and contacts to other students become more challenging. On the other hand, flexibility brings with it the ability for the student to study when his/her alertness is at its highest. It is possible to revise lecture topics, and, when so wished, pace the lecture with pauses made to suit to the student's own needs. It has been noted in various studies that the way students participate in education also has its effect on learning. According to some studies, study with lecture videos might

ITiCSE '12 Haifa, Israel

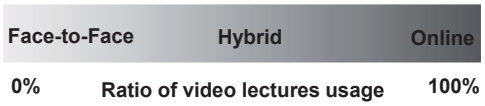

Figure 1: Students' study participation can be classified by video use.

have a positive effect on students' performance when examined in light of their grades and course completions [3, 8, 9]. There are also some study results according to which study with the help of videos has positive effect only on course completions but not on grades [10], or no effect on learning outcomes at all [2].

Earlier studies have mainly focused on the purpose and the way videos are used [5, 9, 11]. The main focus of these studies has been students' motivation and attitudes regarding the use of videos. Nevertheless, the research has not considered the suitability of different study modes for different kinds of students, learning opportunities for students participating in different ways and classification of students by their study mode. Nor has the profiling of students by these factors been considered.

When education is organized in such a way that students themselves can choose their study mode between face-to-face and distance learning, it becomes apparent that the students make use, in very different ways, of the flexibility provided. Some of the students continue studying almost without a fail in a face-to-face setting, whereas others keep studying almost always as distance students. Also, a great many of the students are so-called hybrid students, who evenhandedly take advantage of both face-to-face and distance study. The degree to which the students participate in study with the help of videos thus moves freely along the line in Figure 1.

This study includes, in addition to students whose study is clearly oriented towards video use or who study in a face-to-face setting, students who fairly evenly make good use of both study modes. It is important to include these students in the investigation because it seems probable that when their learning outcomes are examined no correlation with the outcomes of those who participate in other ways will be found. According to [8], these kinds of students did not achieve as good grades as students who generally participate in face-to-face mode or students who mainly participate with the help of videos.

The purpose of this paper is to find out how students themselves choose their study mode. The paper investigates the suitability of the study modes and the motivation and learning opportunities of students participating in different ways. In this way, we seek to find out what the students that typically participate in face-to-face mode and the students who take advantage of videos are like and to get an idea of those combining both study modes. The research data includes the results of an extensive interview of students in 2010.

2. STUDY DESIGN

This article investigates the differences between students who participate in organized study in different ways. The research data consists of the results of an extensive interview of students realized in the form of a structured interview during the latter part of 2010 as well as statistics collected in connection with the Master Studies in Mathematical Information Technology education at Kokkola University Consortium Chydenius of the University of Jyväskylä arranged between 2008 and 2010.

All teaching in the degree program was arranged as face-to-face teaching. In addition, the face-to-face teaching was offered as real-time videos produced from a face-to-face setting. The videos transmitted in real time were also recorded and offered to students to be viewed later as so-called on-demand video. An unedited version of the recording was made available for the students in the evening of the lecture day, and a lightly edited video was also provided during the first weekday. The videos couldn't be stored on the student's own computer; they were kept in the media server. Thus, an active web connection was needed for their viewing. The web connection required for viewing of the videos was accessible for all the students of the degree.

The voice of the lecturer and a picture of the image source that the lecturer uses in the face-to-face teaching situation are recorded on the lecture video produced in the degree program. In other words, all electronic teaching material that the lecturer shows in the lecture room with a video projector is also shown on the video. Instead of using a traditional blackboard, a document camera, touch screen or smartboard were used during the lectures. In addition to the lecture videos, a web-based Learning Management System was used for the courses. The students could get via that system, in a written format, all the lecture material used in the course.

All the students that the data includes are adults, and almost all of them work. In addition, more than a half of the students live more than an hour's travel from the location where the face-to-face education takes place. The distance from the places of the farthest living students to the campus area is approximately 500 km. The students can participate in a lecture either by participating in face-to-face teaching, viewing a real-time video or watching the video later on at the time of their choosing. The students were not required to decide about their study mode beforehand; for each lecture session they could choose the mode that suited best for their own life situation. Thus, in each course the student could participate in education in many different ways by flexibly combining various alternatives.

The role of videos in study participation in the degree program under investigation was very important. Of all the single lecture participations between 2008 and 2010 approximately two-thirds took place with the help of videos and just one-third as face-to-face teaching, in other words without the help of videos. Figure 2 shows the shares of the students' study modes in all lecture participations for the students included in the data.

2.1 Student Classification

The results of student interviews are processed in accordance with the student classification made on the basis of the amount of video use. To help in student classification, attendance data collected in face-to-face teaching situations and log data accumulated of viewing lecture videos are used. The classification is based on the statistics gathered from 25 courses held between 2008 and 2010. The number of students classified who participated in at least one of the courses in question was 56. The number of course participa-

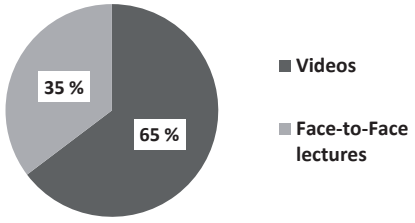

Figure 2: Relative shares of study modes of all lecture participations (n=2068).

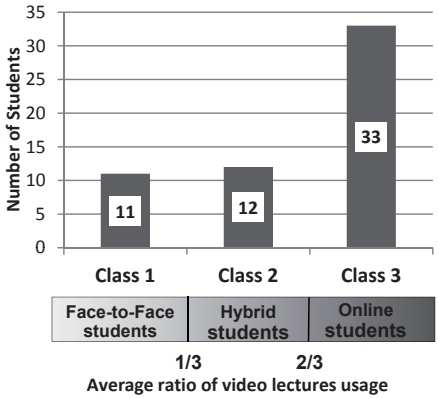

Figure 3: Classification based on the amount of video use, and the number of students in different classes (n=56).

tions accumulated by the students during the investigation was 273 while the number of lecture participations during the same time period was 2068. For the classification purposes, a student was counted as a participant of a course if he/she participated at least in one of the course lectures, either through face-to-face education or with the help of a lecture video. The structure of the student classification is as follows:

Class 1: The student belongs to class [0, 1/3[, if the average share of his/her participations with the help of videos in all lecture participations is within 0-33.3%. The students that belong to this class are called face-to-face students.

Class 2: The student belongs to class [1/3, 2/3[, if the average share of his/her participations with the help of videos in all lecture participations is within 33.4-66.6%. The students that belong to this class are called hybrid students.

Class 3: The student belongs to class [2/3, 1], if the average share of his/her participations with the help of videos in all lecture participations is within 66.7-100%. The students that belong to this class are called online students.

When the students in the research data are placed in the above categories, we get a distribution shown in Figure 3. As participations in the data are examined, it becomes fairly apparent that the use of videos to aid in participation is a well-established practice. When the students were completely free to choose their study mode between face-to-face teaching and videos, the focus of participation was on the participation with the help of videos. Only about 20% of the students participate mainly in face-to-face mode.

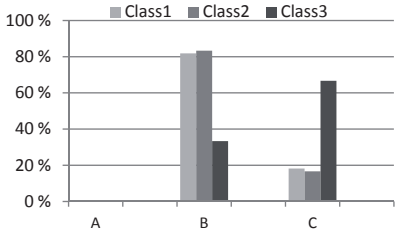

Figure 4: The ways of study that best suit for students (*A=written material only, B= face-to-face teaching and written material, C=utilizing videos one way or another*).

3. THE EFFECT OF INTERNAL FACTORS

3.1 Suitability of Different Study Modes

To map out the suitability of the different study modes, students were asked to evaluate them. In the master's degree program in mathematical information technology the study modes are participation in face-to-face teaching, participation with the help of real-time videos, participation with the help of recordings, and study by combining face-to-face teaching with videos. In all these modes, the student can make use also of all written course material available. Moreover, it is possible to study without resorting to videos or face-to-face teaching, just by getting to know the written material. To evaluate the study modes, the students were asked what their most preferred way of study would be.

In the opinion of the face-to-face students, learning face-to-face with written material would clearly be their most preferred study mode. This was the opinion of 82% of them. Also a clearly greatest share (83%) of the hybrid students were of the opinion that face-to-face teaching and written material would be the most preferred of the study modes. Hybrid students, therefore, show clear willingness to participate in face-to-face education. There were no hybrid students with the opinion that the most preferred way to study would completely exclude teaching and would merely consist of getting to know the written material. Of the online students, only 33% would prefer the use of face-to-face teaching and written material while 67% would prefer taking advantage of videos in one way or another (either videos on their own, or combination of videos and face-to-face education). There were no online students with the opinion that the most preferred way to study would consist merely of the use of written material. The responses concerning the most preferred way of study are shown in Figure 4.

When evaluating the different study modes, some students raised the issue that absences from face-to-face teaching make study, to a certain extent, more difficult. In this, there is not much difference between the responses of the hybrid students (25%) and online students (24%). The corresponding percentage for face-to-face students was 18%. Of the hybrid students who told of themselves being affected negatively by their absences from face-to-face teaching, all would expressly prefer face-to-face study. Of the online students who similarly told of themselves being negatively affected by their absences from face-to-face teaching, only half would prefer face-to-face study.

It may be thought that when compared with other study modes the benefit of face-to-face study typically is that of

better communication opportunities. Perhaps, somewhat surprisingly, communication opportunity is not the explaining factor to that hybrid students would like to participate more in face-to-face study. There were no hybrid students who would regard the lack of communication opportunities as a factor that would make learning significantly more difficult. On the other hand, of the online students almost one-sixth (15%) felt that this was making their study more difficult.

When evaluating the suitability of different study modes, it behooves to raise the issue that, according to the questionnaire responses, those who study with the help of videos seem, in light of the study, achieve their study objectives better. Of the online students, 66% told of having progressed in their studies as they had expected. The corresponding figure for the hybrid students was 50% and for the face-to-face students 36%.

3.2 Motivation For The Choice of Study Mode

One of the aims of the questionnaire was also to find out about students' motivation for participation with the help of face-to-face teaching, on one hand, and with the help of recordings, on the other.

When asked about the motivation to participate in face-to-face teaching, 55% of the students told that they could learn best with it. Participation with the help of face-to-face teaching rather than with the help of videos was regarded more suitable by 73% of the face-to-face students. Compared with the responses of other student groups, their emphasis was more on the desire to ensure availability of teaching and on the opportunity to participate in the study within its schedule as well as on a better chance to concentrate on the education provided in the face-to-face study. When motivation for viewing recordings was examined, it turned out that only 27% of the face-to-face students were of the opinion that concentrating on study is best when it takes place with the help of recordings.

Also the hybrid students feel their learning is at its best in face-to-face study. This was the opinion of 67% of them. According to the responses, participation in face-to-face study suits also to hybrid students by far better than participation in lecture sessions with the help of videos. This was the opinion of 75% of them. As with the face-to-face students, the emphasis with the responses of the hybrid students was on the possibility to participate in study within course schedules and on a better chance to concentrate on the teaching provided in a face-to-face setting. These factors explain, for their part, why hybrid students want to participate in face-to-face study, and they might also explain why hybrids get worse grades than distance students. When motivation for viewing recordings was examined, it was noticed that only one quarter of the hybrid students were of the opinion that participation in lecture sessions with the help of videos would suit them better than participation in face-to-face study. Only 25% of them had the opinion that concentrating on study would be best when studying with the help of recordings. Similarly, only 17% of the hybrids told that they learn best by viewing the recordings.

Of the online students, who sometimes participate in face-to-face study, only 23% felt they learnt best in a face-to-face setting. Similarly, of the online students only 8% told that participation in face-to-face study suits them better than participation in lecture sessions with the help of videos. Compared with other student groups, the online students were motivated to participate in face-to-face study by a thought that face-to-face study transmits information that is not obtained via videos. When motivation for viewing lecture session recordings was examined, it was noticed that 73% of the online students were of the opinion that recorded lecture videos can substitute face-to-face study and participation in lecture sessions with the help of videos would suit them better than participation in face-to-face study. Here one should also pay attention to the fact 33% of the distance students had a different opinion in this question. Thus, even among them there is some willingness to participate in face-to-face study. Approximately a half of the distance students had the opinion that one can concentrate on teaching best when studying with the help of recordings.

When examining the motivation to participate with the help of recorded lecture videos, it became apparent that increase in flexibility is a very significant motivation factor for video use. In this, no differences between different student categories could be found. Of all the students who sometimes watch videos at all, 97% watches recorded lecture videos because they allow one to view a lecture at the time desired. In addition, 91% of all students view the recordings because they enable viewing a lecture in parts and 95% because they make it possible to view again the parts desired.

4. THE EFFECT OF EXTERNAL FACTORS

4.1 Timetables

The students were also asked about which study modes would best suit to their study schedules. Only about a quarter (27%) of the face-to-face students were of the opinion that participation in face-to-face study suits best also to their timetables. Combining face-to-face study with videos would be the best alternative, schedule-wise, for approximately half of them (46%). Only a quarter (27%) thought that studying with the help of recordings would be the most reasonable approach from the viewpoint of scheduling.

Of the hybrid students 92% were of the opinion that study in which videos are utilized (either just recordings or a combination of videos and face-to-face study) fits best to their schedules. Here one should pay attention to the fact that there were no hybrid students who would regard the use of real-time videos alone as the most suitable study mode in their study schedule. This tells us that the study mode of the hybrid students is defined, above all, by things related to time use rather than to distance. It also should turn our attention to that all hybrid students agreed, to a certain extent or completely, with that one reason why recorded lecture videos are used is because they facilitate watching the lectures at the time of one's choosing.

For online students' timetables videos naturally suit well. Of them 94% thought that study in which videos are utilized (either just recordings or a combination of videos and face-to-face study) fits best to their schedules.

Figure 5 depicts the responses related to the study modes that best suit for the students' study schedules.

4.2 Studying Alongside Work

The effects, on the study mode, of studying while working were mapped out for example by asking the students whether they could use work time for study when their work tasks allowed that. There was no difference to talk of in this

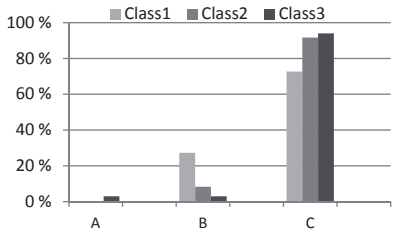

Figure 5: study modes that are suit best for the students' study schedules (*A=written material only, B= face-to-face teaching and written material, C=utilizing videos one way or another*).

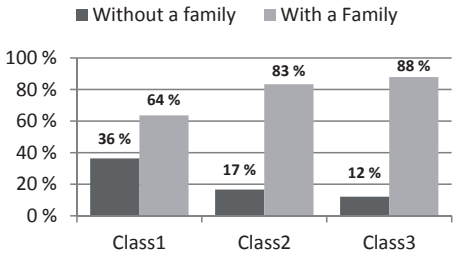

Figure 6: Distribution of students with a family and students without a family, in student categories.

issue between the hybrid and online students. Of the hybrid students 50% replied in the affirmative and also of the online students 44% did so. On the other hand, those participating in face-to-face study can use, on the basis of their responses, more work time for their study (73%). A great many of the hybrid students would regard participation in face-to-face study as suitable for them but do not, as a rule, participate in it. Therefore, it might be thought that, at least as far as they are concerned, the option to use work time for study means, first and foremost, that the students have better opportunities to view lecture videos during their work time but are not allowed to be off work for face-to-face study at the campus area.

4.3 Distance

Distance has a great impact on the use of videos. According to the responses of the students, the distance from which a student can participate at will in face-to-face study is about 70 km, which corresponds to about an hour's drive by car. It seems that the effect of distance is stronger for exclusively online students. Of the face-to-face students 36% told that the motivation for viewing recordings is their inability or unwillingness to travel. The corresponding figure for the hybrid students was 42%. Of the online students, 79% thought the same way. The importance of distance for the face-to-face and hybrid students seems, however, be mostly related to time spent on traveling rather than to impossibility to participate due to the distance involved. This can be concluded from the responses to a question mapping out the distance to the place of residence to which 90% of both groups replied that they are living near enough to participate also in face-to-face study if they so wish. Thus, in their case it appears that limitations in time use brought by work and family is one of the important factors that restrict participation in face-to-face education. Only 42% of the online students live close enough to the campus to participate at will in face-to-face study. A student's idea about whether he/she can participate in face-to-face study as far as distance is concerned is, naturally, subjective. A portion of the students who live quite far feel, however, that they can participate in face-to-face study if they so wish, whereas some of those living quite near cannot, in their own view, do so.

4.4 Students' Life Situation

One important factor, especially when we consider adult students, is the effect of their life situation on study mode. Family creates limitations in time use for the student. The limitation in time use caused by family life is shown by the fact that the students who participate in studies more with the help of videos often are with a family. Figure 6 shows more accurate results of this.

5. CONCLUSIONS

Lecture videos are a good means for increasing flexibility of participation in education. Especially in adult education that takes place alongside work, videos play such an important role that without them student recruitment would be extremely difficult in practice.

The results of this study clearly argue for the important role that videos play in the search for teaching solutions that would be as flexible as possible. If the students are allowed to freely choose their mode of study, they will create strategies, which are quite distinct from each other, in order to complete their studies. Some of the students study with a fairly strong emphasis on face-to-face teaching, whereas others make good use of videos. In addition, some of the students utilize evenly both face-to-face mode and distance mode.

In the opinion of the face-to-face students, learning face-to-face is the best option for them. In fact, even for them it is not the best alternative as far as timetables are concerned. This clearly shows that the data consists of working adult students. Face-to-face students can choose their study mode freer than other student groups. Thus it is natural that 3/4 of the face-to-face students regarded face-to-face study as a study mode that is more suitable than participation with the help of videos. Their motivation to participate via face-to-face study was due to the desire to ensure availability of teaching and to the opportunity to participate in study within the course schedule as well as to a better chance to concentrate on the education provided in the face-to-face study. However, increase in flexibility sometimes motivated even face-to-face students to use videos. This outcome agrees quite closely with [5]. In their study, they noted that also students living close to the campus area need flexibility in their studies. Typically, the chances of a face-to-face student to use work time for study are good. Among the face-to-face students, the proportion of those with a family is smaller than in other student groups. It should be noted that only a third of the face-to-face students told of having achieved the objectives they had set for their study.

The desires and motivations of the hybrid students are very close to those of the face-to-face students. Based on the results of this study, it could be seen that the hybrid students would like to study in a face-to-face setting and

that they did not feel that study with the help of videos would suit them as well as it would should to face-to-face students. They also feel that their learning is at its best in face-to-face study. As with the face-to-face students, the motivation of the hybrid students to participate in face-to-face study is the possibility to participate in study within course schedules and a better chance to concentrate on the teaching provided. Even though the hybrid students would be willing to participate in face-to-face study, it wouldn't suit to their schedules that well. The study mode of the hybrid students is defined, above all, by matters related to time use and not by the distance involved. In fact, the students utilize videos in their study participation due to reasons pertaining to scheduling. Approximately a half of the hybrid students can use their work time for studying. It doesn't seem, however, that this would lead to a situation where the hybrid students could participate more in face-to-face study. Typically, students with families are more common among the hybrid students than among the face-to-face students. A half of the hybrid students told of having progressed in their studies as they had expected.

Use of videos suits well to the online students and they think that videos can replace face-to-face teaching. This may be due partly to that in connection with student recruitment, flexibility brought about with the help of videos has been prominently displayed. Thus there are students who have found their way to the education and already at the beginning of their studies oriented towards the use of videos. It has been noted also in earlier research [10, 11] that a positive attitude towards and belief into videos as learning aids increases their use, and those who use videos a lot regard them as well suited for studying purposes. Also among the online students, however, the desire for participating in face-to-face teaching is smaller. Compared with other student groups, the online students were motivated to participate in face-to-face study by a thought that face-to-face study transmits information that is not obtained via videos. Among the student groups, the online students' chances to use work time for study are the worst. In addition, the portion of online students with a family is greater than average, and distance has a greater effect on their motivation to watch videos. The number of online students who feel that they cannot participate in face-to-face study even when they want to do so is, as a matter of fact, greater than the average. Increase in flexibility brought about lecture videos is, naturally, a very significant factor regarding their study mode. Absence from face-to-face teaching makes the study of some online students more difficult, but, nevertheless, it seems that those studying with the help of videos would achieve the objectives they have set for their studies. Two-thirds of the online students thought this way.

The face-to-face students and online students apparently study the way they prefer to study, and for that they have fairly good opportunities. The hybrid students, however, end up studying against their preferences for practical reasons. One should, moreover, notice that there is at least some willingness in all student categories to participate in face-to-face study. Similarly, in all categories the students use, to some extent, videos due to the increased flexibility they provide.

To ensure that the benefits that face-to-face participation and participation with the help of videos bring with them would be available as far as possible for the use of different students, one of the top priorities of the future is to reduce the differences between these study modes. This is aimed at, above all, by bringing participation aided by videos closer to participation in face-to-face study. For this, there is a novel application [6]. The application enables students' telepresence and communication and taking note of them better than before in a face-to-face teaching situation. In this way, participation with the help of videos is made to resemble more and more participation in face-to-face studies without, however, losing the added value that videos bring with them.

6. REFERENCES

[1] S. Andberg and K. Tuononen. *Videoviestintä suomalaisissa korkeakouluissa 2008*. University of Helsinki. Educational Centre for ICT, Helsinki, 2009.

[2] C. Chiu, G. Lee, and J. Yang. A comparative study of post-class lecture video viewing. In *5th IASTED international conference on Web-based education Conference Proceedings*, 2006.

[3] P. Dean, M. Stahl, D. Sylwester, and J. Pear. Effectiveness of combined delivery modalities for distance learning and resident learning. *Quarterly Review Of Distance Education*, 2(3):247–254, 2001.

[4] C. Dziuban, J. Hartman, and P. Moskal. Blended learning. *EDUCAUSE Center for Applied Research, Research Bulletin*, 2004(7):1–12, 2004.

[5] M. Gosper, D. Green, M. McNeil, R. Phillips, G. Preston, and K. Woo. *The impact of web-based lecture technologies on current and future practices in learning and teaching*. Australian Learning and Teaching Council, Sydney, 2008.

[6] I. Hakala, T. Härmänmaa, and M. Myllymäki. Cinetvideo: video sharing application for educational use. In *22th EAEEIE Annual Conference Proceedings*, 2011.

[7] I. Hakala, S. Laine, and M. Myllymäki. The effect of lecture videos on participation in teaching. In *WBE Web-based Education Conference Proceedings*, 2010.

[8] I. Hakala and M. Myllymäki. The use of lecture videos: attendance and student performance. In *CATE 14th International Conference on Computers and Advanced Technology in Education Conference Proceedings*, 2011.

[9] T. Traphagan, J. Kucsera, and K. Kishi. Impact of class lecture webcasting on attendance and learning. *Educational Technology Research and Development*, 58(1):19–37, 2009.

[10] B. VonKonsky, J. Ivins, and S. Gribble. Lecture attendance and web based lecture technologies: A comparison of student perceptions and usage patterns. *Australasian Journal of Educational Technology*, 25(4):581–595, 2009.

[11] S. Walls, J. Kucsera, J. Walker, T. Acee, N. McVaugh, and D. Robinson. Podcasting in education: Are students as ready and eager as we think they are? *Computers Education*, 54(2):371–378, 2010.

V

VIDEO-BASED BLENDED LEARNING PRACTICE IN MASTER STUDIES

by

Mikko Myllymäki & Ismo Hakala, 2013

In V. Uskov (Ed.), The proceedings of Iasted international conference web-based education, 872-878

VIDEO-BASED BLENDED LEARNING PRACTICE IN MASTER STUDIES

Mikko Myllymäki, Ismo Hakala
University of Jyväskylä, Kokkola University Consortium Chydenius
P.O.Box 567, FIN-67701, Kokkola, Finland
mikko.myllymaki@chydenius.fi, ismo.hakala@chydenius.fi

ABSTRACT
Challenges for an organizer of modern education can be met with the help of blended learning. There can be many different starting points and motivations for it. One way to arrange blended learning is to realize it using lecture videos alongside with face-to-face teaching. In Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius, the flexibility to participate in education has been increased with the help of lecture videos produced of face-to-face teaching for many years. For each lecture, the students of the degree program can select the best possible way to participate in the education and in a manner that suits to their current life situation. This paper describes a strong video-based practice that has taken root in the masters' program. The paper examines the importance of videos for study participation and considers, from the viewpoint of participation, the changes that videos have brought with them.

KEY WORDS
blended learning; lecture videos; educational technology; distance learning

1. Introduction

Education providers, whether they are companies or educational institutes, have often very different requirements and approaches in relation to organizing their own education. With the help of blended learning, these multifarious needs can be met in diverse manners. The term blended learning means the educational environment that combines face-to-face instruction with technology-mediated instruction [1]. So the term can be used for example to describe learning which takes place with the help of the mix of face-to-face classes, on-demand videos and real-time videos [2]. There are number of reasons for arranging education as blended learning [1], [3], [4].

The arguments for blended learning are often based on its possibilities to provide increasing flexibility [5], [6], [7]. It enables both compensation of occasional absences as well as very long-term distance study. Thus, the problems brought about by students' time use limitations can be addressed. Increasing flexibility is important also in situations where the students have families, live far away from the campus area and subsequently cannot always participate face-to-face in the education offered [8]. Getting better learning outcomes is another aim in the use of blended learning [5], [8], [9]. Technological solutions would allow the opportunity to revise topics studied, for example. By offering several different participation alternatives for organized study, various kinds of learners can be provided with support [6], [7], [10]. In the best of cases, each learner can choose to participate in a way that is the best possible for that person. Diversified teaching arrangements with the help of technologies enable, in some cases, the use of completely new didactic teaching solutions. If blended learning is implemented in a way that some face-to-face learning could be replaced with another teaching mode, this can also result in economic savings [5], [11], [12]. Savings can be achieved, for example, in connection with travel and as decreased need for face-to-face teaching premises.

Different approaches also place many types of conditions for organizing education in the blended mode. One of the most critical conditions is the economic resources available. If cost-efficiency were to be included in these conditions, it would be necessary to make compromises in relation to quality and search for solutions that enable automation and, through it, implementation of the blended learning in as lightweight manner as possible. Another important thing to consider is whether the change to the blended mode would apply to the entire degree program or individual courses. Other points of departure to be considered that are dependent on education include transparency of the selected technologies to the lecturers, issues related to the distribution of materials such as support for mobile equipment, file formats, user rights and copyrights, as well as didactic solutions which these and other technologies must be able to provide support for. In addition, there may be many different viewpoints to the motivations to use blended learning and to its conditions of use, and these include the viewpoints of the teacher, the student and the education provider. Each viewpoint regards different key issues as critical.

To diversify teaching, traditional implementation of blended learning has relied on replacing some face-to-face modules by e-learning or including, from time to time, face-to-face situations to e-learning. In these cases, the student thus studies sometimes face-to-face and sometimes through e-learning. One differing interpretation about the implementation of blended

learning in a manner referred to above is to organize teaching in such a way that, for the same teaching situation, there would be several different alternative participation modes made available with the help of educational technology

Use of lecture videos produced from face-to-face teaching is an educational arrangement that would make different participation alternatives feasible. The videos produced could be offered to the students in real time, making participation flexible regarding the location. As the videos would, in addition, be recorded and later offered to the students for viewing, one could talk about participation that is flexible regarding the time and location.

Market offers commercial video recording systems. However, if solution is wanted to be cost-effective and as suitable as possible for the needs of the education organizer, the modification of the solutions is often required. For this reason, a serious alternative to commercial solutions is to build a custom video recording system which is exactly customized to the intended use. Still, more important than technological solutions, are working practices, which are formed on top of them.

In Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius, the flexibility to participate in education has been increased with the help of the practice that is very strongly based on lecture videos. Education thus realized would allow the student him/herself decide about how to participate in it and at the same time determine what the degree of blending should be. This kind of blended learning that adapts to the student's life situation would seem to lead to the best level in participation.

This paper presents an educational practice that has developed in connection with the Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius. The practices related to classroom education has become well functioning between years 1999 and 2005, when all the teaching of the education program was arranged as traditional face-to-face education. In 2005, lecture videos were tested in few courses, and due to the good results it was decided to use the lecture videos throughout the education program. So video production in the master's degree program really started in 2006 and it is also well established over the years. The current practice is based on a blended education model which adapts to the student's life situations while strongly relying on lecture videos.

Apart from introducing the current practice, the paper examines issues related to the use of lecture videos: the importance of videos as a participation mode and the changes to study brought about by the use of lecture videos, among other things. The results are grounded on the outcome of extensive student interviews carried out in the second half of 2010, on log data collected about video use, attendance records from 2005 and 2010 as well as on data from the register of study credits.

2. Blended Learning in Master Studies in Mathematical Information Technology

The practice that has developed in connection with the Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius is very strongly based on lecture videos produced about face-to-face teaching and on the use of technologies complementing the videos. All the master's degree students are adults in active employment and most of them are also with a family. These students work in the IT sector where the work is often project-based and from time to time very taxing. The majority of the students also live far away from the campus area. Due to family and work considerations, the students living far away, unlike full-time young students, do not have the possibility of moving to the campus area.

In practice, the above-mentioned initial conditions mean that the students' chances to participate in the education offered are from time to time poor and due particularly to the limitations in time use. Increase in flexibility to participate in the education has, in fact, emerged as the most important motivation for the use of teaching technologies in the master's studies of information technology. The aim of the improvements in participation opportunities has been to enable the students to complete their studies better while keeping the throughput of students good in education. It wasn't desired, however, that the improved course completion brought about by new participation opportunities would take place at the cost of learning. Thus, no-one wanted that the practice based on lecture videos would weaken the grades.

To ensure that the increase in flexibility would benefit the students, it must cover all the teaching offer of the degree program. This will make studying possible also for students whose chances to participate in face-to-face education are very infrequent. However, the implementation of the practice with the master's studies in information technology has lacked significant economic resources. It is for this reason that one of the important conditions from the very beginning has been cost-efficiency.

Another important condition for the development of the practice is due to the desire to keep it as transparent as possible from the viewpoint of the lecturer and that of the student. Thus the desired aim has been that the activities in relation to the blended model would affect the face-to-face teaching situation as little as possible.

2.1 Face-to-face Education

Face-to-face education is the foundation for the teaching as a whole. All teaching in the degree program is arranged as face-to-face teaching. In addition, face-to-face teaching is offered as real-time videos and as recordings made of it. Face-to-face teaching situation therefore, works as a production environment for lecture videos. Shooting of videos in face-to-face teaching situations is arranged in

such a way that the lecturer does not need to adapt his/her own teaching for the video recordings.

The courses are scheduled to be run as very compact entities in such a way that, typically, a single course is carried out in a few weekends. In practice this means that the duration of a single lecture session, and also the duration of a single lecture video, equals 3-4 traditional lectures.

2.2 Lecture Videos

All face-to-face situations of the degree program are recorded on video. The lecture videos can be viewed when desired either in real time at a pace determined by face-to-face learning or in a delayed mode with the help of the recordings. Students will get the use of the recordings in the evening of the day of lecture. The videos cannot be stored. To view them, the students need an Internet connection. The bandwidth requirement for videos is so moderate that a connection that satisfies it is available for all the students in the educational program. The lecture videos are kept ready for students' use for the duration of the whole course.

All the lecture material shown by the lecturer's video projector can be seen on the video produced from the face-to-face teaching situation. Naturally, all discussions that have taken place in the teaching situation are well distinguishable on video also. Opportunities for two-way interaction between the lecturer and the student, who participates with the help of the video, did not exist at the time of study. Learning Management System's (LMS) course-specific discussion forums take care of interaction. Figure 1 shows an example capture of a lecture video where a document camera is in use. Figure 2 shows capture of a lecture video where the lecturer uses digital teaching material and an interactive whiteboard.

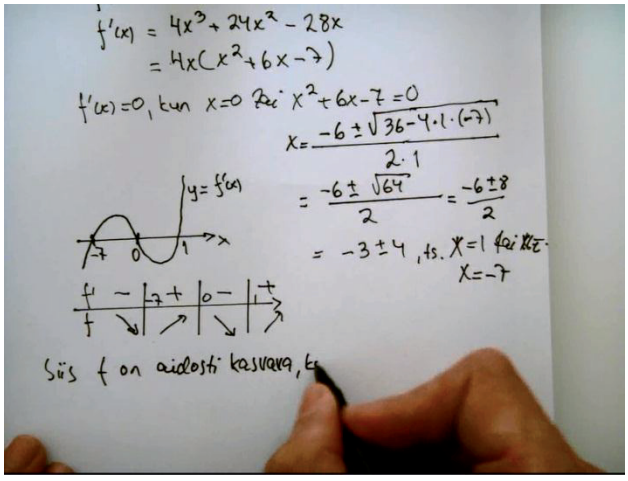

Figure 1. A window capture of a lecture video where a document camera is in use.

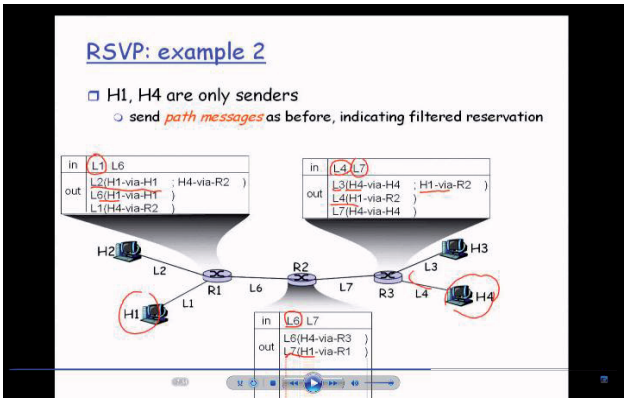

Figure 2. A window capture of a lecture video where digital data and an interactive whiteboard are used.

2.3 Technological Solutions that Support the Practice

Of course, lecture videos alone are not sufficient to adequately diversify the teaching. Other solutions that support videos are also needed. Some of the solutions are directly connected with the lecture videos. These solutions include a LMS used for the distribution of lecture videos and a interactive whiteboard as the lecturer's tool to improve video usability. The role of the LMS as a distribution channel is more closely examined in Section III. Deployment of interactive whiteboards has made it possible to provide the lecturer with an unconstrained interface to show digital study material while in a face-to-face teaching situation. Notes and markings made on the interactive whiteboard show naturally also on the lecture videos.

Some of the technological solutions that support lecture videos are, by their nature, complementary to the videos. The aim with these solutions has been to make studying as flexible as possible also from viewpoints other than that of participation in face-to-face education. Here as a central technological solution emerges the LMS, which in the degree program is used as a material distribution channel, a communication device, a course management tool and a significant component in student administration. LMS functions as a kind of tool that brings together matters related to study, and also as a tool through which the student can get access to all study information and materials whenever he/she has an internet connection available. One important technological solution seems to be the web meeting system, which enables guidance from distance and is well suited for instructing small groups or individual students.

2.4 Participation in the Degree Program Study

The carrying thought of the education model in the master's program in mathematical information technology is to make participation in education as flexible as possible. Participation in the degree program education can take place in many different ways. The participation modes are participation face-to-face, participation with

the help of direct video transmissions, and participation by using on-demand videos. In addition, the student always has possible written course material at his/her disposal. Moreover, it is, of course, possible to study without resorting to videos or face-to-face learning, just by getting to know the written material. Lecture videos are made available for the students for the duration of the course. Thus, regardless of the participation mode, the recorded videos can be used for revision purposes.

Students do not need to decide about their participation mode beforehand; they can choose to participate in each lecture the way that is the most suitable in their own particular circumstances at any moment. Therefore, the student can participate in lectures of a course study in many different ways by flexibly combining various participation alternatives.

3. Production and Distribution of Lecture Videos

From the very beginning, the starting point for video production has been cost-efficiency and transparency for the lecturer and face-to-face students. An important principle, as far as distribution is concerned, has been that the student cannot store the videos. With this, problems related to copyrights have been avoided. Also, lecture videos are discarded once each course has been carried through.

3.1 Recording

The teaching premises of the Kokkola University Consortium have been designed with the production of videotapes in mind: among other things, the equipment required for recording is integrated into those premises. This is the precondition for being able to produce the teaching of the whole degree program cost-efficiently as lecture videos. Cost-efficiency has been achieved, above all, by high degree of automation. Automation potential needs also to be kept in mind always when planning new development targets.

The purpose of transparency in production is to allow the lecturer to concentrate on teaching in a way he/she wishes without having to pay attention to video shooting. Keeping the viewpoint of face-to-face students in mind, the aim has also been to ensure that shooting video would disturb the students as little as possible. The image source recorded on video automatically changes when, in a face-to-face teaching event, the lecturer changes the image source shown by the video projector. In this way, all the material shown by the lecturer's video projector can be seen on the video without the lecturer having to attend to that aspect. Thus, changes to the lecturer's teaching habits are not required. Only the chalk board and the overhead projector in the teaching area have been replaced by modern document cameras. If so wished, an interactive whiteboard can function as an interface to the computer.

As far as sound is concerned, all discussions taking place in the teaching situation are well distinguishable on video. The aim has been to build the microphone solutions for the premises in such a way that the lecturer's voice is audible from any location in the teaching space and that the students' comments and questions can be heard on video also.

Local recordings are also made of lectures – the problems in data networks, for example, will not affect the success in these cases. This ensures that there is a local backup copy if the real-time version becomes corrupted or fails otherwise.

3.2 Distribution

An unedited version of the video is distributed to the students in the evening of the lecture day, some hours after the lectures. The distribution system is timed to transfer the video to the media server as such, automatically. If required, small-scale editing can be done for the video during the weekday following the lecture.

Lecture videos are distributed to students from the media server. The videos cannot be stored by the students. The links for the videos are distributed to students through the Learning Management System and allocated in such a way that only those participating in the course can see the links to the course videos. The students also log on to the media server with their personal IDs for an access to the videos. This ensures that only the degree program students can access the videos. Additionally, personal log-ins facilitates research into videos and more efficient solutions for possible problem situations.

Lecture videos are discarded once each course has been carried through. This is possible because the production process is so light that the videos can be reproduced during the next face-to-face teaching session. With the disposability of videos, a situation has been reached where there are no problems as far as lecture payments and copyrights are concerned.

3.3 Future Developments

The practice related to video distribution lacked, most of all, two-way interaction between the lecturer and the student participating with the help of a video. It also lacked information about the identity of the students who had been watching the real-time transmission. Also, the students viewing the videos did not have opportunities for mutual interaction. To introduce these kinds of things requires that the practices and, above all, tools associated with video distribution be replaced. Distribution of videos is, as a matter of fact, at the focus of constant development work in Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius. As a solution to enable interaction and telepresence, a start has been made to develop a video sharing application just for this purpose [13]. The application will be integrated in the highest possible degree to the current practices and to LMS. With

the help of the application, it is also possible to further increase the flexibility of participation by making the application to support mobile devices also.

4. Evaluation of the Practice

The practice is evaluated in terms of participation before and after the introduction of lecture videos. In addition the cost efficiency of video production process and students' opinions of the suitability of lecture videos are considered.

In 2005, most of the teaching in the degree program was arranged as face-to-face teaching only. The practices related to face-to-face education has been developed since 1999. In 2005, lecture videos were tested in few courses, and due to the good results it was decided to use the lecture videos throughout the education program from the beginning of 2006. In 2010 all education was provided as a blended model based on videos. In 2010 participation in any study in the degree program was possible in three ways: by taking part in face-to-face learning, participating with the help of real-time video, or by participating in a delayed mode through on-demand videos.

The video-based blended learning practice enables distance learning. This has made it possible to market education to a wider area. It is clear that students' geographical dispersion has increased dramatically. This has, of course, the impact on participation and results. In data from 2005, only 8% of the students lived more than 100km away from the campus. In 2010 corresponding percentage was 41%.

The research data consists of statistics and attendance records for face-to-face study collected in connection with teaching that took place during Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius in 2005 and 2010. In addition, the results of an extensive student survey, which was carried out towards the end of 2010 as structured interviews of students, have been available. The student questionnaire was responded to by 67 students, which in practice includes all active students in the degree program.

The data for 2005 covers 10 courses, in which a total of 34 different students participated. Teaching arranged in these courses had a total worth of 54 study credits, and the courses included a total of 131 lectures. In 2010, 13 courses was organized in Kokkola. The research data for 2010 includes 10 of these courses for which the necessary statistics have been collected. A total of 58 individual students participated in these courses. For these courses in the 2010 data, teaching worth 40 study credits was arranged. The number of lectures in these courses totaled 104.

4.1 Participation

Resulting from a change to the practice, a significant increase of flexibility has been introduced to participation since 2005. The effects of the increasing flexibility are clear to see as a growth in the degree of participation presented in Figure 3. The lecture-specific degree of participation in the education in 2005 was on average 54% whereas in 2010, considering all the participation modes, the lecture-specific participation degree in the courses included in the data was on average 70%.

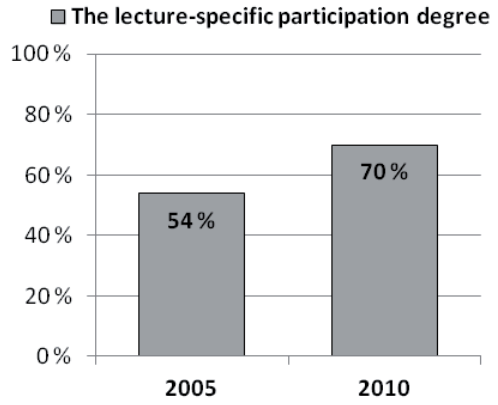

Figure 3. The lecture-specific participation degree in the courses in years 2005 and 2010

In the current practice videos play quite an important role for the participation in the degree program's educational offer. The real-time transmissions of 10 courses in the 2010 data were watched for about 600 hours while the viewing time spent for recordings was about 1800 hours. However, scrutinizing the proportions of students' participation modes tells more about the role of videos than do the user numbers. Figure 4 shows that of all the lecture participations nearly three-quarters took place with the help of videos and only one-quarter as face-to-face learning. Here a participation during which the student views the lecture concerned first time is counted as a participation.

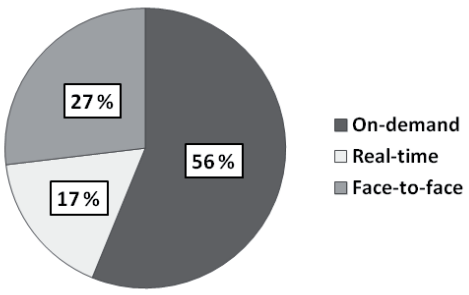

Figure 4. The relative shares of different participation methods in 2010 (n=1101).

Though, on the whole, the participation rate has increased, participation through face-to-face learning has nevertheless fallen to 27% (2010) since 2005 (54%). This result is in line with other research [9][14]. When pondering over the significance of face-to-face education,

one should take note of the fact that participations with the help of real-time videos formed 17% of all participations. Nearly a half (44%) of the participations thus keeps in pace with face-to-face learning. Participation in this way naturally requires that there is face-to-face education available.

4.2 Cost-efficiency

One of the important conditions for the video production has been cost-efficiency. Equipment purchases needed for video production are one-off expenditures by nature, and in the long run the greatest cost will be due to work required by the production of videos. In practice, cost-efficiency in relation to lecture videos means, above all, automation of video production processes as far as possible. Thanks to automation, videotaping lectures for a single weekend requires about an hour's work, regardless of the number of lecture hours offered during the weekend. Timing of longer lecture sessions or larger lecture series can be done beforehand, once and for all, many of the work stages having been rendered easier by the distance control facility in use. So it can be said that production process is very cost-efficiency.

4.3 Students' Opinions

The results of an extensive survey conducted among students during the winter of 2010 indicate that the desire to participate in face-to-face learning is well alive. Based on the survey, 54% of the students would prefer face-to-face study as the participation mode, 24% would prefer videos and 22% would prefer a combination of videos and face-to-face education (Figure 5). In practice, however, adult students in active employment do not have the opportunities to participate in face-to-face education. When asked about which participation mode would suit best to the students' schedules, the response was that participation with the help of recordings would suit best to 51% of the students. Participation in face-to-face education suited best only to 11% of them. According to earlier studies also, this can depend on the course and the students' life situation: even students whose studies have emphasis on video participation, participate during some courses extensively in face-to-face education [15].

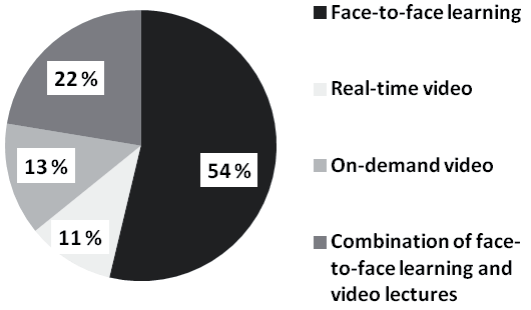

Figure 5. Which participation mode would you prefer.

When we examine the students' experiences about the benefits obtained from videos, the important role of the videos and their increased use is easy to understand. The opinion of almost all the students who took part in the student survey was that lecture videos are beneficial for study participation, time use efficiency, revision, completion of learning tasks and for understanding many kinds of issues. A mere 4% of the students felt that lecture videos make learning more difficult to some degree. A clear majority did not regard videos as disturbance. The results provide support for earlier studies, according to which video use has a positive effect on both course completions as well as on grades obtained [9], [16].

Functionality of videos for their use purpose is underpinned by the student survey, in which nearly two-thirds of the students stated that absences from face-to-face education and participation with the help of videos instead do not make learning more difficult. One should nevertheless pay attention to the fact that one in four students experienced absences from face-to-face education as a factor that makes learning more difficult. This, of course, provides support for face-to-face education.

In addition to lecture videos playing an important role in study participation, their availability from the viewpoint of the education provider is a matter of a great importance, also when viewed from a marketing angle. As a positive consequence of the practice, we can also see that deployment of videos has enabled a growth in student numbers. When education can be made available as distance study, the set of potential students becomes considerably larger. The number of students who live far away from the campus has, in fact, increased constantly, which further emphasizes the necessity for videos. Of the students who responded to the student survey, 94% were of the opinion that what attracted them towards master's studies in information technology had a lot to do with or was greatly influenced by that the studies were made feasible to carry out alongside work.

5. Conclusion

The results clearly show that the practice that has developed in connection with the Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius is functional and taken into use by the students. The practice is based on a blended teaching model which strongly relies on lecture videos. Practice consists of three elements, face-to-face teaching, real-time videos and on-demand videos.

The presented blended model is at its best in giving the students an opportunity to flexibly participate in the education provided. The educational arrangements can be made such that, for each lecture, the students can select the best possible way to participate and in a manner that best suits to their current life situation. Organized this way, the teaching offers maximal flexibility from the participation point-of-view. The clear positive impact of

the practice is growth in the degree of participation which is due to more flexible participation opportunities. Another positive thing that lecture videos enable is a possibility to revise the difficult issues. This is useful for students especially when preparing for exams. The practice which enables distance learning makes it possible to market education to a wider area, which will make the set of potential students much larger. The number of students has increased considerably since the introduction of blended learning practice. It is also important to notice that the practice is very cost-effective.

One might regard the changes in interaction brought by the use of lecture videos as the negative impact. Forming groups is also more challenging in the blended model education that is based on lecture videos. It must be noted, however, that the practice enables the participation in face-to-face education, if desired, if a student is experiencing that the use of videos is making the learning more difficult. The negative impacts are, therefore, relevant specifically to those students who cannot participate in face-to-face education even if they wanted, for one reason or another.

The practice enables participation in face-to-face learning or participation with real-time video that keeps pace with face-to-face learning. It would seem that when students can freely select their participation mode, the recordings' share is clearly the most significant but nevertheless only about the same size as the share of real time participation.

The research results show that in order to serve a heterogeneous set of adult students, face-to-face learning, real-time and on-demand videos cannot be removed from the practice. The practice should be maintained as it is, so that the student can choose his/her participation mode, even if the selection is not always feasible due to practical considerations. From the viewpoint of the education provider, the positive impacts of the practice are significant enough to justify directing resources for the development of education based on the model.

Acknowledgements

The authors wish to thank the European Commission and The European Regional Development Fund for the grant given to the ”Ubiquitous Learning Environment for Adult Education” project, the Executive Agency for its help and all the partners of the project for their contribution.

References

[1] C. R. Graham, *Blended learning systems: definition, current trends, and future directions* In C. J. Bonk & C. R. Graham, *Handbook of Blended Learning: Global Perspectives, Local Design*s (San Francisco, CA: Pfeiffer Publishing, 2006).

[2] G. Harriman, What is blended learning?, E-Learning Resources, [online]: http://www.grayharriman.com/ blended_learning.htm, 2004.

[3] A. G. Picciano & C. D. Dziuban, *Blended learning research perspectives* (Needham, MA: The Sloan Consortium, 2007).

[4] R. T. Osguthorpe & C. R. Graham, Blended learning systems: Definitions and directions, *Quarterly Review of Distance Education, 4*(3), 2003, 227-234.

[5] C. Garnham & R. Kaleta, Introduction to Hybrid Courses, *Teaching with Technology Today, 8*(6), 2003.

[6] T. Gould, Hybrid classes: Maximizing institutional resources and student learning, *Proc. ASCUE Conference*, Myrtle Beach, South Carolina, 2003.

[7] D. Stewart, Classroom management in the online environment, *Journal of Online Learning and Teaching, 4*(3), 2008, 371-374.

[8] C. D. Dziuban, P. Moskal & J. Hartman, *Higher education, blended learning and the generations: Knowledge is power-no more* In J. Bourne & J.C. Moore (Eds.), *Elements of Quality Online Education: Engaging Communities* (Needham, MA: Sloan Center for Online Education, 2005).

[9] T. Traphagan, J. V. Kucsera & K. Kishi, Impact of class lecture webcasting on attendance and learning, *Educational Technology Research and Development, 58*(1), 2009, 19-37.

[10] J. Young, Hybrid teaching seeks to end divide between traditional and online instruction, *The Chronicle of Higher Education, 48*(28), 2002.

[11] C. D. Dziuban, J. L. Hartman & P. D. Moskal, Blended learning, *EDUCAUSE Center for Applied Research, Research Bulletin, 2004*(7), 2004.

[12] S. Hijazi, M. Crowley, M. L. Smith & C. Schaffer, Maximizing learning by teaching blended courses, *Proc. ASCUE Conference*, Myrtle Beach, South Carolina, 2006.

[13] I. Hakala, T. Härmänmaa & M. Myllymäki, CiNetVideo: Video sharing application for educational use, *Proc. 22th EAEEIE Annual Conference on Innovation in Education for Electrical and Information Engineering*, Maribor, Slovenia, 2011.

[14] M. Gosper, D. Green, M. McNeil, R. Phillips, G. Preston & K. Woo, *The impact of web-based lecture technologies on current and future practices in learning and teaching* (Sydney, Australian Learning and Teaching Council, 2008).

[15] I. Hakala & M. Myllymaki, A blended learning solution and the impacts on attendance and learning outcomes, *International Journal of Emerging Technologies in Learning, 6*, 2011

[16] B. R. von Konsky, J. Ivins & S. J. Gribble, Lecture attendance and web based lecture technologies: A comparison of student perceptions and usage patterns, *Australasian Journal of Educational Technology, 25*(4), 2009, 581-595.

VI

PRODUCING LECTURE VIDEOS FROM FACE-TO-FACE TEACHING

by

Mikko Myllymäki, Jari Penttilä & Ismo Hakala, 2013

International Journal of Information and Education Technology, vol. 4, no. 1, 18-24

Producing Lecture Videos from Face-to-Face Teaching

Mikko Myllymäki, Jari Penttilä, and Ismo Hakala

***Abstract*—There is a clear demand for lecture videos in modern education. Nevertheless, the desire to keep face-to-face education remains as well. In such a case, the natural option is to produce videos in face-to-face teaching situations rather than in a studio environment. The challenge this kind of production faces is how to make it to cover an entire degree program cost-efficiently while serving the purpose intended. This article explains the demands set for video production in the context of face-to-face education at the scale of a degree program and how to effectively respond to them in practice. The paper also evaluates the effectiveness and impacts of the production model developed in connection with the Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius. According to the results, with the help of a recording system satisfying the requirements of the education provider it is possible to produce lecture videos at the scale of a degree program, cost-efficiently and in a way that reliably provides support for study.**

***Index Terms*—blended learning, lecture videos, video production.**

I. Introduction

Technological development together with the speeding up of data communications and their widespread presence have, among other things, enabled video that can be distributed through networks. Today, videos are produced for a variety of purposes. One common purpose of video production which includes many special features is that for educational use. A lot is expected from modern education in the form of e.g. flexibility and study methods customized for individuals. In many educational institutes, also in universities, clear needs have arisen for increasing flexibility in education with the utilization of video technologies.

Videos meant for educational use, in particular, have many special features that are challenging from the viewpoint of video production. Meeting these challenges has often been seen so exacting that introduction of videos at a larger scale is regarded sometimes as impossible even in spite of the benefits they can provide.

Videos for educational use can be produced either in studios or live in face-to-face teaching situations. Studio production is expensive and requires a great deal of work, especially if it is intended to be offered also as face-to-face teaching. Preserving face-to-face teaching alongside with videos brings some benefits when compared to teaching realized with videos only. It for example gives the students a choice in the participation mode among face-to-face learning, real-time video transmissions and on-demand videos and thus supports a variety of learning styles. It also provides an opportunity to attach interactivity to video lectures. For these reasons, it is often seen desirable to produce videos directly from face-to-face teaching situations.

Producing lecture videos from face-to-face teaching is challenging if the intention is that the production should cover the teaching for an entire degree program and not just individual lectures. This would require that videos would have to be simultaneously produced e.g. from several session-related locations to ensure the production's suitability for different courses and lecturers. Extensive productions also face the challenge of keeping the practices associated with quality production cost-efficient. In addition to challenges faced by video production in connection with face-to-face teaching, there are more demands for transparency and visibility of the material presented: video production should not distract face-to-face teaching sessions, and it should provide distance students with a starting point for study as similar as possible to face-to-face teaching.

There are numerous different commercial products that make the production process of videos easier. There are also recording solutions especially designed for teaching use: e.g., PanOpto, SonicFoundry, vBrick and echo360. These commercial recording solutions typically provide software for recording and real-time transmission. In some of the systems, video distribution can be integrated into a learning management system (LMS). Often, commercial solutions provide administrative features that make the timing of recordings easier. Some systems may also provide support for mobile equipment. However, in the case of PanOpto for example, this applies only to iPhone and iPad equipment. Commercial recording solutions have, in addition, manufacturer-specific features, which may be useful in some cases. These include the commenting option as well as various activation choices for the viewers of video.

For some types of use, the commercial recording solutions may be suitable almost out of box. Typically, it is nevertheless difficult to find a turnkey production system that would, comprehensively and without compromises, meet the many challenges presented above. Often the most functional solution is to build one's own production system by utilizing, combining and complementing various equipment and software solutions available. A system created in this way suits the best way possible to the special features of the education concerned and integrates optimally to the already existing systems. It is also easier to construct functional practices for video production around a recording system developed from the producer's own perspective.

Typically, commercial recording solutions include only the

Manuscript received May 23, 2013. This work was supported by the European Commission and The European Regional Development Fund.

M. Myllymäki, is with the Kokkola University Consortium Chydenius, University of Jyväskylä, Finland (e-mail: mikko.myllymaki@chydenius.fi).

J. Penttilä, is with the Kokkola University Consortium Chydenius, University of Jyväskylä, Finland (e-mail: jari.penttila@chydenius.fi).

I. Hakala, is with the Kokkola University Consortium Chydenius, University of Jyväskylä, Finland (e-mail: ismo.hakala@chydenius.fi).

required software; in addition, the equipment must still be acquired. There are large variations in the prices of commercial systems, reflecting the intended extent of recording. The greater the number of concurrent recording points and users, the higher the price is. If the system is made to suit the producer's own needs by utilizing and combining various commercial equipment and software solutions, it is possible to develop the system economically in smaller steps as the requirements grow. This kind of autonomously constructed recording system is considerably better for circumstances where big one-time investments are out of question.

Earlier research related to lecture recordings has primarily focused on the impacts of recording from the viewpoints, e.g., of learning outcomes [1]-[3], amounts of use [4], [5], reasons for use [3][6] and participation [1], [7]. It is harder to find research on implementation of actual recording systems. Moreover, in these studies the production process and recording system itself has been evaluated very little or not at all [4], [6], [8], [9].

This paper deals with the challenges of lecture video production in connection with face-to-face teaching and presents a production model as well as technical solutions suitable for it. The functionality of the model presented is evaluated with the help of data collected in connection with the Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius.

II. Video Production from a Face-to-Face Teaching Situation

This chapter presents some video production challenges and some special features of production carried out in face-to-face teaching situations particularly. This is followed by a presentation of a production process for lecture videos from a face-to-face teaching situation and the technological solutions that accompany it.

A. Production Challenges

There are several challenges associated with the production of videos meant for study purposes. Many of these challenges become emphasized especially when it is seen desirable to produce videos directly from a face-to-face teaching situation.

Naturally, one would hope that video production wouldn't distract the face-to-face teaching session. Thus, the production must be as transparent as possible when a video is produced from a real face-to-face teaching situation. Transparency here means that the lecturer can concentrate on lecturing without having to significantly adapt the teaching and that the technology involved wouldn't disturb and divert attention from the teaching. It is also hoped that the technology and recording would not distract the students participating in face-to-face teaching.

The aim in making lecture videos available is to provide students who study with the help of video with starting points that are equal to those of face-to-face students. For this reason, the general approach must be such that all the material shown in the classroom is also shown in the video, be it lecture material or text written by the lecturer. This is important especially where the task of the lecture videos is, in addition to facilitating revision, make absences possible there. One of the topics that merits consideration is whether to prioritize the image of the lecturer in the video or optimal visibility of lecture material. Prioritization of the lecturer's image poses some additional challenges to the production process, e.g., in deciding how to arrange the lighting.

One of the aims of video use is, typically, add flexibility to study. For this to occur, the video production must cover all the teaching provided as comprehensively as possible. The benefits of flexibility to the provider of education are questionable if they are related just to individual courses. The recording system used, and above all the practices constructed around it, must be able to manage with also larger volumes of video production while satisfying all other requirements set for it. Flexibility is also increased by that the videos are made viewable on as many technological platforms as possible. When planning video production, it is important to pay attention to the format the videos are produced in and whether to enable their viewing for example with mobile equipment. Changing the video format afterwards can be a fairly laborious and expensive process.

Typically, education providers do not have large financial resources at their disposal for the realization of video production. For this reason, one of the primary concerns in video production is cost-efficiency. Naturally, some costs are incurred by the infrastructure required. The costs due to equipment are nevertheless one-time costs only. Most of the costs are generated in the long term by the human resources required in the production. Minimization of man-days is largely based on automation and distance control of equipment.

To enable study with videos at all, they must be of good quality. However, as far as the quality of videos is concerned, some compromises might need to be made in order to satisfy other demands. If the quality is improved, in practice that means that more bandwidth is required for data communications. This, to some extent, limits the reachability of videos. Even then, it is nevertheless necessary to ensure that the quality remains sufficient for its purpose of use, that is, for study.

Once videos form an essential component for studies, video production must function properly. Reliability of production must always be kept in mind during development work. Reliability can be increased, for example by paying attention to backups. Recording of lectures must function well, regardless of problems in the data network for example.

B. Technological Solutions

In the development of a technological environment, choices that define the technologies must be made. These kinds of choices must be made, for example concerning the quality of image and sound and that of the video image itself. There will be questions such as whether it would be desirable to have an HD quality video image or whether, in addition to the lecture material shown in the video, we would also need the image of the lecturer or a general image of the class room. The technologies to be chosen are also determined by the requirements set for automation, transparency and file types to be produced.

To ensure comprehensiveness and cost-efficiency of video

production, it is important to take video production into account already at the planning stage for the spaces required. From the lecturer's perspective, transparency in video production means that the lecturer can show with the projector any image source connected to the system at the class room and that the image from the source will be recorded. Also, it should be possible to automatically and without separate individual microphones record speech. Thus the lecturer needs to take only minimum care about the recording of sound and image.

When assembling the production equipment, it must be considered what the image sources that the lecturer should use are. Usually, at least a computer and a document camera are used as image sources. If a versatile system is wanted, an image source can also be realized through a connection to external video and image sources. If so desired, the system can also be connected to an interactive drawing board or terminal, which will function both as an image presentation equipment and as an image source.

It is also important to take into account transparency when recording speech. To prevent burdening the lecturer with the recording of sound, it is practical to use phantom-current powered microphones that are always kept on. In far-automated production, a situation where for example the battery of a microphone transmitter goes flat unexpectedly or it is forgotten to turn the microphone on cannot be tolerated.

Operation reliability for the production can be increased with a separate backup equipment. The backup equipment should be such that a recording of the video can be realized even when no direct transmission is possible due to network problems. Laptops of various kinds are practical for that role because their batteries can also help overcome short power outages. Devices inputting images and sound need, naturally, electricity to function and thus recording with them won't succeed during outages. The only purpose of the backup systems equipped with batteries is to ensure that once the power is restored the production will resume by itself.

Software used in the production includes a live media encoder, editor and media server and possibly also programs connected with timing and automatic data transmission. A possible inclusion among these programs is a media player used for viewing lecture videos. The task of the media server is to receive media flow material from the encoder and forward that material to the clients, in this case to media players. The choice of the software is influenced, above all, by the file formats to be produced.

C. Production Process

The administrative capacities of a media production system can be made more efficient by enabling distance control for computers and media flow servers that produce media flow. This is done with the help of a remote desktop, with which it is possible to affect the control through Internet and a VPN connection. The setup enables a fast reaction in problem situations when needed. However, in physical problem situations a visit to the location is always required.

A production process can be divided into preliminary arrangements, recording stage, distribution and post-production. These stages and the actions related to them are summarized in Fig. 1.

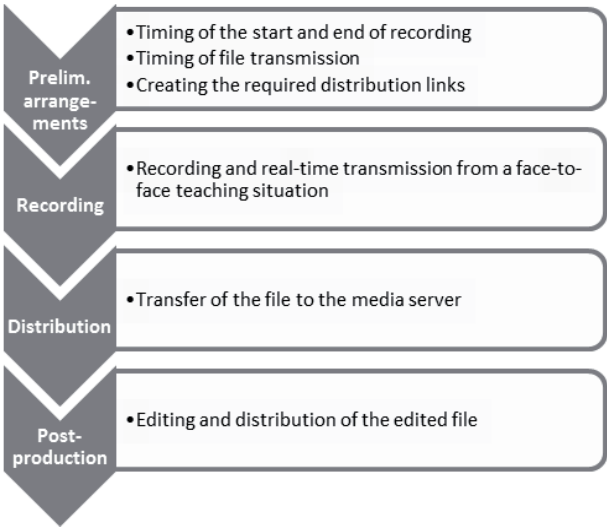

Fig. 1. The stages in the production process of lecture videos

1) Preliminary Arrangements

Timing of the start and end for a recording should be done well before the recording itself takes place. Combined with the timing operation, it is also possible to define, for example, the bandwidth, frame rate and size and other settings related to the compression of image and sound.

Transfer of the recorded raw version to the media flow server is best achieved with automated program code. During the preliminary arrangements, the transfer can be timed to be carried out once the lecture has ended. Depending on the distribution methods, linkages required by the distribution can be made, for example, to the LMS's or WWW pages, at least as far as real-time video is concerned but probably also for recordings. In this way, the recorded videos will be available to students immediately after the automatic file transfer.

2) Recording Stage

In an automated system, the image shown with a projector by the lecturer is automatically directed from the image source to the recording equipment. If the system is not automated, the lecturer must select the source to be recorded. This clearly reduces the transparency and reliability of production.

The media encoder saves a local version of the teaching session and, using push technology, transmits the compressed material further to the media server. Also the media server can be configured to store a backup copy of the material. That copy can then be retrieved for use in case the indexing of the recording saved by the media encoder fails or is damaged.

3) Distribution

Real-time media flow is transmitted from the media server to the clients by using unicast or multicast technologies. The unicast solution is appropriate if the number of simultaneous viewers is moderate enough not to put excessive strain on the network's active devices. In other cases, it might be better to think about using a multicast technology or Content Delivery Network solutions. Distribution of on-demand videos to students should be carried out as soon as possible once the recording has been made. The delay in the distribution can be minimized by realizing the transmission of the lecture recording from the encoder to the media server automatically with the help of program code and by timing it to take place as

soon as possible after the lecture to be transmitted as a media flow has ended.

4) Post-production

Depending on the needs, the recordings can be edited. In a cost-efficient solution, only very small amount of editing is done to the recordings by, for example, cleaning up extra material from the beginning and end of the raw version of the recording. The cleaned-up version replaces the unedited version of the recording automatically transferred to the media server. For editing, it is best to use a program that does not recompress the material, which guarantees that the quality of the material will remain unchanged.

III. Video Production of the Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius.

Lecture videos have been produced since 2002 in connection with the master's studies in mathematical information technology, and the number of video transmissions has been increasing constantly. Currently, the annual volume of teaching sessions transmitted as real-time video amounts to hundreds, and the viewing time per student reaches dozens of hours. Lecture videos form, thus, an essential element of the education arrangements for the master's studies in information technology.

Production of videos for these studies follows the model presented above. The videos are produced from face-to-face teaching and offered both as real-time and on-demand videos to students. The primary considerations for the production are, above all, availability, transparency, good visibility of lecture material and cost-efficiency. These considerations also include that the video production must cover all the teaching of the degree program.

Cost-efficiency is supported by the fact that face-to-face teaching is paced over and assembled over two days per week. This allows many of the operations, such as timing of the recording that is applied to several lectures simultaneously. To reach the goals, attention is paid to software that supports the practices as well as to technical and quality-related solutions in video production equipment.

From a technological perspective, the basic idea for the video production of the master's studies in information technology is that the signals from image sources are distributed to the video production systems, prior to a signal reaching the projector. In this way, all the material shown by the projector in the class room is recorded on the video. Therefore, it is enough that the lecturer knows how to bring the desired image to the view in the projector at that class room. In this solution, the core of the video production equipment is the media presentation switcher where the image and program sound inputs are directed to. The media switcher's image signals are guided through the required distributors and converters to the recording and backup systems and to the projector. The program audio sources from the switcher and speech from the microphones are directed through an audio mixer to the recording and backup systems. The system similar to the one described above is presented in Fig. 2.

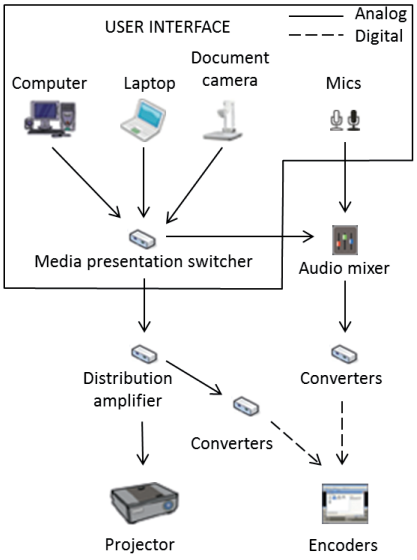

Fig. 2. The equipment making up the storage system for the master's studies in information technology.

The production takes place in Windows Media environment. The media server implementation is based on the Streaming Media Server –role of the Microsoft Windows Server 2003 Enterprise Edition. Windows Media Encoder is used as the encoder. The timing of the encoder's file templates is realized with the graphical Scheduler timing program available in the Windows Media Software Development Kit, which utilizes the Windows operating system's own Task Scheduler function. Post-production is done with the Windows Media File Editor program that accompanies the Windows Media Software Development Kit.

To view the videos, students need an active Internet connection and user rights. Videos can't be downloaded by students. With the help of user rights, the video distribution can be limited only to the students who have enrolled in the course. The videos are removed from distribution once the course has ended. User rights and disposability of videos have helped us to avoid problems related to copyright and intellectual property. In addition, user rights also make it possible, in problem situations, to search for user-specific solutions and to conduct research on utilization of videos. Maintenance of user rights for videos does not create extra work because it is carried out with the help of user rights of LMS's courses.

IV. Evaluation of the Production Model and Assessment of the Effectiveness of its Technologies

The research data was collected in connection with the Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius. The material was obtained from the data of the university consortium's space reservation system, from the 2010 structured interviews of master's studies' students, from the accounting of the education provider about failed events as well as from the media flow server's log data and its 2008–2011 attendance records.

A. Suitability for the Purpose

The students of the degree program can freely choose their mode of participation in each lecture between face-to-face study, real-time video and on-demand video. The suitability of lecture videos for their intended purpose can be examined by comparing the numbers of those participating with the help of lecture videos to those participating with the help of face-to-face teaching. One would think that possible unsuitability of lecture videos would be reflected in their popularity ratings.

Fig. 3. shows the shares of the students' participation modes in all lecture participations during 2008–2011. The data includes 30 courses for which attendance records have been collected. A total of 80 master's degree students participated in these courses, adding up to a total of 2988 lecture participations. The important role of videos in study participation can clearly be seen from the figure. When the students were completely free to choose their participation mode between face-to-face learning and videos, they gravitated towards participation with the help of videos.

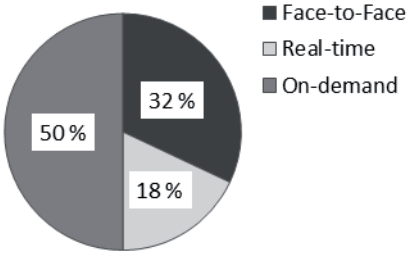

Fig. 3. Relative shares of participation modes of all lecture participations 2008–2011 (n=2988).

Student's opinions also reflected the suitability of videos. According to a structured questionnaire survey of students carried out in 2010, only 4% of the students felt that lecture videos (real-time or on-demand) made learning more difficult. The questionnaire was responded to practically by all active students at that time (n=67).

Videos' effectiveness in study can also be evaluated from the perspective of learning outcomes. The impact on learning outcomes in connection with master's studies in information technology was examined separately in an earlier research [10]. When the learning outcomes were examined with the help of completion performance and grades, the research found that participation with the help of videos had a positive effect on students' learning outcomes. Videos enabled an increase in the degree of participation, which in turn improved the course completion figures and grades. The results were in general agreement with the results of research carried out elsewhere, e.g. [1], [2], [11], [12].

B. Transparency

One of the starting points in video production has been its transparency for the lecturer and students. In practice, recording itself does not distract the lecturer. The lecturer doesn't need to worry about starting the recording or stopping it, for example. The only occasion when the lecturer needs to change his/her habits of acting is when the whiteboard is replaced with a document camera. However, the lecturer must be able to control the technical infrastructure of the class room, either through one's own know-how or with the help of the written instructions and personal operation practice devised on behalf of the education provider, One should remember, however, that some of this equipment would be used in the class room even without any recording taking place. For the students participating in face-to-face study, the production process is transparent. Video production does not disturb face-to-face study, and, according to earlier research, for example the document camera is regarded by the students as even a better alternative than the whiteboard [13].

C. Cost Efficiency

The costs of the video production for the master's study in information technology consist of initial costs, development costs and operation costs. The initial costs such as acquisition of equipment are one-time costs, and their magnitude depends on, e.g., the quality of materials wanted.

When the system is self-implemented utilizing and combining various commercial equipment and software solutions, development work can be carried out step by step from the standpoint of economy. Big one-time investments won't be necessary. In this kind of system, it is easy to integrate add itional parts as needed with the advancement of the development work. The extra parts required can be self-constructed, and commercial solutions may be considered if they have interfaces to connect them as parts to the existing environment.

However, in the long term, the ability to control operation costs is important as far as cost efficiency is concerned. Cost efficiency in the case of operation costs is based on task automation, remote equipment control and planning of the teaching schedule by the education provider.

Timing of education can have a great impact on operation costs. As the teaching in the master's studies in information technology is spread over two subsequent days, the operations related to the information flow can be executed concurrently and the work won't need to be distributed over several days. In practice, all the video production arrangements for teaching during a weekend take about two man-hours. This time is divided fairly equally between preliminary arrangements and light editing of the material produced. Video production carried out for the master's studies in information technology takes slightly below 100 man-hours on an annual basis.

The cost-efficiency of operation costs is emphasized in the initial arrangements for video production and in post-production because these stages require most man-hours. One should, nevertheless, bear cost efficiency in mind also when dealing with matters related to distribution, quality control and backup.

D. Operational Reliability

Hundreds of hours of lecture videos are yearly produced in connection with the master's studies in information technology. Compared with the total number of recorded lectures, complete failures (e.g., a lecture couldn't be viewed in real time and no recording could be made) are remarkably rare. Even the number of partial failures (a real-time lecture transmission could not be realized or it was necessary to resort to a poorer quality backup recording for later viewing) was

only slightly higher,

Table I shows the number and duration of the lecture videos in the master's studies in mathematical information technology and the number of complete and partial failures during 2008–2011. The table presents matters related to the recordings of face-to-face study sessions but not the problems related to the viewing of recordings. The table shows that the annual number of all failures is about 4% and that the number of complete failures is even smaller (approx. 1%). For example, in 2011 there was only one complete failure.

TABLE I: NUMBER OF LECTURE RECORDINGS, THEIR DURATION AND THE DOCUMENTED FAILURES.

	2008	2009	2010	2011
No. of lecture recordings	145	215	185	164
Duration/hr	453	707	635	518
No. of complete failures	2	2	2	1
No. of partial failures	7	5	6	4

A complete failure in the recording of a lecture video can have various reasons behind it. The most probable of these reasons are lack of timing in the encoder or its incorrect timing, failed activation of a timed task and power failure. In the production model of the master's studies in information technology, complete failures have always been due to these factors. For partial failures, there are numerous reasons. In practice, the reasons are the same as in complete failures, but they take place in a more reduced scale. Examples include the cases where an encoder transmitting real-time media flow or an encoder recording it cannot capture the image input. This may be due to the breaking of the hardware or the computer has turned itself off as a result of a power outage. Nevertheless, the backup system has saved the lecture.

It can be stated, therefore, that the problems with lecture videos are related to preliminary arrangements and recording as well as to external factors such as power and equipment failures.

V. CONCLUSIONS

Production of lecture videos is a topical issue for many of those who provide modern education. Often there is reluctance to give up face-to-face teaching, and for the reasons of cost efficiency there is preference towards video production connected to face-to-face teaching situations. Production circumstances of this kind pose many challenges to video production.

The technological environment required in video production is fairly simple. However, integration of a production system to existing systems, automation taken to as far as possible, transparency of production and wide reachability of videos are quite demanding to accomplish. In addition videos are often solicited simultaneously from several locations and production processes should be suitable for different courses and lecturers. These kind of demands placed on production diversity create an additional challenge. In many cases, challenges are easier to meet with the help of a self-constructed production system that utilizes various commercial equipment and software solutions than with the help of a comprehensive commercial recording system.

The more we want to take into account the demands presented above, the more technological environment we must build by ourselves. From the perspective of cost efficiency, the practices developed around technological solutions are more important than the solutions themselves.

The research results indicate that lecture videos are suitable for the purpose they are intended. In practice, this means that with their help availability of teaching can be improved and, through this, students' learning can be supported. Apart from the increased flexibility, videos offer also other benefits such as opportunities for revision and support for different learning styles.

By individual construction - utilizing, combining and supplementing equipment and software on the markets to obtain a technological environment that is just right for the practices and needs of the education provider – it is possible to create a production model that enables a very cost-efficient way to produce lecture videos. Based on the results, it is possible to assert that the operational reliability in systems built in this way can be brought to a quite reasonable level. One should keep in mind, however, that creating this kind of recording system requires that technological know-how can be found in the organization.

REFERENCES

[1] I. N. Toppin, "Video lecture capture (VLC) system: a comparison of student versus faculty perceptions," *Education and Information Technologies*, vo. 16, no. 4, pp. 384-395, 2011.

[2] G. Preston, R. Phillips, M. Gosper, M. McNeill, K. Woo and D. Green, "Web-based lecture technologies: highlighting the changing nature of teaching and learning," *Australasian Journal of Educational Technology*, vol. 26, no. 6, pp. 717-728, 2010.

[3] S. Engstrand, and S. Hall, "The use of streamed lecture recordings: patterns of use, student experience and effects on learning outcomes," *Practitioner Research in Higher Education*, vol. 5, no. 1, pp. 9-15, 2011.

[4] H. Brecth, and S. M. Ogilby, "Enabling a comprehensive teaching strategy: video lecture," *Journal of Information Technology Education*, vol. 7, pp. 71-86, 2008.

[5] M. Gosper, M. Mcneill, R. Phillips, G. Preston, K. Woo and D. Green, "Web-based lecture technologies and learning and teaching: a study of change in four australian universities," *Research in Learning Technology*, vol. 18, no. 3, pp. 251-263, 2010.

[6] K. T. Tan, E. Wong, and T. Kwong, "Piloting lecture capture: an experience sharing from a Hong Kong university," *Enhancing Learning Through Technology*, vol. 117, pp. 268-279, 2010.

[7] A. Le, S. Joordens, S. Chrysostomou and R. Grinnell, "Online lecture accessibility and its influence on performance and skills-based courses," *Computers and Education*, vol. 55, no. 1, pp. 313-319, 2010.

[8] F. Bodendorf, M. Schertler, and E. Cohen, "Producing Reusable Web-Based Multimedia Presentations," *Interdisciplinary Journal of Knowledge and Learning Objects*, Vol. 1, pp.127-142, 2005.

[9] R. Kannan and F. Andres, "Towards automated lecture capture, navigation and delivery system for web lecture on demand," *International Journal of Innovation in Education*, Vol. 1, No. 2, pp. 204-212, 2010.

[10] I. Hakala and M. Myllymaki, "The use of lecture videos: attendance and student performance", in *Proc. 14th International Conf. on Computers and Advanced Technology in Education*, Cambridge, United Kingdom, 2011.

[11] M. Wieling, and W. Hofman, "The impact of online video lecture recordings and automated feedback on student performance," *Computers & Education*, vol. 54, no. 4, pp. 992-998, 2010.

[12] T. Traphagan, J. V. Kucsera and K. Kishi, "Impact of class lecture webcasting on attendance and learning," *Educational Technology Research and Development*, vol. 58, no. 1, pp. 19-37, 2009.

[13] I. Hakala, M. Myllymäki, "Video lectures alongside with contact teaching," In *Proc. 18th Annu. EAEEIE Conf. Innovation in Education for Electrical and Information Engineering*, Praque, Czech Rebublic, 2007.

VII

TEMPORAL DIFFERENCES IN PARTICIPATION MODES IN VIDEO-BASED BLENDED LEARNING PRACTICE

by

Mikko Myllymäki & Ismo Hakala, 2014

In L. G. Chova, A. L. Martínez, & I. C. Torres (Eds.), EDULEARN14 Proceedings.
6th International Conference on Education and New Learning Technologies,
2000-2006

TEMPORAL DIFFERENCES IN PARTICIPATION MODES IN VIDEO-BASED BLENDED LEARNING PRACTICE

M. Myllymäki, I. Hakala

University of Jyväskylä (FINLAND)

Abstract

In traditionally organized education, the education provider also determines the teaching schedules. Education in accordance with the blended model and based on videos can be realized, when so wished, in such a way that the student will be free to decide about his/her time use. In this kind of environment students can still study in accordance with the proposed pedagogical model at a pace determined by lecture sessions so that the previous lecture is always seen before the next face-to-face teaching session. Study can also completely adapted to one's own pace. In this case, the student watches the lecture videos before an exam, not worrying about the pace of face-to-face teaching. This research examines, with the help of temporal classification of participation modes, students' participation and the effects of the participation mode on learning outcomes in an environment based on videos and in line with the blended model. The learning outcomes are examined from the viewpoint of both course grades and course completion. The results suggest that the choices related to time use made by the student have effects on learning outcomes.

Keywords: blended learning, lecture videos, distance learning, adult education, lecture attendance, study modes.

1 INTRODUCTION

Arranging education for adult students creates new challenges for education providers. Working adult students and adult students with families often have special needs related to time use. These needs often manifest as reduced opportunities to participate in the education provided. One way to increase the flexibility of participation in education, while better taking the student's life situations into account, is to realize that education in accordance with the blended learning model employing lecture videos. Lecture videos can, in these cases, function as an alternative to face-to-face teaching in study participation. Maintaining face-to-face teaching alongside videos enables choosing of one's study participation mode: it is possible to physically attend face-to-face teaching, study from distance with a real-time video transmission taking place simultaneously with face-to-face teaching, or study from distance in a delayed mode with the help of on-demand videos. When lecture videos and other study-related activities, such as interactivity and distribution of study material, are realized so that they are suitable also for mobile devices, the student can access, independent of time and place, all the material needed for study.

In education realized in a traditional way, face-to-face teaching, but often also online teaching, is already scheduled by the provider of education. Even though the course start in the case of online courses can be flexible, the progression of the course is typically, however, scheduled. In education based on videos and in line with the blended model, the variety in the ways of participation allows the student to time the study in accordance with his/her own personal schedule. In this kind of learning environment, the student is able to choose the participation mode that best suits for his/her life situation. The student can study fully traditionally, relying on face-to-face teaching, or, on the other hand, as a distance student relying on lecture videos and other tools enabling study from distance. The student can also flexibly combine face-to-face study and distance study and study according to the blended learning model the way he/she wishes. The participation mode of the student thus moves on the scale, similar to that depicted in Fig. 1, between face-to-face and distance study, depending on the ratio of video lecture usage.

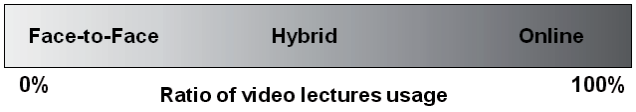

Figure 1. Distribution of students' study participation by the extent of video utilization

ISBN: 978-84-617-0557-3

Purely from the viewpoint of face-to-face teaching, the student can, in a temporal sense, participate in study in real time, simultaneously with face-to-face teaching, or in non-real-time, deviating from the pace determined by face-to-face teaching. Real-time participation thus includes, in addition to participating in face-to-face study, also study with the help of real-time video. On the other hand, study at the pace of face-to-face teaching is, in the case of videos, a flexible concept. If a lecture video is to be viewed before the next face-to-face teaching situation, one can still refer to this as study at the pace of face-to-face teaching. So it may be thought that a student who studies with the help of on-demand videos studies still at the pace determined by face-to-face teaching. On the other hand, the student's ability to freely define his/her time use enables study at one's own pace without being dependent on face-to-face teaching. This is referred to as studying with delay. In this case, the student watches the lecture videos before an exam at the time regarded as the best for the purpose.

Earlier studies have examined student participation in connection with lecture videos. These investigations, however, have focused mainly on the amount of participation in teaching and, above all, on the effects of lecture videos on the participation in face-to-face study [1][2][3][4][5][6][7]. Also the effects of lecture recordings on learning outcomes have been considered in earlier research [3][8][9][10][11]. On the other hand, we are not aware of any studies in which participation and learning outcomes would have been examined through a participation mode classification defined temporally in relation to face-to-face study.

Although flexible teaching solutions are constantly being developed it is still difficult to find implementations where the students can freely select the flexible ways to participate to the education and which covers the whole educational program. So the educational solution that this research examines is a very unique. Still the results of this study can be generalized widely for example to many kinds of distance education.

In this research, we examine participation modes with the help of temporal classification in an environment based on videos and in line with the blended learning model. The investigation aims to find out how students participate in study timewise and whether temporally determined participation modes affect the extent of participation or learning outcomes. The learning outcomes are examined from the viewpoint of both course grades and course completion. The results in this article are based on analyses of log data collected from transmissions of videos for 38 courses between 2008 and 2012, on attendance statistics collected about face-to-face education and on the register of study credits.

2 RESEARCH FRAME

The research data was collected in connection with the Master Studies in Mathematical Information Technology at the Kokkola University Consortium Chydenius. The students participating in the degree program are working adults for whom participation in studies is challenging due to time use limitations.

The students live across a wide geographical area. Those living at the furthest distance are located 500 km away from the campus. A long travel distance to the place of learning together with simultaneous work and study are the most significant limitations placed on the students' participation in face-to-face teaching. To increase flexibility, all teaching in the program is arranged according to the blended model.

All teaching for the students is arranged as face-to-face teaching, which is recorded and offered to them as real-time and on-demand video. The timing of the teaching is based on the face-to-face lectures. Face-to-face teaching is arranged for Friday afternoons and Saturdays. The courses are scheduled to be run as very compact entities in such a way that, typically, a single course is run in a few weekends. In practice, this means that the duration of a single lecture session equals 3-4 traditional lectures. Thus, from the temporal point of view, the courses are typically implemented, so that the lectures are every week, or every other week, on Fridays and/or Saturdays. Lecturers plan their courses pedagogically taking this timing into account.

The students can participate in the degree program's study either face-to-face, with the help of direct video transmissions or by using on-demand videos. The students do not need to decide about their participation mode beforehand; they can choose to participate in each lecture the way that suits best for their life situation or study preferences. Thus, the student can participate in each lecture of a course study in many different ways by flexibly combining various alternatives. Lecture videos have been used in the degree program already for several years; therefore, studying with their help was already familiar to students during the research.

The research data consists of information on 77 students. These students participated in 38 courses during 2008–2012. The total number of course participations was 500. The material consists of attendance data collected from face-to-face teaching situations, log data of viewing of lecture videos and information from the register of study credits. A student was counted as a participant of a course if he/she participated at least in one of the course lectures, either through face-to-face education or with the help of videos. The courses were assessed using either a pass/fail scale or a whole number scale from 0 to 5 where 0 indicates fail. The data was subjected to statistical manipulation.

2.1 Student Classification

For the research, the students are classified in relation to temporal differences in study participation. They were divided into two categories based on the time component in their study. Fig. 2 shows the classification

The student can, in a temporal sense, participate in study in real time, simultaneously with face-to-face teaching, or in non-real-time, deviating from the pace dictated by face-to-face teaching. Timewise, participation in study is a flexible concept if recordings are made available. If a lecture video is viewed in the form of an on-demand recording before the next face-to-face teaching session, one can still refer to this as study at the pace of face-to-face teaching. On the other hand, if the first participation in study with the help of on-demand video occurs only after the next lecture session, one may think of this as studying with delay in relation to face-to-face study.

Therefore, participation in education can be classified timewise as follows:

A student is counted to study at the pace of face-to-faces if at least 50% of his/her average study participation takes place as face-to-face study or with the help of real-time video or with the help of on-demand video before the next face-to-face teaching. Otherwise, the student is regarded as studying with delay.

In first category studying takes place in accordance with the proposed pedagogical model at a pace which teaching is designed to study. In the second category the student watches the lecture videos before an exam, not worrying about the pace of face-to-face teaching. It means that studying is completely adapted to one's own pace and it is conducted against the proposed pedagogical model.

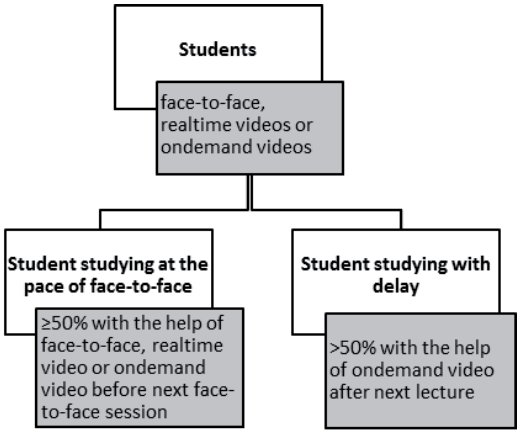

Figure 2. Classification based on temporal differences in study participation.

3 RESULTS

First, we will examine the distribution of students in categories explained above. After this, we will concentrate our examination on students' learning outcomes, aligning them with the classification. The learning outcomes will be examined from the viewpoint of both course grades and course completion.

3.1 Monitoring of Temporal Participation in Education

Fig. 3 shows how students are divided into those studying at the pace of lecture sessions and those studying with delay. It is important to note that face-to-face teaching seems to have great significance in pacing the study in a blended teaching model organized in this way where participation in the study

can be very flexible. Based on Fig. 3, five-sixth of all students study at the pace determined by face-to-face teaching. Thus only one-sixth of the students in this research seem to study independently of face-to-face teaching and according to their own schedules.

Of these students 85% live at a distance of more than 50 km from the campus and 15% at a distance of 50 km at most from the campus area. Because of distance it might be difficult for them to participate with the help of face-to-face teaching, but they could still participate in real-time or watch the videos before next lecture if they wish.

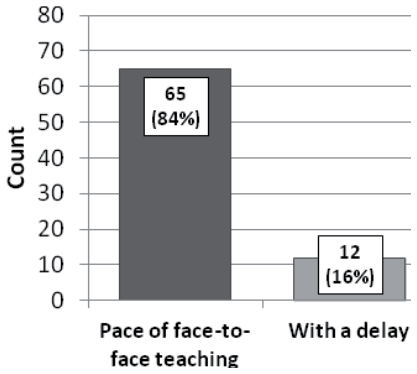

Figure 3. Classification of students (N=77).

Table 1 provides more details of the participation modes within the classification presented earlier. When we look the participations of those studying at the pace of lecture sessions, we can see that the clear majority, five-sixths, takes place by the next lecture session at the latest. Similarly, of the participations of those studying with delay, the clear majority, four-fifths, are delayed. Therefore, the classification of students seems to separate students on the basis of their participation mode into two coherent categories.

Based on the results, it seems that the students, when necessary, can make use of the flexibility that videos provide. Participation modes of the students studying at the pace of face-to-face teaching are distributed relatively evenly. Students take advantage of the increased flexibility, however, mainly by taking the designed pedagogical model into account. On the other hand, those studying in pace of face-to-face teaching use on-demand videos sometimes (14,1%) also after next lecture.

Students who are studying with delayed mode participate mainly with the help of videos. About their participations of more than 95% is conducted by using on-demand videos and face-to-face teaching is almost in non-existent role.

The results indicates that typically, the students are not constrained into only one way of participation in education provided; as far as time is concerned, they seem to participate in a very flexible manner. Quite a few things have influence on temporal choices: work load at the time, study subject, own study preferences or time use limitations due to family life.

Table 1. Average temporal participation modes for students studying at the pace of face-to-face teaching and students studying with delay. (N=77).

Participation modes	Students studying at the pace of face-to-face teaching	Students studying with delay
Face-to-face	30.9%	0.6%
Real-time	21.4%	4.1%
On-demand video (before next lecture)	33.6%	15.0%
On-demand video (after next lecture)	14.1%	80.3%

As the Fig. 3 illustrated the major part of the students study undoubtedly at the pace of face-to-face teaching, though with some delay. Still one-sixth of all students used the opportunity provided by the videos to study fully in accordance with their own schedules. The existence of this group was possible to notice only by examining the temporal differences in participation modes. For these students, the

selection of study mode is probably a conscious decision rather than a solution dictated by circumstances. It is therefore useful to examine whether temporally determined participation modes affect the learning outcomes.

3.2 Importance of Study Pace on Learning Outcomes

Learning outcomes are examined in relation to the classification presented. Fig. 4 and Fig. 5 present the learning outcomes of students studying at the pace of face-to-face teaching and those studying with delay. The learning outcomes are examined with the help of course completions and grades obtained.

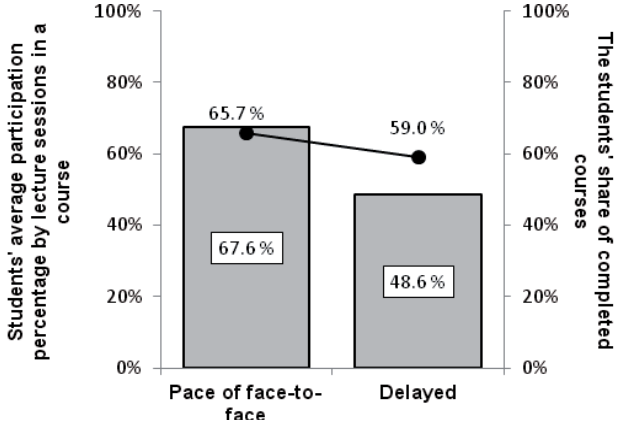

Figure 4. The averages of average temporal participation shares and the averages of the shares of completed courses. (N=77)

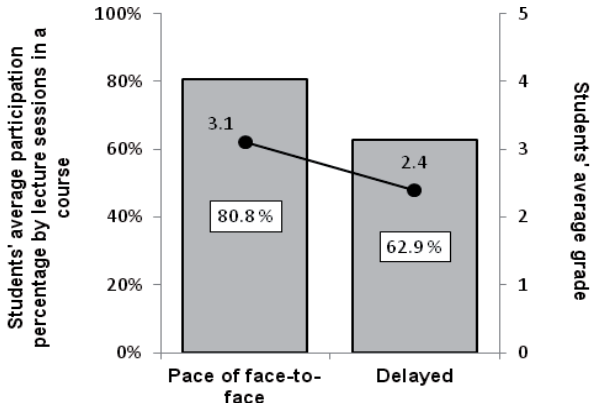

Figure 5. The averages of average temporal participation shares and of average course grades in (includes the courses that have been completed with approved grades). (N=57)

Fig. 4 shows that there are no big differences in completion percentages between those studying at a pace which teaching and those studying with delay. The difference is not statistically significance either ($p<0.327$). When the students' average participation degrees are examined, it can be seen that students who are studying at the pace of face-to-face teaching have a better degree of participation. The difference between groups in relation to participation degree is also statistically significant ($p<0.016$)

The examination of grades includes only the courses that have been completed with approved grades. It can be seen in Fig. 5 that the grades of those participating at the pace determined by lecture sessions are on average clearly better (3,1 against 2,4). Although the difference is clear no statistical significance could be shown ($p<0.166$). Also in this case students studying at the pace of face-to-face teaching have a clearly better degree of participation. This difference is also statistically significant ($p<0.010$).

The group studying at the pace of face-to-face teaching includes students participating in many different ways. When focusing on students who participate mainly with face-to-face teaching, one can observe that the degree of completion, 63.0%, and the grade average, 2.9, were slightly below those of the whole class. On the other hand, when considering the students who participated mainly with on-demand videos before the next lecture, it was noted that both the average degree of course completion 77.8% and the grade average 3.5 were clearly better in comparison with the completion and grades of the whole class. The corresponding values for the whole class were 65.7% for completion and 3.1 for grade average. Thus, it seems that, when studying at the pace of lectures, those who in their participation make use of the flexibility provided by videos perform better. This result supports an earlier research result [9] according to which students using videos a lot complete their courses better and also get better grades. In that research, the focus was on tool use instead of chronological considerations.

4 DISCUSSION

With the help of videos, students can be provided with flexible opportunities to participate in study. The results of the research seem to indicate that the students, in fact, use the flexibility afforded by videos for their benefit. However, when the students are offered the chance to freely choose their participation mode, most of them endeavor to study at the pace with face-to-face teaching. The students thus seek to participate in the study in accordance with the pedagogical model defined by the education provider. This would clearly suggest that the education provider should consider pacing of the study and its timewise design as carefully as when organizing face-to-face teaching, even where the education in accordance with the blended model is in question. The results, in this respect at least, can probably be generalized also to actual distance study courses.

In the research data we still have small group of students who study completely adapted to one's own pace. The existence of such a group of students also raises the question if it can be better taken into account in the future when designing the implementations and pedagogical solutions of the courses. Nevertheless, it should be noticed that in spite of belonging to a certain category the students participated in study in other ways also when necessary. Participation by the students was very flexible, and they clearly made good use of the flexibility that videos provided.

In light of the results, it seems that the students who participate in accordance with the pedagogical model defined by the education provider, that is, participate in the lectures always before the next lecture, get grades that are above average and complete the courses better than average. This is quite certainly explained by that the average participation degree of these students is notably better than that of the students who do not study, timewise, in accordance with the pedagogical model. The students who study with delay probably put more effort on their study during the final stages of their course, closer to the exam. This research does not give an answer to whether the choice of participation mode of those who study with delay is due to that they feel this kind of study suiting best for them or that the requirements of work and family life force them to participate in this way. Nevertheless, we can assume that, at least to a certain degree, it is a matter of voluntary choice for the student because participation at the pace with face-to-face teaching would be possible by viewing the lecture videos any time, typically within a week.

In earlier research [9] it was noticed that students using videos a lot complete their courses better and also get better marks. Better degree of participation made possible by videos has been seen as the principal reason for this. In this research, the focus was on timewise participation instead of tool use. The results of this research and those of the earlier research suggest that the education realized with the help of videos in accordance with the blended model provides the greatest benefits to students who use the increased flexibility, afforded by the technologies, in their participation in education while nevertheless abiding with the pedagogical model designed by the education provider.

5 CONCLUSIONS

In traditionally organized education, the education provider also determines the teaching schedules. Typically also online courses are, to a certain extent, following a schedule of some kind. Education in accordance with the blended model which is based on the lecture videos provides the student with a fairly far-reaching freedom to decide about his/her time use. When the lecture videos are offered to the students the concept of study participation is wider. In addition to the face-to-face teaching area, it is possible to participate also in other places with the help of real-time video and also at other times with

the help of on-demand video. Participation must therefore be understood in a different way. This paper considered these choices of participation modes and their effects on learning outcomes.

The students in the research data were divided into those studying at the pace of face-to-face and to those studying with delay. The major part of the students belongs in the first category. Still one-sixth of all students used the opportunity provided by the videos to study fully in accordance with their own schedules. The existence of this group was possible to notice only by examining the temporal differences in participation modes. For these students, the selection of study mode is probably a conscious decision rather than a solution dictated by circumstances.

The research results indicate that there are differences in the extent of participation and in learning outcomes between students' participation modes. According to the results, for those studying at pace of face-to-face teaching obtain better grades and also complete the courses better than students who watch the lecture videos before an exam, not worrying about the pace of face-to-face teaching.

Overall, according to the results obtained, the videos seem to be an excellent solution in the context of the study. From the viewpoint of the education provider it is important to understand that face-to-face teaching has great significance in pacing the study in a blended teaching model. Also, in the context of distance learning courses sequencing and temporal aspects of the implementation are very important.

The results of this study suggest that it would be useful to examine the topic more deeply from the viewpoint of learning styles, for example.

REFERENCES

[1] Brotherton, J. A. and Abowd, G. D. (2004). Lessons Learned from eClass: Assessing Automated Capture and Access in the Classroom. ACM Transactions on Computer-Human Interaction 11(2), pp. 121-155.

[2] Chang, S. (2007). Academic Perceptions of the Use of Lectopia: A University of Melbourne Example. In Proceedings of the Australasian Society for Computers in Learning in Tertiary Education.

[3] Gosper, M., Green, D., McNeil, M., Phillips, R., Preston, G., and Woo, K. (2008). The Impact of Web-based Lecture Technologies on Current and Future Practices in Learning and Teaching. Australian Learning and Teaching Council.

[4] Hakala, I. and Myllymäki, M. (2011). A Blended Learning Solution and the Impacts on Attendance and Learning Outcomes. International Journal of Emerging Technologies in Learning 6(2), pp. 42-49.

[5] Traphagan, T., Kucsera, J. V. and Kishi, K. (2009). Impact of Class Lecture Webcasting on Attendance and Learning. Educational Technology Research and Development 58(1), pp. 19-37.

[6] Walls, S. M., Kucsera, J. V., Walker, J. D., Acee, T. W., McVaugh, N. K. and Robinson, D. H. (2010). Podcasting in Education: Are Students as Ready and Eager as We Think They Are?. Computers & Education 54(2), pp. 371-378.

[7] von Konsky, B. R., Ivins, J., and Gribble, S. J. (2009). Lecture Attendance and Web Based Lecture Technologies: A Comparison of Student Perceptions and Usage Patterns. Australasian Journal of Educational Technology 25(4), pp. 581-595

[8] Chiu, C. F., Lee, G. C. and Yang, J. H. (2006). A Comparative Study of Post-class Lecture Video Viewing. In Proceedings of 5th IASTED international conference on Web-based education.

[9] Hakala, I. and Myllymaki, M. (2011). The Use of Lecture Videos: Attendance and Student Performance. In Proceedings of the 14th International Conference on Computers and Advanced Technology in Education.

[10] Ross, T. K. and Bell, P. D. (2007). No Significant Difference, Only on the Surface. International Journal of Instructional Technology and Distance Learning 4(7), pp. 3–13.

[11] Wieling, M. and Hofman, W. (2010). The Impact of Online Video Lecture Recordings and Automated Feedback on Student Performance. Computers & Education 54(4), pp. 992-9