NEW WAYS TO TEACH AND LEARN IN CHINA AND FINLAND
- CROSSING BOUNDARIES WITH TECHNOLOGY

Eds.
Hannele Niemi, PhD., Professor of Education, University of Helsinki, Finland, hannele.niemi@helsinki.fi

&
Jiyou Jia, PhD., Professor, Department of Educational Technology, School of Education, Peking University, China, jjy@pku.edu.cn
Table of contents:

Preface and Acknowledgements

What are New Ways to Teach and Learn in China and Finland?
Hannle Niemi and Jiyou Jia

PART 1. STUDENTS AS KNOWLEDGE AND ART CREATORS IN DIGITAL FORUMS

1. Using Smart Phones to improve the Classroom Instruction of University Students
Jiyou Jia

2. Student-driven knowledge creation through Digital Storytelling
Marianna Vivitsou, Veera Kallunki, Hannele Niemi, Johanna Pentttilä and Vilhelmiina Harju

3. Beyond the Classroom: Future Music Education through Technology
Inkeri Ruokonen and Heikki Ruismäki

4. Faculty of Medicine as a Mobile Learning Community
Eeva Pyörälä, Teemu Masalin and Heikki Hervonen

5. E-Schoolbag Use in Chinese Primary Schools: Teachers’ Perspectives
Fengkuang Chiang, Shuhan Jiang, Mingze Sun and Yana Jiang

6. An E-learning Project for Language Instruction in China
Bao-Ping Li, Xiao-Qing Li and Lulu Sun

7. A Study on the Online Learning Behaviors of Secondary School Students
Xiaomeng Wu

PART 2. PERSONALIZED LEARNING SUPPORT IN THE DIGITALIZED ERA

Pirjo Aunio

Kristiina Kumpulainen and Tarja-Riitta Hurme

10. Game-based Inquiry Learning: Design and Application
Lu Zhang, Yu Jiang, Morris Siu Yung Jong and Junjie Shang

11. Personalized Learning in Early Education in the Digitalized Era (title may change)
Daniel Chen

PART 3. DIGITALIZATION IN TEACHING AND LEARNING ENVIRONMENTS

12. Teachers as Researchers: Current Trends and Hot Topics
Shelly Zong, Jingjing Jiang and Yizhou Fan
Maija Aksela, Jenni Vartiainen, Maiju Tuomisto, Jaakko Turkka, Johannes Pernaa and Sakari Tolppanen  

14. Designing the First Finnish MOOCs  
Otto Seppälä, Juha Sorva and Arto Vihavainen  

15. Learning Analytics  
Jari Multisilta and Ari Korhonen  

Epilogue Crossing Boundaries with Technology  
Jiyou Jia and Hannele Niemi  

AUTHORS
PREFACE AND ACKNOWLEDGEMENTS

In 2014, the Ministry of Education of the People’s Republic of China and the Ministry of Education and Culture of Finland signed the Learning Garden agreement with the intention to establish synergies among various projects and agents involved in Sino-Finnish education cooperation. The University of Helsinki has promoted cooperation with Chinese universities as one of its strategic aims. In late 2014, the mutual understanding between the University of Helsinki and Peking University was updated and signed, and in November 2015 the University of Helsinki and Beijing Normal University decided to establish the joint Sino-Finnish Learning Innovation Institute for cooperation in educational issues in both countries.

The editors and authors of this book want to thank the ministries of both countries for the important initiative and for their systematic cooperation. This book is a product of a research collaboration between Chinese and Finnish researchers, especially in the area of educational technology. During the last two years, researchers have held several joint symposiums and conferences in both Peking and Helsinki. It has been amazing how much we have learned from one another despite the vastly different scales of our two countries.

All authors are very grateful to their own universities for providing an opportunity for inspiring international collaboration. The Finnish researchers also want to thank the Finnish funding agencies, the National Agency for Technology and Innovations (Tekes) and the Academy of Finland, which have supported the development of educational technology in Finnish educational settings in recent years. The Tekes project Finnable 2020 at the University of Helsinki has been especially important to this book.

As editors we want to thank all authors for their constructive and fruitful cooperation. We would also like to extend our thanks to our research assistant Pauli Peräinen, who has been an excellent help in technical editorial work and in the communication between the researchers from both countries.

In addition, the Chinese authors also want to express their deepest thanks to Professor Hannele Niemi for her devotion to and persistence in the joint research and this book. She has borne the main responsibility for finding resources and editing this book for a wider international audience.

We hope that this book will encourage the active cooperation between China and Finland in the future.

In Helsinki and Peking, May 6, 2016

Hannele Niemi  Ph.D. Professor of Education  University of Helsinki  Finland

Jiyou Jia  Ph.D. Professor of Education  Peking University  China
Current trends in the Chinese context

Computer technology has been utilized in Chinese education since the 1980s, with audio-visual technology having been utilized since the 1950s. The growing popularity of the Internet and wired or wireless phone communication technology from the 1990s onwards brought a wider concept of ICT (Information and Communication Technology), which was then introduced into China and Chinese education. The Chinese-English word ‘informatization’ was invented by Chinese scholars at the end of the twentieth century and indicates the application and integration of ICT into other disciplines. For example, educational informatization means the application of ICT into education and the integration of ICT into education.

In 2010, a national plan for educational reform and development was issued by the central government. This plan declared “ICT has a revolutionary impact on education” (MoE China, 2010). The national propaganda at this time demonstrated the government’s insistence on the high priority of ICT for educational reform and development. In 2012, the “Development Plan of Educational Informatization for the next decade (2011-2020)” was published by the Ministry of Education to concretize the policy and methods of promoting the application and integration of ICT into education (MoE China, 2012).

Since then, with the steady increase of government expenditure on education, vast investment from central and provincial governments has gone to the application of ICT in education. For example, in Beijing’s Digital Campus Program, founded in 2009, 10,000 typical and outstanding lectures from primary and middle school teachers were recorded and aired on wired TV channels and uploaded to the Internet as ‘on demand’ programs, which could be freely accessed by pupils and teachers. Meanwhile, 100 schools were selected as “Experimental Digital Schools” and were granted an
investment of approximately 300,000 Euros to buy hardware such as notebooks, tablet computers, electronic whiteboards and educational software.

From May 23 to May 25, 2015, the UNESCO and the Chinese Ministry of Education jointly held the International Conference of Educational Informatization in the city Qingdao in Shandong Province (MoE China, 2015). Educational officials, researchers, principals and school teachers as well as ICT companies from more than 90 countries came together to explore an effective approach to the integration of ICT into education and to examine the increased popularity of ICT usage in education.

In the congratulation letters, Chinese President Xi Jinping called for the construction of a digitalized education system based on the Internet for individual growth and life-long learning, the building of a learning community for every person for any time and any place, and the training of a large number of innovative talents. He also declared that educational informatization can help more schools, teachers and students to use excellent educational resources and enable billions of children to share quality education and change their own destiny with knowledge.

On March 16, 2016, the National People’s Congress (Chinese Parliament) voted and passed the “thirteenth five-year plan for national economic and social development”. This plan aimed to enhance the educational level of all people and to promote the modernization of education. The concrete approaches detailed in this plan include the development of online education and distance learning, the integration of all kinds of educational digital resources and their service for society as a whole, and the deep integration of ICT with teaching and learning (National People’s Congress China, 2016).

In addition to governmental investment, high enthusiasm and investment from the industrial and business sectors in form of venture capital have been extended to educational informatization, as investors hope to profit from related industries and businesses.

Though many schools have been equipped with the latest hardware and software, and teachers are required and encouraged to use ICT in their teaching, there are still many problems with ICT application in China. The chapters in this book written by Chinese researchers attempt to address those problems and to explore potential solutions. For our purposes, ‘technology’ refers to the use of tablet computers and smartphones in education, game-based learning, and online instructional platforms. Subjects dealt with include Chinese as a first language, English as a foreign language, mathematics and science education. The target students vary from kindergarten children, primary and middle school pupils to university students. The teachers’ attitude and concern toward ICT usage is also investigated in two chapters.
In Chapter 1, Jia presents his research on using smartphones to improve the classroom instruction of university students. He designed drills for the required vocabulary corresponding to the textbook. The students were allowed to use their own smartphones to do the drills for about ten minutes in the classroom every week. After one semester of quasi-experiment with an experiment class and a control class, the “drill students” had increased their score in vocabulary tests significantly, and decreased their distance in regular exam to the control class significantly. The performance improvement was caused by the immediate feedback function of the vocabulary drills implemented by the course management system and smartphones. This chapter shows that the increasingly popular smartphones can easily be blended into classroom teaching and learning of university students.

In Chapter 5, Chiang et al. introduce the survey and interview results of 34 teachers from 4 eSchoolbag pilot schools in Shenzhen, Guangdong Province, a developed metropolitan city near Hong Kong. They found that the teachers’ attitudes toward eSchoolbag changed from positive to negative after using it due to many reasons, including the lack of appropriate resources for classroom instruction, students becoming negatively distracted by useless functions, and the unpredictable positive effect of this technology on students’ learning performance mainly represented by examination scores.

In Chapter 6, Li et al. present a large-scale e-learning project to promote the Chinese and English language learning in primary and secondary schools which has been implemented by the institute of Modern Educational Technology of Beijing Normal University since 2000. ICT like personal computers, tablet computers and the Internet are used as cognitive cooperation and communication tools to help the students to learn and explore by themselves. From 2011 to 2014, 4218 students and 174 teachers participated in the project for three terms in total. Li et al. determined the number of Chinese characters the students’ recognized and the scores of both Chinese and English language ability tests. The statistical analysis has proved that the test group achieved a significantly better learning performance than the non-experiment students. The teaching and learning model coined in this project can be extended to more rural schools to decrease the gulf between them and their urban counterparts.

In Chapter 7, Wu analyzes the log file for a large online learning environment originally developed for 110,156 secondary school students and found 5936 students (about 5%) who took part in some online learning activities. Three distinct patterns exist among those online learners: active learning participants, socially active participants and lower participants. Comparison between genders shows no significant difference between the learning behaviors of boys and girls. However, comparison between grade groups indicates that 7th grade students tend to learn for longer periods of time than
older students, and 7th and 8th grade students tend to participate in more social activities than 9th grade students. This chapter suggests that some measures are needed to encourage students to effectively use the large amount of online resources.

Chapter 10 discusses how, based on literature review and theory analysis, Zhang et al. designed a game-based inquiry-based learning model. Guided by that model, they developed the “Farmtasia” inquiry-based learning curriculum and completed an empirical study in a high school. The result shows that this game-based inquiry learning model helps to expand the advantages of educational games, and cultivates students’ inquiry learning abilities.

Chapter 11 shows how Chen designed an integrated learning analytics and personalized child development support framework for kindergarten kids. Within this framework the author hopes to fully use the emerging technologies from machine learning through big data to construct an intelligent, interactive and adaptive learning environment for kids in practical preschool education. An international company has adopted his model for preschool education in China.

In Chapter 12, Zong et al. analyze three Chinese MOOCs’ (Massive Open Online Course) data with text analysis, word frequency analysis and coding techniques. They found that mainland Chinese teachers generally care about six research questions or aspects in particular; students’ motivation, learning ability, differences between students, pedagogy of teaching, technology of teaching as well as effective and efficient teaching.

The above chapters seek to give the reader just a glimpse of ICT application and integration in China. Because of time constraints and the length limitation of this joint book project, these chapters certainly cannot illustrate the whole story of Chinese education and ICT in Chinese education. For example, one important component in the dynamic and complex educational system, the students’ parents, is not discussed in those chapters. Parents are very concerned about their children’s usage of new technologies in schools and universities. They are afraid of their kids’ addiction to online video games, the negative influence of unrelated and even harmful online content on their kids, and the eye strain caused by the small screens of tablet computers and smartphones.

Figure 1 illustrates the structure of the dynamic and complex educational system regarding the ICT products applied in education. Educational authorities and school administrators, ICT providers, teachers, students and parents are all stakeholders in this giant system. They interweave with each other. ICT companies provide schools and students with educational ICT products, including hardware and software, with the allowance and appropriation from educational authorities and school administrators, and make profit from it. Teachers and students use the ICT products and can be
influenced by them. In some cases, the parents pay for the ICT products. The students’ learning performance, as the outcome of the educational system, is paid special attention to by all stakeholders in the system: students, parents, teachers, administrators, etc. This model extends the understanding of an ICT-equipped educational system and emphasizes the efficiency of the system (Jia, 2014).

Figure 1. The dynamic and complex educational system

Current trends in the Finnish context

Finland, as a small country with 5.4 million inhabitants, needs all of its inhabitants’ talents and learning capacity. Since the late 1960s, the main objective of Finnish education policy has been to ensure that all citizens have equal opportunities to receive an education, regardless of age, domicile, financial situation, sex or native language. Education is considered to be one of the fundamental rights of all citizens (FNBE, 2011). Ensuring equal opportunities has had several consequences. Well-functioning educational structures and services are needed in order to enable people to use their opportunities in an equal manner. The main principle is that every school must be a good school and provide additional support to those learners who are at risk of dropping out. Learning to learn skills are emphasized at all educational levels and are seen as an important means to prevent exclusion (Niemi & Isopahkala-Bouret, 2012). Educational technology also has to be considered in this light. It is a tool for acquiring skills that people need in their lives; it helps one to grow in a knowledge-intensive society and in the middle of continuous changes.

In the 1990s Finland was one of the leading information technology societies in the world. The government supported the educational use of ICTs (information and communication technologies). At that time, Finland already had national strategies and guidelines for an IT society for all age
groups and levels of the educational system. Finland developed an international image as an innovative and technology-rich country (e.g. Kozma, 2003; 2008). As early as the late 1990s, Finnish schools had several innovative projects such as distance education networks and advanced video conferencing. Mobile learning was introduced in several pilot projects.

With the new millennium, the 2006 SITES study found that financial investments in the educational use of ICT were not in line with the high expectations. It also revealed that investments in technical resources or infrastructure alone did not create new school culture and learning experiences that would promote 21st century skills and learning competences (Law et al. 2008; Niemi, Kynäslahti & Vahtivuori-Hänninen 2013). Finland had invested in both infrastructure and teachers’ competences. However, SITE (2006) and the OECD (2009) reported that students used new communication technology outside of schools, particularly social media, but it was only used at a moderate level in their everyday school lives. In Finland were schools with excellent technological infrastructure, enthusiastic teachers using new pedagogical models and practices, but there were also schools that lagged far behind in their ICT use.

These results initiated several national efforts to make ICT more of an everyday driving force for 21st century skills in schools. Preparation of a new national strategy for the educational use of ICTs in schools was started. The main aim was to identify the major factors that had promoted or prevented effective ICT practices in different schools. The goal was for ICT to be used in a sustainable way to empower learning for all children in a school community, rather than a temporary project or something applied by only a few individual teachers (Vahtivuori-Hänninen & Kynäslahti, 2012).

Awareness of the importance of 21st century skills for knowledge production, labour markets’ new needs and people’s versatile and often unexpected learning paths puts high requirements on the ways to teach and learn in schools. The acceleration of the digitalization of work life, production and services became important targets in national governmental strategies. The ability to use digital tools and resources should be learned at all levels of the educational system. Schools must enable students to grow into active members of society. This means that students should be treated as active learners. It is important that students learn to set goals and solve problems both independently and with others (Vahtivuori-Hänninen et al., 2014). In 2016, large-scale national core curriculum reforms at pre-primary, basic and secondary schools were launched in Finland. The major aims are that students become active learners who take care of their own learning and also
have capacity to learn to work as a team member. Technology is not an aim itself; it is a tool with which one becomes an active citizen both locally and globally.

The central idea behind the national core curriculum for basic education is that “schools should be learning communities” (FNBE, 2014). In the learning communities all members learn together; they share their ideas and experiences and learn from each other. The learning community encourages its members to make inquiries, lead investigations and conduct experiments; to strive for new knowledge through problem solving, even to take risks when trying to find new solutions and take inspiration from their learning. The new core curriculum emphasizes that teaching and learning in schools are based on interaction, collaboration and versatile methods for promoting different students’ learning and well-being. The schools must recognize that knowledge can be created in multiple ways and provide flexible chances to different learners.

Digital learning tools, materials environments and educational technology provide the means to create meaningful learning conditions and supporting different learners in their learning paths. Schools need to offer solid foundations by which every student can learn to use new technological resources and, thus, become active knowledge creators both individually and collaboratively. The national core curriculum provides basic values, broad objectives and general guidelines to schools; however, the Finnish education system leaves much freedom to local providers, and therefore schools can have various implementations of the national core curriculum. Students’ learning outcomes are assessed on a local level by the schools because national standardized testing does not exist in Finland. This also provides much autonomy to teachers and schools regarding how teaching and learning can be arranged. Learning can also happen in different environments: new digital tools can combine formal and informal learning settings and connect the schools with their local surroundings. In this book, we describe some Finnish examples of how students can become active knowledge creators and how they can be supported in overcoming learning difficulties.

In Chapter 2, Vivitsou et al. offer insights into digital storytelling as a pedagogical method that allows students’ learning and teachers’ practices to meet the needs and requirements of 21st century skills. Students created digital stories, which could be subject-based, interdisciplinary, or totally student-initiated. The findings indicate that the digital storytelling experience has an impact on subject-based content learning, the use of English as medium for international communication and the establishment of networking and collaboration with peers both online and locally.
In Chapter 3, Ruokonen and Ruismäki provide examples of how to overcome boundaries between formal and informal learning in music education in Finland. Three different case studies introduce and reflect upon new trends in connecting music education and new technology. This chapter describes how instrumental pedagogy and distance learning can be connected. The researchers have obtained convincing findings on how technological environments promote playful learning and creative music composition.

In Chapter 4, Pyörälä et al. describe how the Faculty of Medicine created a mobile learning community, and how the use of iPads brought together students and experts in medical education. Longitudinal data has also suggested that with new technological environments, hands-on support for both students and teachers is needed when integrating iPads into Problem Based Learning. In the projects, students also learned new types of collaborative learning and networking.

In Chapter 8, Aunio et al. describe research-based developmental work that has been done in Finland for designing web-services related to mathematical learning difficulties, assessment and interventions. The strong emphasis on equality in education has been a driving force behind ideas of how to provide support or extra help to learners with learning difficulties or special circumstances. Web-based materials encourage educators to provide educational support for children according to the responsiveness to intervention model. Digital tools provide many chances for personalized learning.

In Chapter 9, Kumpulainen and Hurme explain how digital technologies can be used to support hospitalized children’s agency and learning. They use cultural-historical theorizing in human agency, learning, and development. They conclude that there are promising findings on the ways in which digital technologies can connect children to their family, school, and peers during and after sickness. However, more attention needs to be given to sociocultural contexts and practices when using digital technologies to support hospitalized children’s agency and empowerment in their healing and learning processes.

In Chapter 13, Aksela et al. describe how to promote meaningful science teaching and learning through ICT in the LUMA (STEM) ecosystem. They provide a model of how to advance children’s’, youths’ and teachers’ competences in mathematics, science and technology. It also shows how to create an ecosystem for inspiring science learning when researchers, educators, educational administrations, the business sector, teacher associations, science museums and centers, families and the media work together.
In Chapter 14, Seppälä et al. describe how two leading universities in Finland, Aalto University and the University of Helsinki, offered a programming course as a free online course: a MOOC (Massive Online Open Course). Thousands of Finnish-speaking students have studied through these online courses, and they have received outstanding student feedback. A crucial issue within the Finnish educational system is providing learning opportunities as openly and as widely as possible. The authors recognized that in spite of positive feedback, MOOCs need continuous pedagogical development in order to offer support to all learners.

In Chapter 15, Korhonen and Multisilta reflect on how learning analytics can provide new tools for identifying students’ learning paths. In online learning, many Learning Management Systems (LMS) and Massive Online Open Courses (MOOC) collect data from the users. Particularly in scalable courses that target a large number of students, automatic assessment and feedback provide an interesting source of data. The learning platform can collect not only the submitted solutions and the corresponding grading information (such as the points or other marks given to the student), but it also traces the paths the students took while solving the problems. The authors claim that there is a great need to utilize learning-related user data in order to understand the learning process in much deeper way. To be able to do so, learning data should be collected and analyzed in relation to the content, and the content needs to be structured in a pedagogically meaningful way.

The Chinese and Finnish examples are different but complementary. While the Chinese cases are mainly focused on students’ learning outcomes, the Finnish studies seek ways to engage students and transform them into active knowledge creators and to develop approaches that ensure all learners have access to continuous learning paths. The book’s message is that new technology can enhance learning outcomes and provide processes and support that help learners to internalize 21st century skills and competences.

References


PART 1. Students as knowledge and art creators in digital forums

1. Using Smart Phones to Improve the Classroom Instruction of University Students

Jiyou Jia

Peking University

Abstract

We designed a personalized and web-based vocabulary drill system targeted at the required new words and phrases from the university student’s English textbook. We asked students to volunteer in the drill programs using their own smartphones via wireless network in the classroom for 10 to 20 minutes in their English class each week. In one semester, the quasi-experiment resulted in a significant improvement of the treatment class in vocabulary tests and also in a decrease from a statistically significant level to a not significant level of performance distances between the treatment class and the control class in the regular exams. The present research demonstrates that the students’ smartphones can be easily used in the university classroom to effectively facilitate teaching and learning in university classes. According to the learning theory of behaviourism, the instant feedback feature of smartphones motivates the students to participate in learning activities and contributes to performance improvement.

Keywords: smartphones; instant feedback; effect; classroom teaching and learning; English class
**Introduction**

Because of its high quality-price ratio, smartphones have been used worldwide, and especially by young students. For example, according to the latest internet survey published by the China Internet Network Information Centre on February 3, 2015 (CNNIC, 2015), until December 2014 internet users using smartphones in China numbered 557 million. Students across all educational stages were the largest population, accounting for 23.8% of all Internet users. The Internet users aged between 20 and 29 accounted for 31.5%, the largest proportion of the total. The weekly average online duration of the Internet users in China reached 25.9 hours. However, according to the same Chinese survey, of all the various Internet functions offered by smartphones, it is instant messaging, search engines, online news and others, rather than online education, which are most used by the Internet users and absorbed into the fabric of their daily lives.

Smartphones have a high computing capability comparable to that of a personal computer. Their functions range from instant voice and text communication, to multimedia and Internet browsing, and all come at a more affordable price compared with notebooks and laptop computers. The ready availability of smartphones for students means that there is no need for the institution or the teacher to provide learners with special hardware in order to incorporate a technology-enhanced learning component into their teaching context (Stockwell, 2010). Jacobsen & Forste (2011) reported that portable devices have been increasingly used in the classroom, for example 62% of students reported the use of electronic media for non-academic purposes while in class, studying, or doing homework. Tindell & Bohlander (2012) estimated that 95% of college students bring their cell phones to class every day.

**Related work**

Wu, Wu, Chen, Kao, & Lin (2012) took a meta-analysis approach to comprehensively review the 164 studies, which were conducted from 2003 to 2010, about mobile learning. They found that most studies on mobile learning focus on effectiveness, followed by mobile-learning system design, and surveys and experiments which were used as the primary research methods.

The use of mobile devices in classrooms can have positive effects on classroom learning. For example, it can promote participation in class (Ashour, Alzghool, Iyadat, & Abu-Alruz, 2012; Munoz-Organero, Munoz-Merino, & Kloos, 2012; Samson, 2010) and increase students' motivation

Whether and how young students’ smartphones can be utilized for language learning has become an important and valuable research topic of technology-enhanced language learning in recent years. A great deal of attention has been devoted to mobile-assisted language learning (MALL), and the range of research is diverse. Kennedy and Leavy (2008) sent the learners short messages (SMS) about what they had learnt during class or details of upcoming television programs they wanted the learners to watch. Hsu, Wang, & Comac (2008) studied the pilot testing of a system that linked mobile phones to an online voice recording application and had 22 L2 English university students create web-based audioblogs for the submission and archiving of oral assignments. The instructor also used the audioblogs to communicate with the learners, evaluate their performance, and provide feedback. Each of these studies made us of the different features of mobile phones (e-mail, web browsers, SMS, video and audio production, etc.) and illustrates the broad potential of smartphones as learning tools.

Many studies are focused on the effect of mobile learning on students’ academic achievement. Houser, Thornton, Yokoi, & Yasuda (2001) sent six words of about 100 target words (definitions, multiple usage in context, story extracts) at pre-set intervals three times a day for rote memorization via SMS to 44 female university students in Japan per week for four weeks. Compared to studying the same words via PC and on paper, lessons delivered via SMS proved to be significantly more effective.

Kim (2011) investigated the effectiveness of using SMS in L2 English vocabulary learning. The study involved a total of 62 university students in three English classes. One class was a control group which received only class instruction; the second class received SMS with no interactivity; and the third received SMS with interactivity. Students who learned vocabulary via SMS outperformed the control group, and those who received SMS with interactivity learned significantly more words than those without it.

Lin & Chen (2012) reported the preliminary results of a study on the effect podcasts had on L2 English learning when the podcasts were sent to students’ smartphones via e-mail. Twenty-five college volunteers participated in the study which utilized publicly available podcasts targeting specific vocabulary items and grammar points sent to students twice a day for a month. A post-test
after the first two weeks confirmed large gains in listening ability, vocabulary learning and grammar knowledge.

In summary, the above reviewed literature on MALL mainly studied the effect of mobile learning by sending learning materials to students’ phones. However, few studies among the reviewed literature investigated smartphones’ instant feedback function when used by university students in classrooms and its effectiveness on their learning achievement. Therefore, the present study focuses on the usage of smartphones’ instant feedback functions for academic purposes during class and its effect on students’ learning performance in regular exams.

CSIEC system and learning activities design

CSIEC (Computer Simulation in Educational Communication) is an intelligent and personalized web-based system for teaching and learning English as a foreign language (Jia, 2009; Jia, Chen, Ding, Bai, Wang, Yang, et al., 2013). In previous studies (Jia, Chen, Ding, Bai, Wang, Yang, et al., 2013), students from four diverse high schools in China used the CSIEC system with multimedia desktop computers in their computer pools during a school term or a school year and achieved a more significant exam score improvement than the students from the control group who only learned with the traditional approach and were taught by the same teacher. After further development with responsive HTML 5 technology (Jia, 2014, p.236-266), the CSIEC system can be accessed by tablet computers or smartphones through a wireless network.

“New College English 3”, the English textbook used by many Chinese universities and published by Shanghai Foreign Language Teaching Press includes eight units. In each unit, a list of key words and expressions are provided for the students to memorize. In the CSIEC system, four types of vocabulary drill activities are designed for the targeted new words and expressions in each unit: a crossword game, spelling & matching the words’ pronunciation with their definition, gap filling and multiple choices in a real time quiz. We will introduce the activities in the following subsections.

The first activity is a crossword game. The words in the rows and columns of the crossword are randomly given by the server system and are vary from student to student. After filling in the rows and columns and clicking “check crossword”, the server will check the correctness of the answers and give a grade. Considering the smaller screens of smartphones, we limit the maximum rows and columns to ten words so that the students do not need to drag the screen repeatedly to view the whole crossword matrix.
The second activity is a quiz to assess the recall and recognition of new words and phrases in the unit via listening. This quiz consists of questions about the new words and phrases in one unit. For every question, the student listens to the pronunciation of a new word or phrase, fills in the blank with the correct spelling of the word, and selects the corresponding Chinese explanation and possible English meaning, which are transcribed from the word list in the textbook. For the first word or phrase in this quiz, which has both a Chinese explanation and an English meaning from the textbook, the student answers one multiple choice question about the Chinese explanation and one multiple choice question about the English explanation. For the second word or phrase, as there is just a Chinese explanation but no English meaning from the textbook, the student answers just one multiple choice question about the Chinese explanation.

Though the new words and phrases in a unit are specified, their order of appearance in the quiz is randomly defined by the server system so that the quizzes vary from student to student. Moreover, the order of the four explanation choices for a new word or phrase is also randomly defined by the server system.

Once the student has written all the answers to the questions in the quiz and submitted the answers, instant feedback about their grade for the quiz is displayed. Figure 1 is a screenshot of one quiz feedback result, showing that the student finished this quiz within 33 minutes and 51 seconds, and the quiz grade is 91.4%. The feedback on this grade is “Super star!” with five thumbs up. In the left upper corner, the correctness of every answer is labeled by color; light green for fully correct and orange for partially correct. For each question, the correct answers to both the gapfills and multiple choice questions are also presented.
In each unit, one crossword game and one word quiz on the required new words and phrases from the textbook were designed. A total of 8 crossword games and 8 word quizzes for the 727 new words and phrases were designed.

While the first and second activities aim to help students learning the new words and phrases by heart, the third and fourth activities aim for drilling them to use those words in sentences. The third requires students to write the missing word or word phrase in a given sentence. In the fourth activity students are asked to select one appropriate word or phrase from four choices to complete a meaningful sentence in a real time quiz. The former three activities can be accessed by the learners at any time and asynchronously. They can do them as many times as they wish. However, during the fourth activity they can only read the chosen question on their own smartphones once the teacher has sent the question via his or her computer or smartphone, and the students have to complete the task in a given time, for instance, 30 seconds. This is also the essence of the so-called real time quiz. After sending all the questions in a quiz, the teacher can review the students’ responses. For every question, both correct and incorrect answers are counted and displayed.

In summary, the four types of activities are implemented according to the learning theory of behaviorism and give instant and individual feedback corresponding to the students’ answers.

Methodology
Based on the review of related works, we can speculate that the in-class usage of smartphones by students directed by the teacher has positive effects on the students’ academic performance.

To evaluate this hypothesis, we designed a quasi-experiment with university students who are usually allowed to bring their smartphones and other mobile devices into the classroom. From October 2014 to December 2014, two classes, each consisting of 60 freshmen, of a technical university in Beijing, China participated in this research. They were taught by the same English teacher and learned the same content from the same English textbook *New College English 3* within the same time plan. As there was no local wireless network on campus, the students could only access the Internet through the third generation (3G) or the fourth generation (4G) networks of the phone carriers, i.e., the Internet service providers (ISP) such as China Telecom or China Mobile.

The students’ grades in the English entrance exam held at the beginning of this semester (September 2014) showed a very significant mean difference between the two classes. One mean was 69.61 and the other was 71.85, and the P value in t-test (2-tailed) was 0.000<0.01. The researchers decided that the students from the class with lower grades would be the test group. These students were invited to use the CSIEC system, while the students with higher grades were the control group. The purpose of this kind of research design is to assess the actual impact of the technology-enhanced learning or blended learning on students’ academic performance in reality, rather than in a deliberately created environment, just like in one of our previous studies (Jia, Xiang, Ding, Chen, Wang, Bai, et al., 2013).

In the first period of both classes, the teacher asked if the students could bring a smartphone to class, and if they could afford to browse the Internet through the phones’ Internet service provider. The answers from more than 90% of the students were positive. As freshmen, most students have new smartphones with the cheapest voice and data package provided by an ISP. Every student in the treatment class was then given a user ID and password to log in to the CSIEC system. During the weekly two hour class in the semester from September 29th, 2014 to December 29th, 2014, the teacher first implemented the traditional teaching plan. In the last 10 to 20 minutes of the class, the English teacher asked, but did not oblige, the students in the test class to participate in the CSIEC system: they used their own smartphones to connect to the Internet, logged in to the CSIEC server, and completed the crossword, word quiz and other activities. Certainly they could still use the system outside the classroom or in their free time. Figure 2 is a photo taken in the English classroom when the students were using their smartphones to do the exercises. The teacher could present the students’ quiz grades using the projector and the large curtain in the front of the classroom.
The students in the control class were asked to learn the new words and phrases by heart by traditional approaches. We designed a vocabulary test to assess the word recall and recognition skills of the students in addition to regular tests which the test and control group were required to complete in order to receive a semester grade for the course. Our vocabulary test consists of 50 questions which were selected from eight word quizzes for the eight units. In the first session of both classes, i.e., on September 29th 2014, the students were asked to complete the vocabulary test using their mobile devices. In the last session of the two classes, i.e., on December 29th 2014, the students were asked to sit the same test again. Thus, the first test is regarded as the vocabulary pre-test, and the second test is regarded as the vocabulary post-test.

Experiment Results

The means and participants of the pre- and post-tests of the test and control classes as well as the p value of the t-test to compare the mean differences, are shown in Table 1. In the pre-test, the grade mean of 40 participating test students is 80.96, while the mean of 46 participating control students is 80.95. The mean difference 0.01 is statistically very trivial (p=0.997>0.05). Thus, it can be said that the CSIEC test class and the control classes had equal vocabulary knowledge before the experiment. In the post-test, the grade mean of 39 participating test students is 92.27, while the mean of 41 participating control students is 87.58. The mean difference 4.69 is statistically significant (p=0.04<0.05). Because the vocabulary test content in the post-test was the same as that
of the pre-test, the longitudinal grade comparison of either the test group or the control group is meaningful. The average grade of the test students in vocabulary test increased (11.31) more significantly than that of the control students (6.63) throughout the experiment. The Cohen’s d based on sample size considering Hedge’s adjustment is calculated to compare the effect size of both classes (Cohen, 1988; Cohen, 1992; Hedges & Olkin, 1985). It is 0.261 for the test group, while 0.167 for the control group.

Table 1. Vocabulary test grades

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Mean difference</th>
<th>P value in T-test(2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>80.96</td>
<td>92.27</td>
<td>0.01</td>
</tr>
<tr>
<td>Participants</td>
<td>40</td>
<td>39</td>
<td>0.997</td>
</tr>
<tr>
<td>Standard</td>
<td>40.69</td>
<td>44.95</td>
<td>0.040*</td>
</tr>
<tr>
<td>deviation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>80.95</td>
<td>87.58</td>
<td>4.69</td>
</tr>
<tr>
<td>Participants</td>
<td>46</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>36.21</td>
<td>42.11</td>
<td></td>
</tr>
<tr>
<td>deviation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean difference</td>
<td>0.01</td>
<td>4.69</td>
<td></td>
</tr>
<tr>
<td>P value in T-test(2-tailed)</td>
<td>0.997</td>
<td>0.040*</td>
<td></td>
</tr>
</tbody>
</table>

*: significant at 0.05 level

It is worthwhile to mention the number of participants both in the pre-test and in the post-test. Because both groups were asked by the teacher to participate in the research, the student amount varied in two tests. After auditing the participating students, we found that 28 test students and 35 control students were involved in both tests. The means of those students in both tests and the p value in the t-test to compare the mean difference are listed in Table 2. The test students had an advantage over the control students, with 1.73 in the pre-test at a statistically insignificant level (p=0.636>0.05), and gaining a higher advantage over the control students with 5.86 in the post-test at a statistically significant level (p=0.021<0.05). As shown in the last column in Table 2, the test
group made greater progress (10.76) than the control group (6.64). The paired t-tests to compare the means in the pre-test and the post-test of both the test group and the control group reveal a significant difference (p=0.000<0.01 in the test group and p=0.019<0.05 for the control group). The Cohen’s d based on sample size considering Hedge’s adjustment is 0.914 for the test group, whereas it is 0.526 for the control group.

Table 2. Vocabulary test grades of students participating in both the pre-test and post-test

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Mean increase</th>
<th>Cohen’s d based on sample size with Hedge’s adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>82.53</td>
<td>93.29</td>
<td>10.76</td>
<td></td>
</tr>
<tr>
<td>Participants</td>
<td>28</td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>15.65</td>
<td>5.67</td>
<td></td>
<td>0.914</td>
</tr>
<tr>
<td>deviation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>80.80</td>
<td>87.44</td>
<td>6.64</td>
<td></td>
</tr>
<tr>
<td>Participants</td>
<td>35</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>13.23</td>
<td>12.01</td>
<td></td>
<td>0.526</td>
</tr>
<tr>
<td>deviation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean difference</td>
<td>1.73</td>
<td>5.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P value in t-test (2-tailed)</td>
<td>0.636</td>
<td>0.021*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*: significant at 0.05 level

To compare the academic performance of both classes throughout the experiment, we also collected the students’ grades in the regular exams before the experiment and in their final exam. The means and the results of the t-test to compare the means of the two classes are shown in Table 3. The entrance exam in September 2014 prior to the research was regarded as the pre-test, and the final exam at the beginning of January 2015, after the research, was regarded as the post-test. All test papers and exams were designed not by the teacher herself but by the English teaching unit of the university. In addition to the students in this research, all other students in the same grade at this university were also required to sit the regular exams.

Table 3. Regular English exam grades

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean increase</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment (N=60)</td>
<td>Control (N=60)</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Mean difference</td>
<td>-2.24</td>
<td>-1.18</td>
</tr>
<tr>
<td>P value in T-test(2-tailed)</td>
<td>0.000**</td>
<td>0.263</td>
</tr>
</tbody>
</table>

**: significant at 0.01 level**

In the pre-test, the grade mean of the test class was distant from the grade mean of the control class at a statistically significant level (p=0.000<0.01). In the post test at the beginning of January 2015, the mean distance from the test class to the control class was observed again but at not a significant level (p=0.263>0.05). Through the usage of the CSIEC system in and outside the classroom with mobile devices, the CSIEC test students decreased their grade distance to the control students from a statistically significant level to a statistically insignificant level.

**Discussion**

The analysis of exam data confirms the significant and positive effect of smartphone-usage in English teaching and learning in higher education. The effectiveness can be explained by the instant feedback feature supported by the smartphone and the web-based CSIEC instruction system. The system enabled the students to get familiar with pronunciation, spelling, meaning and usage of the new words and phrases by participating in the drilling activities supported by the smartphones in the classroom and in their free time. As vocabulary is the basis of many language skills including listening, speaking, reading and writing, the vocabulary improvement contributed to the students’ progress in comprehensive regular exams.

The control students also brought smartphones to class just as the treatment students did, but they were not allowed to access the drilling resources for all units. In the classroom, they possibly used their smartphones to browse internet news, chat with others, write emails, view videos, go online shopping or do other things, all of which was unrelated to the learning content. As smartphones, like other portable devices, can serve as a distraction when used in uncontrolled and non-directed contexts (Fried, 2008), and even lead to lower exam grades (Rosen, Carrier, & Cheever, 2013; Froese, Carpenter, Inman, Schooley, & Barnes, 2012; Lepp, Barkley, & Karpinski, 2014; Ravizza, Hambrick, & Fenn, 2014) and anxiety (Lepp, Barkley, & Karpinski, 2014), the control students made less academic progress than the CSIEC ones.
Rambe & Bere (2013) argued that one of the most complicated academic endeavors in transmission pedagogies is to generate democratic participation of all students and the public expression of silenced voices. The present research attempted to encourage all students to participate in the learning activities with the help of their own smartphones by writing or selecting the new words or phrases, submitting the answers, getting corresponding feedback instantly, and comparing their performances with each other. However, the participants’ grade in the post-test was lower than that in the pre-test, as observed both in the test and the control class. The reason may lie in decreasing learner motivation since the designed learning activities, required so much effort and time from the students that some of them gave up these activities.

**Conclusion**

We designed the vocabulary exercises to help the university students to master the required new words and phrases from the English textbook. Students could do the drill programs using their own smartphones via wireless network both outside the classroom and 10 to 20 minutes in the weekly English class for two months. The quasi-experiment in one semester resulted in the significant improvement in the grade mean of the test class compared to that of the control class in vocabulary test. The improvement was so much higher that the grade mean difference of the two classes increased from nearly null to a statistically significant level. In the regular exams, the mean distance between the treatment class and the control class (both with 60 students) decreased from a statistically significant level to an insignificant level. This quasi-experiment demonstrates the significant positive effect smartphones can have on students’ academic performance when used in regular university classes and suggests a useful framework to connect the intelligent features of smartphones with language learning activities, which is needed in mobile-assisted language learning (Ballance, 2012).

Although the conclusion based on the test scores seems promising, there are some limitations to this work. Despite the fact that most students had smartphones, the participants in the vocabulary pre-test and post-test accounted for about 70% of all students, and the students participating both in the pre- and post-tests accounted for only about 50% of all students. How to engage all the students in the learning-related use of smartphones in the classroom is still a valuable question deserving further exploration. Furthermore, the learning content and form of the web-based CSIEC instructional system itself should be improved to be adapted to smartphones.
Acknowledgement

We would like to thank the Education Committee of Capital Beijing, China for supporting the project “The English Instruction Supported by Tablet Computers” with the grant number AJA13145. This chapter is an intermediate achievement of this project. We also appreciate the voluntary students and their English teacher Professor Zhenzhen Chen who participated in this project.

Reference


2. Student-driven knowledge creation through digital storytelling

Marianna Vivitsou, Veera Kallunki, Hannele Niemi, Johanna Penttilä and Vilhelmiina Harju

University of Helsinki

Abstract

This chapter offers insights into digital storytelling as a pedagogical method that allows teachers’ practices and students’ learning to meet the needs and requirements of 21st century skills by making student-driven knowledge creation in school possible. Through this lens, the study views digital stories as student-generated artifacts that recount single or multiple events. In this way, the stories mediate knowledge creation within a context of multimodality where digital and traditional literacies blend together to spark the production of meaningful outcomes. The study builds on the global sharing pedagogy (GSP) theoretical model that places the focus of interest on learners. The primary objective of the model is to provide a conceptual frame of factors which are related to 21st century skills and interactions for improved student engagement in learning. Digital storytelling is a pedagogical method that triggers such student engagement. The study is based on student interviews and the analysis of the content of student-generated digital stories. The data was collected during the implementation of two experimental research projects. According to the results, stories can be divided into three main types depending on the underlying teaching approach. One type involves subject-based digital stories, the second centers upon interdisciplinary stories, and the third is about student-initiated stories. Also, the findings of the study indicate that the digital storytelling experience had an impact on subject-based content learning, the use of English as a medium of international communication and the establishment of networking and collaboration with peers both online and locally.

Keywords: digital storytelling, student-driven knowledge creation, types of digital stories

Introduction

In this chapter we discuss student engagement in and learning of 21st century skills with digital storytelling as a background pedagogical method for student knowledge creation. The study was conducted with students and teachers in schools in Finland, Greece, and California. It also offers insights into various types of digital stories, and how they can create links between digital technologies and active learning in the human and natural sciences. To achieve these ends, the
content of student-generated digital stories and data resulting from student interviews are discussed and analyzed.

The digital stories described in this chapter were produced as parts of two research projects. The first was the ‘Digital Story Telling in the Finnish Boundless Classroom’ research project (2012-2014), whose aim was to seek new ways to connect formal and informal learning environments and encourage students’ active learning and knowledge creation with videos. One of the goals was also to promote tools for sharing knowledge and to advance 21st century skills, especially problem solving and creativity. It involved students from diverse school environments in primary and secondary education in Finland, Greece and California. The second project was called ‘Video Inquiry Project: STEM Learning and Teaching with Mobile Video Inquiries and Communities’ (2013-2015). It was part of a big joint Finnish-American project that wanted to create innovative tools and provide research findings that support new pedagogical models that simultaneously foster learners’ and teachers’ interests in and joint attention to the power of science and mathematics in explaining phenomena ‘in the everyday world’. The students involved attended primary schools in Finland and California. Both projects also sought to investigate the added value of digital technology integration into classroom practices. In both projects, the students created short video stories collaboratively. Having designed, captured and edited the stories, the students shared their work with peers online.

The theoretical framework of this study builds on the global sharing pedagogy (GSP) model (Niemi and Multisilta, 2015; Niemi et al., 2014). In the GSP, the focus is placed on learners while the primary objective is to understand what factors interact for student engagement in learning. According to Niemi and Multisilta, the GSP model is based on socio-cultural theories. Learning is viewed as a result of dialogical interactions between people, substances, and artifacts (Pea, 2004; Cole & Cigagas, 2010; Säljö, 2012; Hakkarainen, Paavola, Kangas, & Seitamaa-Hakkarainen, 2013). The primary objective is to strengthen student engagement in learning and mediate students, as they become active learners and knowledge creators in changes they are already facing and will face increasingly in their future. However, engagement is not only viewed as an end. It is also a means for further learning. Vygotsky (1978) introduced the idea of tools, symbolic and social mediators, to the analysis of the learning process, and defined the role of mediators as being to select, change, amplify, and interpret objects for the learner (1978, 67).
The framework of the GSP sorts mediators into four categories (Figure 1): 1) Learner-driven knowledge and skills creation; 2) collaboration; 3) networking; and 4) digital media competencies and literacies.

The role of mediators is very interactive. They are interconnected and can act as both means and ends (Niemi & Multisilta, 2015). For example, according to Multisilta and Perttula (2013), when students learn using digital technologies, these technologies enrich their learning experiences and contribute to the continuum of learning. The mediators of the model can be summarized as follows (Niemi & Multisilta, 2015):

- **Learner-driven knowledge and skills creation** is a mediator that provides learners with symbolic tools for the development of active learning methods and metacognitive skills. This is a dynamic process in which learners, guided by reflection and metacognition, manage their thinking and learning resources. Learner-driven knowledge creation is an active learning process during which critical thinking, creativity, argumentation, “learning to learn” skills, and ethics and values related to the substance can be learned.
**Collaboration** is a social mediator that allows or requires students to work together (Hull et al., 2009; Pea & Lindgren, 2008; Rogoff, 1990; Wells 1999). It is related to learning and working in the global world in the future; students need competencies which go beyond the purely “cognitive”, such as social skills, cultural literacy and understanding, help-seeking, and help-giving strategies.

**Networking** is a social mediator that uses the synergy of other people’s expertise and also provides tools for intercultural learning (Starke-Meyerring, Duin, & Palvetzian, 2007; Starke-Meyerring & Wilson, 2008). Learning is a continuous process of dialogical interaction with other people and cultural artifacts. In distributed cognitions and interaction with different artifacts, people introduce remarkable value that enhances their learning and competencies. These processes are mutually constitutive. All learners are also contributors. Thus, networking means learning from others as well as sharing ideas and experiences.

**Digital media competencies and literacies** is primarily a mediator that enriches learning through new technology environments, but it can also consist of social and symbolic mediators in different kinds of digital environments (Säljö, 2012). In technological environments, learners are both content producers and consumers. As such, they need the skills to study and work in digital environments. Students must also learn to critically assess and validate the knowledge they find and create.

Within this framework technology is seen as a tool that can promote motivation and allows for student-generated scenarios and artifacts to occur. Based on this insight, we can add that such an approach enables learners to connect formal and informal settings and, thus, transcend boundaries by enriching the space of the learning experience and opening up pathways for student autonomy in learning. To this end, both aspects of engagement as fun and as commitment to hard work are necessary.

Taking these into consideration, in this study we seek responses to two main research questions:

1. What types of digital stories did students generate during the storytelling activities?
2. What learning outcomes emerge when students learn with digital storytelling?
In order to achieve the study aims, we will discuss and analyze student interviews and the content of student-generated digital stories.

**Student-Centeredness in Digital Storytelling**

Technological advancement has accelerated the way in which we live and learn in terms of the possibilities it generates to access information everywhere and to be constantly connected. The advent of digital technologies and social media networks in our daily lives is putting pressure on us to rethink the ways web-based environments and tools enhance knowledge creation. According to sociocultural theories (e.g., Vygotsky, 1978), knowledge creation takes place during social interaction and happens at the intersection of dialogical encounters among people, substances and artifacts. The pedagogical method, in which modern information technology, knowledge creation and narrative are mixed, can be referred to as 'digital storytelling' (Duveskog, Tedre, Sedano, & Sutinen, 2012; Lambert, 2013; McGee, 2015; Page & Thomas, 2011; Robin, 2008; Rossiter & Garcia, 2010). Digital storytelling pedagogy is based on learner-centered approaches that aim to enable student learning through the use of connective technologies, digital mobile devices and language, with the goal being the production of meaningful stories (McGee, 2015). A salient feature of this educational method is its pupil-centeredness; it aims to give pupils a chance to tell their own stories and create knowledge from their own starting points about the topic under discussion (Lambert, 2013; McGee, 2015; Robin, 2008; Rossiter & Garcia, 2010). The method highlights a do-it-yourself attitude, participatory practice, and constructive creative elements in creating the story. There is evidence which suggest that this method increases engagement in the topic, is collaborative, and encourages active participation as well as shared learning and creativity (Lambert, 2013; McGee, 2015; Niemi et al., 2014; Sadik, 2008; Shelby-Caffey, Úběda, & Jenkins, 2014; Sukovic, 2014; Woodhouse, 2008). It also blurs the roles of learner and instructor by positioning them both as learners.

Storytelling describes who did what and how and, as such, entails two main processes: the process of action and the process of characters (Ricoeur 1992, p. 146). Therefore, it takes a level of narrative structure to bring the two processes together to assemble a series of events. Traditionally, a story needs a beginning, middle and an end to be considered a story. However, nowadays more avant-garde views question the triple feature and allow for less fixed definitions. A story, then, can also be any recount of events that presents a minimal emplotment. Therefore, stories can recount a single event or an array of events. Given this, and taking into consideration that telling a story is not
attached to one mode of expression (e.g., oral or written speech only), we can say that the use of the term is rather metaphorical nowadays. Although ‘storytelling’ used to be associated with oral expression, it now refers to a variety of modes of fixation and inscription (e.g., writing, acting out a role, filming etc.). Following this, ‘digital storytelling’ is a 21st century metaphor that signifies the use of multiple modes and literacies in order to connect the viewpoints of storytellers by recounting series of events with digital and connective technologies. In pedagogy, digital storytelling brings together students’ viewpoints in relation to the objectives of the curriculum. Hence, Pedagogical digital storytelling enables student-generated knowledge creation.

**Breaking Classroom Boundaries with Digital Stories**

Digital stories can present different sets of events. Some focus on instances of the object of study and others present more complex plots. While the former act like zoom-in lenses of the classroom narrative, the latter build up networks of actions. In both cases the students can act as storytellers and as characters. The characters of the stories can be real or fictional.

Stories can have a close relationship with themes grounded in curricular requirements. In these cases, the teacher’s initiative is often primary. However, not all stories are based on teacher initiative to put forward a topic for student work. Some stories build on student initiative and aim to present a theme which projects, for example, instances of home life and culture or their hobbies. In this respect, digital storytelling relates to the formal content of learning both directly and indirectly and requires both aspects of engagement, as fun and as commitment to hard work, in order to produce meaningful outcomes (Niemi & Multisilta, 2015).

Meaningful outcomes are related to both the formal and informal aspects of learning. As such, they can be produced both at formal and informal settings of learning. Museums, libraries, laboratories and natural surroundings are examples of informal settings. By transferring activities into informal settings, schools become a kind of hub of learning within the community. In this way, schools exercise their capability to extend into the community where knowledge is deployed to serve authentic needs, solve problems and make people’s lives better (Leadbeater 2000, pp. 111-112). In addition, according to many studies, there is a consensus that learning sciences in out-of-school settings or informal learning environments may play a role in improving learning (Anderson, Lucas, & Ginns, 2003; Bell, Lewenstein, Shouse, & Feder, 2009; Braund & Reiss, 2006; Martin, 2004).
Considering the above, this study examines digital stories as student-generated artifacts which recount single or multiple events. In this way, the stories mediate knowledge creation within a context of multimodality where digital and traditional literacies blend together to spark the production of meaningful outcomes that students share with peers online. As a pedagogical method, it offers an opportunity to teachers to expand practices and meet the requirements of the networked era. In this way, teaching curricula are enriched and expanded as well.

The Context of the Study and Earlier Findings

This study draws data from storytelling activities that took place within the framework of the Boundless Classroom and VIP research projects. The projects were coordinated by the CICERO Learning Network, a research unit of the University of Helsinki. Both projects were international and connected teachers and students from Finland, Greece and California, U.S. During the project activity implementation, the students shared their digital stories with connected peers across countries and classrooms on a Web-based experimental connective platform (Mobile Video Experience, MoViE http://cicero-movie.edu.helsinki.fi/). Table 1 below presents the details of participating schools in the projects.

Table 1. Participants of the study by country and age

<table>
<thead>
<tr>
<th>Country</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>16</td>
<td>2</td>
<td>37</td>
<td>141</td>
<td>45</td>
<td>21</td>
<td>27</td>
<td>17</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>314</td>
</tr>
<tr>
<td>Greece</td>
<td>18</td>
<td>5</td>
<td>1</td>
<td>36</td>
<td>60</td>
<td>28</td>
<td>10</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>165</td>
</tr>
<tr>
<td>California</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>53</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>69</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>7</td>
<td>38</td>
<td>188</td>
<td>106</td>
<td>53</td>
<td>37</td>
<td>77</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>548</td>
</tr>
</tbody>
</table>

According to the findings of previous studies (Niemi et al. 2014, Niemi & Multisilta 2015), digital storytelling is a pedagogical method that opens up the opportunity for active, engaged and collaborative learning. More particularly, Niemi and Multisilta’s analysis (2015) indicates that digital storytelling has a strong effect on student engagement, combining both motivation and hard work. One strong predictor of engagement in the study was the Web-based environment (MoViE) where students uploaded and remixed own stories. The other predictor was collaborative work. The students worked together in groups to produce their videos. All the components (i.e., learner-driven knowledge creation, collaboration, networking and digital literacies) of the GSP model had a high
predictive effect on student learning outcomes when students self-assessed their own learning after the project.

In this study we examined the content of student-generated stories in order to further discuss digital storytelling as a pedagogical method.

**Results**

**Types of digital stories**

In this section we discuss the types of stories that emerged out of the analysis of student digital stories. This categorization seeks to offer insights that can expand teaching and learning according to the needs and requirements of 21st century pedagogies for student-driven knowledge artifacts. Furthermore, it aims to highlight connections with curricula themes and, in doing so, offer some practical ways to integrate digital and connective technologies into the classroom.

The focus is on the types of digital stories that students produced during the pedagogical interventions. The types of digital stories are reviewed from several dimensions. First, the stories are divided into three categories: the first two are according to the underlying teaching approach: (1) subject-based digital stories and (2) interdisciplinary digital stories. The third category (3) included student initiative stories that had an indirect connection to curricula-introducing themes and events were interesting and important to students. The topic and perspective focus of subject-based stories were mainly on one school subject, whereas interdisciplinary digital stories can cross the borders of single subjects. Following this initial categorization, the digital stories are reviewed from the perspective of narrative: on one end of this scale there are stories that describe student observations on instances of a phenomenon; on the other, the stories are longer and demonstrate a tighter narrative structure.

Below, Table 2 presents the types of stories that emerged from the analysis of content and mode of production in relation to subject-based or integrated teaching approaches. However, it should be noted that the categories are neither mutually exclusive nor compact.
Table 2. Types of digital stories with examples in this study.

As the table shows, stories could be focused only on a single event or on longer descriptions as a series of events. Students also created both subject specific and interdisciplinary stories. The latter often featured a more structured narrative by recounting multiple events. In their stories students used, for example, ‘real-life’ characters as a peer or as a narrator, whilst in others they used fictional characters to pull the narrative together and convey the message.

Subject-based digital stories

Instances of a phenomenon. These subject-specific stories present the students’ efforts to capture a particular aspect of a phenomenon, in this case a chemical or physical one, in order to study and obtain a deeper insight into it. The production of these stories varied from rather unedited video clips to more structured ones, yet the key attribute was that they consisted only of a single scene that had been captured at once. These clips were about tasks carried out during lessons or events observed on field trips. In a sense, they were captured ‘in the heat of the moment’ in order to document what the students considered relevant and interesting. The duration of the videos varied depending on the topic; some clips lasted only for a few seconds and others for several minutes. Unedited clips also included irrelevant material, such as transitions from phase to phase, which made the focus rather loose.

The possibility of filming one’s learning seemed to increase student motivation when science learning was transferred to off-school sites (e.g., field trips, a chemistry laboratory, science center
etc.). In the lab, students could focus on and observe experiments very attentively through video lenses. Selecting a phenomenon and trying to understand and explain the event, (e.g., a chemical reaction) to a potential video audience were important parts in students’ knowledge creation. In some cases, subject-based stories were recorded at home or during a holiday trip. When conditions permitted, stories were filmed in classroom settings.

**Multiple phenomena-based stories.** These include clearly distinguishable clips that together form the story. In this way, they build a tighter narrative than the aforementioned instance-based stories. Making a bouncy super ball is one example of a multiple phenomena-based story and proceeds through five phases: 1) measuring sodium silicate, 2) adding coloring substance, 3) measuring ethanol, 4) mixing the three substances to initiate polymerization, 5) rinsing and molding the formed super ball in water.

One of the most elaborate multiple phenomena-based digital stories about science was related to air. It was captured on a field trip to a science center. The story grouped different air-related exhibitions into four scenes. The first scene consisted of a short video clip of a scale model of the Earth. The second portrayed a student testing the effects of air pressure with a pump-like device, in which a weight is dropped inside a tube in order to achieve a causal effect in a tube placed next to it. Due to dropping the weight, a tennis ball flew up in the other tube. The third clip dealt with a hot air balloon that rose and fell. The final scene was captured during a live performance where a scientist demonstrated the space requirements of gases by inserting a straw into subliming dry ice.

This digital story combined different themes, which mainly enriched the curricular content taught at school. The storyteller also put significant effort in structuring his story from numerous different exhibitions at the science center and framing them with relevant scientific explanations in the form of annotations. Annotations are a speech-bubble-like type of subtitles that can be added during the editing process for further explanation or descriptions of the object of study. For example, the annotation “Air pressure gets the ball to rise up” was added to the tennis ball scene.

**Interdisciplinary digital stories**
In the following section we will discuss interdisciplinary stories. Most of these stories were multi-event stories. As a single event, a story could be a picture or snapshot of the single phenomenon, for example a video clip from a forest. In interdisciplinary stories the attention is placed on a series of actions. Therefore, the plot displays a more elaborate structure by, for example, introducing a conflict or reaching a climax and resolution. Interdisciplinary stories cross the borders of different subjects for production. For example, stories about myths were created during history and Greek language lessons. Overall, these stories build a tighter narrative and introduce fictional characters. The multi-event stories could be categorized using the following themes:

**Themes from the human sciences.** As discussed earlier, stories can build a more structured narrative by recounting multiple events in the characters’ lives. The following are examples of such multiple-event stories that use fictional characters, dramatization (e.g., body movements and gestures) and narration techniques to support storytelling. These stories are theme-based and draw upon ancient Greek mythology to provide alternative versions of myths. Their secondary aim is to enhance student understanding of a natural phenomenon such as season alternation during the year by drawing links with mythical explanations from ancient times.

In the story *Euro, the birth of Europe*, two narrators support action with scripts delivering the message to the international network of peers using English subtitles. Dramatization techniques are efforts to free the communication of meaning from language barriers. The storyline centered on three main characters: Zeus, Europe and the people. In another story, entitled the *Myth of Persephone*, oral narration pulled plot strings together, and the eight-year-old storytellers alternated text slides with action to support the narrative. This filmic practice not only mimics silent movie logic but also aims to overcome language barriers arising from the fact that the students have just been introduced to learning the English language.

**Combining complex themes.** Some digital stories presented variations of a more complex phenomenon, such as recycling. To produce the videos, students worked together to create a plot and convey the message through the interaction in the story. Unlike the myths, these stories introduced ‘real-life’ characters.

Perspectives can be traced in students’ choices of production mode and filming practices. In the recycling stories, different filmic practices were used. It was left to the students to decide what type of stories they would like to produce and what aspect of recycling they would like to explore in
their videos. All stories aimed to inform and give instructions about how to recycle and, in general, were dramatized and acted. In some of these videos, one character did not know how to recycle, and another told him or her how to do that. Alternatively, a character sought information on ways of recycling from the Internet. Some stories were more documentary-like, in which filmmakers showed how recycling can be done in an authentic place.

In contrast to the subject-based stories discussed above, interdisciplinary stories are produced at the end of a series of lessons. While in subject-based stories the students used annotations to offer explanations, the students added subtitles to the theme-based stories on recycling in the post-production phase. In both cases they did so in order to pass the message to international peers from Greece and California, as the stories were shared online. In addition, some stories were performed in English.

**Student-initiated stories from everyday life**

In the following examples, the students put forward their own ideas and filmed digital stories aiming to introduce themselves to peers and present instances of their lives and culture. Both Finnish and Greek students told stories about who they are, and what their day-to-day life is like during school or after school hours. These were deviations from the original teacher plan for curriculum-based digital storytelling. Therefore, they are student-driven in terms of themes and production mode. The products could be single- or multi-event stories, but in most cases they focused on a series of events.

**Telling the story of who we are.** Stories that deal with self-presentations are descriptive with videos that use a static camera and mainly long shots. Self-presentations can serve as pedagogical icebreakers and are produced within the school timetable. Overall, the filmic practice seeks to give a picture of the class as a whole. However, in the *A few things about us* story, filmic practice shifted the focus of presentation away from the long shot class view to groups of students presenting themselves. This was the English version of introductions that students published in order to address the international audience one month after posting the Greek version. This story not only shifted the focus of attention to the group level, but it also evidenced how the digital skills of the student had advanced as they were able to put together a series of clips to come up with a remixed version of the story.
The local museum is an example of a story produced as part of flexible zone activities. Flexible activities in Greek primary schools are part of the school timetable but, unlike subject-matter oriented teaching, are project-based and, thus, interdisciplinary in nature. As with the myths, thematic and filmic student choices allowed for a longer, more complex narrative to take shape. The museum contrasts the fictional character of the myths. However, the students’ effort to construct a plot to hold the narrative together is evident. Background music is used here to create a sense of reverence and respect for the past.

**Telling stories in after-school hours.** The Finnish 7th grade students told stories about their hobbies during their free time. In one of these videos a female student told a story about riding and taking care of her horse. The story, filmed at a horse farm, documents the process of grooming, taking care of the horse, a demonstration of riding equipment and offers some advice on how to keep the horse. Long shots alternate with close-ups. Tracking shots following the horse led the observer into the scene and add to the truthfulness of the story.

The message seems to be clear: this was a story of young people who cared about nature and non-human beings. In addition, as the students took care to make the sub-themes of the main topic explicit, this story belongs to the multiple- rather than the single-event type. Similarly, in a digital story about computing and playing computer games, the main character (a male student) presented the kind of computer he had and gave tips to beginner and experienced gamers. The video included both long shots of the student’s room and close-ups of the computer. Clearly, technology was the subject here. The camera follows the human character, and at some point close-ups reveal the internal part, the anatomy of the computer. At the end of the video, four male filmmakers applied the screenshot technique showing their faces to tell the audience who the video-makers are. In this way, faces replaced end titles.

**Learning Outcomes Emerging from Digital Stories**

In the following section we discuss learning outcomes in digital storytelling projects using the Global Sharing Pedagogy introduced as theoretical framework at the beginning of the chapter. The learning outcomes are discussed from the perspectives of Knowledge Creation, Collaboration, Networking and Digital Literacy.
Knowledge Creation

Student-driven knowledge creation demands students’ active inquiry and knowledge structuring into a meaningful whole.

Subject-matter content learning

Case: motion. Mechanics was the topic in one of the pedagogical interventions; specifically motion. The learning objectives focused mainly on the ability to identify and classify different types of motion such as linear, curvilinear, and constant, and also on a qualitative understanding of the concepts of velocity, acceleration, and force.

Based on the digital stories, students’ epistemic thinking about the phenomenon of motion changed from everyday-like to more scientific during the learning period. For instance, in their orientation videos students often equated motion to the physical activity of human beings. Thus, they filmed each other while doing different kinds of exercises (e.g., walking, jumping, doing cartwheels etc.). Eventually, the videos that only a few had captured from inanimate objects (e.g., a helicopter flying in the sky) ended up being important in helping the students to see motion from a broader perspective, implying an ability to observe motion everywhere in their surroundings as one of the students stated in the final interview:

‘I’d say that motion can be observed just about anywhere’.

This broader understanding also included definitions of different types of motion phenomena. For example, in their digital stories the students were able to define the motion of a rollercoaster ride as curvilinear, or of a bus leaving from a bus stop as an accelerating motion.

Case: air. During a visit to a science center where students were exploring the theme of air, one popular digital story topic was an exhibition of a hot air balloon. In the exhibition, the balloon was rising and falling depending on air temperature while the temperature was observable from a thermometer placed close to the landing spot of the balloon. While observing this process and listening to the guide explaining its causes and effects, students familiarized with the mechanisms of how a hot air balloon works and used this information in their stories to highlight the key points such as ‘air requires space’ and ‘warm air rises and expands’. In this sense, students also considered
their digital stories as image-based notes of their observations and found them useful in enhancing their memory.

**Networking needs language - Using English for cross-country networking**

Language learning seems to apply to every case examined in this study. The analysis of interviews and online content indicates that Greek and Finnish students develop their understanding of spoken and written English as lingua franca (ELF) (i.e., as a medium of communication, House, 2013) at two levels.

One concerns the comprehensibility of the digital story itself. To achieve this goal, the students add subtitles or annotations in the post-production phase. For example, when the Greek 6th graders tell the story, they add English subtitles to enable the international audience to grasp the idea of the story.

The Greek 3rd graders do the same to convey the meaning of the myth of Persephone. In this method, the young storytellers use ELF for authentic purposes in an authentic learning environment. Similarly, their Finnish peers use English in subtitles or script the scenarios and act it out in English together. A 13-year-old female student from Finland, who was asked to comment on the storytelling experience, reported:

‘I did learn some English words’

In any case, as the female Finnish storytellers admit, it was a far more stressful experience to ‘tell’ the story in English than to subtitle it. However, either choice required student attention and focus on the whole text and its individual parts as well as students’ fluency and accuracy.

Another level of involvement with English as a lingua franca concerns online interaction through comments. In order to share stories, the students communicated in English with international peers through the web-based networking platform. For example, learning chemical reactions required Finnish students to write short descriptions about the digital stories, add annotations and respond to the comments of Californian students. For many of these 11-12 year-olds, this was a new experience. Overall, students considered using ELF to be motivating for the study of chemistry.
They also felt encouraged to use English in order to interact with peers and were happy to convey their meanings on the pedagogical network.

As these 5th graders learning chemistry with digital stories state,

‘It was funnier [to learn], when you had to write... [in] a different language, and then you always learned something.’ (Student 1)

‘It was nice, like... to translate all those tiny experiments in English.’ (Student 2)

Students’ experiences demonstrate that digital storytelling generated the opportunity for a broader networking to occur. As students create stories in informal settings, it offers the chance to make a link between the school and the wider society (Leadbeater 2000). Furthermore, breaking classroom boundaries and connecting nationally and internationally allows schools to develop and sustain bonds at a macro level and, in this way, respond to the needs of the networked era for enhanced global communication.

Collaboration in creating stories

While online networking develops among international peers through comments, collaboration patterns emerge at the classroom level as group work (in pairs or small groups). During group work, students seek and give help, and negotiate the planning and the editing of stories together. At the same time, they build team skills. As this student points out,

“[The most significant thing when working was] collaboration. That you can talk with somebody about what we are going to do and that kind of stuff.” (Finnish 12-year-old student)

Collaboration is sometimes problematic, but, again, requires effort and hard work to achieve, as this Greek 3rd grader argues,
'I had similar problems ..., some students couldn’t stop talking and that did not really help with the filming.'

However, collaboration is seen as a way to learn from one another and a form of peer assessment. As a Greek 6th grader says,

‘First we rehearsed 5 or 6 times and checked for flaws, so that we could direct our focus. Then we shot the scenes and we made joint decisions if we thought that more changes were needed. An idea was put on the table and if we did not agree, then we did not use it. We voted for or against.’

Clearly, student collaboration for digital storytelling was mainly evident at classroom level. Yet, it seems that sharing stories and online interaction did have an impact on student learning, as it influenced both topic selection (i.e., from directly related to the curriculum to more student-initiated choices) and the mode of production (e.g., attention on dramatization techniques and subtitling to convey meaning to international audiences).

**Digital literacy**

According to GSP, learners are both content producers and consumers in technological environments. They need skills to study and work with new tools in order to connect them with learning.

In digital storytelling projects the students used different types of digital media. As a Finnish student comments,

‘I’m not very good with computers or uploading video clips, and I don’t have a clue how to add videos [to some platform]. I haven’t edited videos, but I learned it, at least with this software’.

Furthermore, it seems that the storytelling experience created the space for students to start thinking about the use of the Internet in alternative ways. In the same vein, a Finnish 6th grader remarks that,
Students’ stories varied from rather unedited video clips to more structured ones. Sometimes there was also irrelevant material and quite a loose structure. However, when tracing students’ prior versions and comparing them to the final products we could see improvements in digital skills; students had revisited their videos, evaluated them and remixed them into tighter narratives. A general trend was that interdisciplinary stories lasted longer and constructed a tighter narrative than subject-based stories. Students learned digital skills when aiming for more interesting presentations by editing and remixing and taking also their audience into account.

Students also learned to use different modes of digital communication. In some, students used dramatization, while in others, especially where they introduced themselves and aspects of everyday life to peers, they acted more spontaneously. Both subject-based and interdisciplinary stories, in addition to animated video, included images, drawings and other types of modalities (e.g., oral narration, background music, subtitles and special effects). There were, for instance, examples of stories where the students did recordings in successive phases and remixed these disparate scenes into a new story.

Conclusions

Overall, digital storytelling for student-driven knowledge creation produced subject-based, interdisciplinary and student-initiated stories in multimodal formats. These artifacts required both on-site and out-of-school settings to result in enriched and embodied learning experiences. Therefore, 21st century learning outcomes necessitated the development of multiliteracies and multimodalities as well as holistic and integrative approaches to teaching and learning.

Importantly, digital storytelling for crossing boundaries seemed to enable the blending of formal and informal aspects and the combination of curricular and extracurricular elements.
Many subject-based and interdisciplinary stories were filmed at in- and off-school sites during classroom time and they linked directly with the official curriculum of studies. Many stories were also produced in informal settings such as homes and hobby locations, and they still had an indirect link with the curriculum. In this way, students could take full advantage of the opportunity for learning with digital technologies and storytelling.

The students’ descriptions of their work with digital stories agree with Niemi and Multisilta’s (2015) finding that, while digital storytelling activities are motivating and fun, they also need commitment and hard work in order to achieve the learning objectives. Thus, learning with digital storytelling seems to be a dynamic and spiral, rather than linear, process.

In conclusion, the findings of our research indicated that breaking the boundaries of formal learning entails the consideration of all aspects of sharing pedagogies globally, namely the content of learning, the medium of communication (whether linguistic or technological), willingness for collaboration and the confluence of networking resources for more diverse and flexible communication. Digital storytelling in a Global Sharing Pedagogy framework, therefore, seemed to be capable of enriching the scope of formal learning experiences.

References


3. Beyond the Classroom: Future Music Education through Technology

Inkeri Ruokonen and Heikki Ruismäki, University of Helsinki

Abstract

This article presents Finnish music pedagogical ideas and case study research concerning new technological solutions and environments of learning in music. Three different case studies are introduced and reflected to promote new trends in Finnish music education and new technology. The first case study explores the International Minifiddlers and is connected with instrumental pedagogy and a distance-learning environment. The second and third case studies are related to the music didactic solutions of Finnish teacher education that use online learning environments. The second case study is connected with developing online pedagogy in Finnish teacher education. The aim of this case study was to explore the first experiences on students using internet-based instrumental learning in a blended-learning environment. The research data of a second case was collected through questionnaires (N=100) of Finnish student teachers during the semesters of 2014-2015. The aim of the third case study was to research and give examples of the playful learning and creative musical composing through group interviews with the students (N=16). In these questionnaires, they reflect on their experiences of producing creative ideas in music by using the Rockway and SongHi music learning environments. This article summarizes these three studies and discusses the possibilities of new technology in music education based on their results.

Introduction

The Finnish National Board of Education (FNBE) has urgently encouraged the creation of learning environments with technological innovations in developing Finnish music education. The Development Project of Music Education Environments 2008-2010 of (NFBE) has highlighted that education environments should support the use of technology with information and communication technology (ICT), to provide skills for learning, thinking, problem solving and social activity. The music education methods are expected to be useful in supporting / to be used and support students’ ICT skills (Kauppinen, 2010). The distance learning environment and online learning make it possible to contact people all over the world to share the pedagogical ideas of music learning in the field of instrument pedagogy.
The aim of this study is to learn how a distance learning environment operates according to participants in Finland and participating countries. The second case study is connected with developing online pedagogy in Finnish teacher education. The aim of this case study was to discover the first experiences of the students using internet-based instrumental learning in a blended learning environment. The research data was collected through questionnaires (N=100) and group interviews (N=16) with Finnish student teachers during a semester in 2014-2015. The aim of the third case study was to research and give examples of playful learning in music through group interviews with the students (N=16) wherein they reflect on their experiences of producing creative ideas and composing music by using the Rockway and SongHi web-based music learning environments. This article presents and reflects on the results published in previous studies concerning music education and new technology.

This chapter introduces three cases of how to teach music using the latest technology. For decades people have used informal ways to learn and study music and combined them with face-to-face learning whenever possible. Nowadays, social networking platforms and online communities form an integral part of most students’ everyday lives (Salavuo, 2008). The first case introduced instrumental pedagogy and early violin studies through a distance learning connection (International Minifiddlers, 2016). The two other cases were related teacher education courses at the Department of Teacher Education at the University of Helsinki. They described how The Rockway (2016) online learning environment expands online learning opportunities in music learning with (or in addition to) face-to-face learning. Participating student teachers were part of a very heterogeneous group in terms of their musical background studies and skills. The Rockway environment provided video courses at different levels for beginners or advanced students in several instruments, singing, improvisation, musical production and creativity (Rockway, 2016). The purpose of this article is to introduce and reflect on new ways to teach and learn music in learning environments that enrich face-to-face, teacher-led learning in music.

**Previous studies concerning distance and web-based learning in music**

Finland has been a pioneer in the field of distance education in music. The first pilot distance learning sessions between Finland and the USA were already conducted in 1997 by violinists and music pedagogues Maarit Rajamäki and Pinchas Zukerman (Juntunen, Ruismäki, & Ruokonen, 2011). Pinchas Zukerman, an internationally very well-known violin artist, began distance teaching first in the United States and later taught in Hong Kong, Israel, Canada and Finland. Maarit Rajamäki,
Artistic Director of Särestö Academy, organized the first intercontinental master class for violin students via videoconferencing in September 1997 together with the Helsinki Telephone Association. Pinchas Zukerman was pleased with the Finnish students’ level of playing the violin and wanted to continue co-operating. The partners in the United States were Master Vision International and the Manhattan School of Music in New York (Rajamäki 2007). Since 1997 the co-operation has continued with many multipoint master class sessions via videoconference. Later, Rajamäki organized the distance learning environment of International Minifiddlers (2015), which is a case study in this article. International Minifiddlers master classes are taught by Finnish-Hungarian Professor Géza Silvay using the Colourstrings method (2015). During the distance teaching sessions, violin teachers learn to use the Colourstrings method and children learn to play the violin by using this method.

In the beginning, video conference technology for distance learning in music was primarily developed for transmitting conferences with spoken instruction and sounds, and there was much experimentation and research to be done before the quality of violin sound could be transmitted with high enough quality. Since then, the technology has developed tremendously, but there is still a great challenge to improve the sound quality and timing. According to Rajamäki, the fast internet connections nowadays make the sound quality during videoconference sessions excellent; they are almost as good as listening to the music in the same room (Rajamäki, 2007). Rajamäki (2007) states that distance learning in music is not widely used in Finland partly because the methods are not introduced well enough in music teacher education or instrument pedagogy. To gain experience from many aspects, the students of pedagogy at Oulu University of Applied Sciences took part in the Vi R project as both teachers and students. The most important aim of Vi R Music is to integrate distance learning in the high school curriculum (Rajamäki, 2007). In Northern Finland the population is centralized and in many areas in the periphery, professional teachers of some instruments are almost impossible to reach. Because of long distances it takes much time and money to travel to places of study. Therefore, music schools have become interested in the potential of good quality distance learning via video conferencing from basic to high level instrument education for areas where it is geographically difficult to travel (Rantasuo, 2006; Vi R Music, 2010).

It is very easy to add music technology, audio, videos and scores to distance lessons of music. According to Salavuo (2006) the novelty of video conferencing inspires students and helps them concentrate. Distance learning may also encourage shyer students to play more confidently (Salavuo, 2006). In one study concerning distance learning for the guitar and master classes, Brändström et al. (2012) noticed the overall impression from the study was that teachers and students seemed to
consider the online teaching in the project to be a positive experience. The informants looked upon the distance-learning format as a fruitful complement to face-to-face teaching. Because of the time delay, the most difficult part of the online teaching was playing together, or marking the rhythm. The results suggested that videoconference teaching is more intensive than face-to-face teaching and requires both thorough planning and readiness to improvise during the lesson.

According to Kangasluoma (2010), the student's age and playing level should determine how often distance lessons need to be given. At the very beginning, it is best to concentrate on normal contact lessons, as it is vital to learn a good playing posture correctly from the beginning and face-to-face guidance is needed. When the student has played for several years and achieved a good knowledge of how to practise the violin, distance lessons could be the main method and the teacher might be involved in regulating and directing the practice. The information via videoconferencing is transmitted mainly verbally, which may not be effective enough to produce the change in performance needed to improve issues such as bowing technique, or the quality of sound. Haptic, kinaesthetic information is also needed in string instrument instruction. Distance learning connection can be used from the very beginning of learning how to play the violin but only if there is a violin teacher on both sides of the connection as it is with Minifiddlers distance education.

The Distance from instructors or institutions is not the only reason for students to avail themselves of distance learning opportunities. According to Koutsoupidou (2014), in many places the financial crisis of recent years has led to severe budget cuts for music education at public schools (Pergola & Ober, 2012). It has also diminished the ability of pupils to attend extracurricular music activities. These recent developments have advanced the need for online music learning opportunities, especially in remote communities (see e.g., Ruismäki, 2012).

Shiratori et al. (2006) consider that in many situations regarding music study, it is important to give and receive exact information on muscle movements and position. The use of video recording and body sensors in the way many dancers use them to produce computer animation, could be possible in mediating information in the distance learning process in the future. The animation could be viewed from any position, angle and speed (Shiratori et al., 2006). According to Ojala (2006), virtual, three-dimensional spaces are not yet available in education for economic and technological reasons (Ojala, 2006, p.113). According to Rajamäki (2007) distance teaching is a good method to increase equality between students in the city’s periphery or in even more remote locations around the world. In cities distance learning could be an extra method in addition to basic contact teaching.

Dreyfus (2004) has developed a five-stage model of learning from novice to expert. The first stage is a novice stage. The instruction process begins with the instructor decomposing the task environment into context-free features that the beginner can recognize without the desired skill. In
this stage the beginner is given rules for determining the actions on the basis of these features just like a computer following a program. During the advanced beginner stage, the novice gains experiences by copying real situations and begins to develop an understanding of the relevant context and meaningful additional aspects of the situation or domain. According to Dreyfus (2004), at this second stage learning can be carried out in a detached, analytic frame of mind as the student follows instructions and examples that have been provided. With growing experience, the learner is able to recognize the number of potentially relevant elements and procedures of the process. In this third stage the emotional involvement seems to play an essential role in switching over from the fear of mistakes to a commitment to practicing and learning better. By practicing through experiences, the competent performer becomes increasingly emotionally involved in a task. If the detached stance of novice and advanced beginner is replaced by involvement and the learner can also accept the anxiety of choice, he/she is set for further skill advancement. Dreyfus (2004) calls this fourth stage of learning ‘Proficiency’. In this stage both positive and negative emotional experiences will strengthen successful perspectives and inhibit unsuccessful ones, and the performer’s theory of the skill, as represented by rules and principles, will gradually be replaced by situational discriminations. In the last stage of learning, the learner becomes an expert. The expert not only sees what needs to be achieved but also decides how to do it. In unfamiliar processes, the expert is not solving problems nor calculating or thinking about the rules. The expert is just doing what normally would work. With vast experience and practice, the solutions normally do work (Dreyfus, 2004). This model can be applied both in studying instrument playing and in instrument pedagogy. In teacher education, digital learning environments can be used as a supportive further education throughout the teacher career.

Learning music in the Finnish context

Finnish schools use two strategies to enhance equity in schooling. The first issue is a school-based curriculum that gives teachers and administrators the power to define values, purpose and overall educational goals for their school. The second issue emphasises the professional development of teachers to help schools reach these goals (Niemi, 2012; Sahlberg, 2012). In the Finnish educational system teachers have high professional autonomy in schools. The national core curriculum frames the value basis and overall objectives of education but not an implementation of the teaching or methodological choices. Didactic freedom shows trust in the Finnish teacher training and teacher professionalism (Kansanen, 2004). The curriculum can also be considered a pedagogical frame, and it also contains pedagogical guidance. This does not conflict with the freedom of the teacher’s didactic views but provides the teacher with “pedagogical ingredients” for building and renovating the process
of teaching and learning (Sepp, 2014). Didactics deal with teaching, but learning is the central issue of contemporary constructivism — this does not replace or make the functions of the teacher meaningless. The main role of the teacher is still to take the responsibility and to help students, as it is wiser to practice several skills with the help of the teacher (Uusikylä & Atjonen, 2005).

As stipulated by the National Core Curriculum of Basic Education in Finland (FNBE), the distribution of music lessons in compulsory education is at least 1 hour per week from the 1st to the 7th grade, and after that learning music is optional (FNBE 2014). In the Finnish national curriculum, basic music education takes place in grades 1–7 and is taught in grades 1–6 mainly by class teachers. Music is only taught by specialist music teachers in grade 7 and in the optional courses offered in the following grades. Music as a subject in the FNBE includes several areas that could benefit from students’ independent learning and training. In fact, activities in singing, playing instruments, interpreting music through movement, producing compositions and listening by reflecting on music may all benefit from incoming teachers’ autonomous training in music. Amongst the student teachers there are many who truthfully manifest their awareness about their own knowledge and skills as future music teachers (Sepp, 2014).

In Finland, the responsibility of educating primary and secondary school teachers lies with universities. Kindergarten teachers are required to study to Bachelor level (180 ECTS1), and other teachers are required to reach Master’s level (BA 180 + MA 120 = 300 ECTS). Pedagogical studies (60 ECTS) are obligatory for all students. They also include teaching practice (Niemi, 2012).

In the Department of Teacher Education at the University of Helsinki, there are three compulsory ECTS-credit points for music education and three or four ECTS-credit points for voluntary phenomenon-based arts studies where music is combined with the other arts. The main focus of these studies is the didactics of music education for primary education in the Finnish basic education system (1st to 6th grades) and for early childhood music in kindergarten teacher education. Student teachers may have minor studies in music or arts education in their university degree. Some instrumental studies are included in all of these credit points. These instrumental studies are mostly free accompaniment with piano, but guitar, 5-string kantele, ukulele, recorder and Orff instruments are also used in music education. The new technology and teaching methods of educational instrumental pedagogy are also developed and researched by teachers (Oksanen, 2011, 2012; Immonen, Oksanen, Ruokonen & Ruismäki, 2014). This article presents and reflects on the results published in previous studies concerning music education and new technology.

---

1 ECTS refers to the European Credit Transfer System. 1 ECTS signifies approximately 28 hours of students’ work covering all study activities e.g. lessons and contact hours, workshops, independent work through reading and assignments, online studies, and practice hours.
First case study: sharing instrument pedagogical knowledge through distance connection

The first case introduces a young violinist learning project called International Minifiddlers. It is a distance learning project in violin studies developed by Finnish violin pedagogue Maarit Rajamäki. The Minifiddlers environment combines some of the latest teleconferencing technologies for online and real-time instruction. The sessions and research material are documented for online broadcasting. The aim of the study reported in this chapter was to discover how a distance-learning environment operates among young violin players in Finland and participating countries. Violin professor Géza Szilvay teaches groups in Finland and around the world from initial stages using the Colourstrings method (see, for example, Banney & Logan, 2008). The Colourstrings method is a child-centred way of learning music. The materials are colourful, stimulating and entice children to embark on musical adventures. This playful manner of learning music and instrumental playing increases children’s musical potential through fun and creativity, without pressure. The Colourstrings method is an extension of the Kodály philosophy: everything starts with natural singing which develops inner hearing. The role of play and imagination is valued in learning. This method entails high quality instrumental teaching during the early years when playfulness and colours can be effectively used to learn the connections between notation and violin strings (Colourstrings, 2016). The Finnish students are aged between 6 to 8 years old and attend the East Helsinki Music Institute. The learning program uses some of the latest teleconferencing technology for online and real-time instruction. The sessions are documented for online broadcasting. Through teleconferencing technology, children, violin teachers and parents can communicate online in a real-time setting. The project is carried out in cooperation with the University of Helsinki Music and Brain Research Group and the Department of Teacher Education. During the real-time online sessions, Professor Géza Szilvay acts as a mentor to a local violin teacher who is teaching a group of children. The Colourstrings method builds on the philosophy, ethnomusicology and pedagogy of the great Hungarian composer Zoltán Kodály. The role of Professor Géza Szilvay is essential to the distance learning program: he shares his knowledge of the Colourstrings method both with the violin teachers and the children and their parents. This cooperation creates a firm musical foundation for the child. From the very first moments of playing an instrument the child will master the elements on which all of the later musical and technical requirements are based. The children receive “a musical parcel” which encompasses technical skills, a trained ear for music, a deep understanding of it as well as an outstanding ability in the expression of music (Ruokonen, Juntunen & Ruismäki, 2013).
The Colourstrings method is well-known in many countries through distance learning connections. The Minifiddlers distance learning program was a part of Music4All, an innovative string program run over five years in primary schools in regional Australia. As a recommendation for future programs, they remarked that it is very important to provide adequate information to all stakeholders in the program (principals, school staff, parents and students), so everyone shares a common understanding of what is trying to be achieved and what is expected of their involvement. In addition, vital ongoing training and support should be provided for teaching staff to ensure program sustainability and to empower teachers to contribute to the development and future directions of the distance learning program (Murphy et al. 2011).

![International Minifiddlers](http://sarestoakatemia.org/minifiddlers/)

Figure 1. International Minifiddlers (http://sarestoakatemia.org/minifiddlers/)

There is much interaction between the participants during the distance learning situation. Furthermore, participants play a variety of roles during the distance learning process. Professor Szilvay emphasizes the importance of commitment in the distance learning process and contacts all the parents at the beginning of the process to explain the project to them and to underline the importance of their participation, support and practice. Parents listen to every online lesson and help their children to practice at home (Ruokonen, Juntunen & Ruismäki, 2013).

The role of local violin teacher is a particularly interesting one. She or he is a professional violin teacher who is learning the Colourstrings method in the distance learning situation while simultaneously teaching children in her/his distance learning group to play the violin, while also cooperating with the parents. Professor Szilvay acts as a mentor during the real-time session by advising the local teacher on using the Colourstrings method and encouraging the teacher to motivate the children by giving them positive feedback whenever it is possible and authentic. He also values active ‘learning by doing principles’ (Ruokonen, Juntunen & Ruismäki, 2013).
The real-time violin lesson begins with Finland saying “hello from the Finnish studio” to the local violin group, local violin teacher and parents in the partner country. The lesson proceeds like any violin lesson; interaction is very natural, students are familiar with the real-time online communication and they play their violin pieces one after the other. Professor Szilvay acts as a mentor-teacher while the local teacher presents and demonstrates the techniques and positions to each child in a very concrete way. The student group often plays pieces together or in duo or trio. The real-time online session mostly consists of violin playing, listening, learning and making beautiful music together. The most challenging issue for the future is to develop real-time techniques, so group playing between different countries becomes possible in real-time sessions. Currently, student groups from different countries play separately while the others listen. These kinds of international concert sessions have been organized. Students can also try to play at the same time in each country, but timing is not very exact. And this is precisely what needs to be developed.

The countries involved in the project include Australia, Denmark, the Faroe Islands, Finland, Germany, Greenland, Israel, Italy and South Korea. The number of participating countries is constantly increasing. In this case study, the data has been collected from three participating countries: Denmark, Finland and Germany.

As the teachers learn to use the Colourstrings method (2016), the early gifted violin players simultaneously learn to play the violin according to this method in a distance learning environment. Thus, talent, or evidence of being knowledgeably skilful, is considered present when individuals demonstrate their propensity for forming particular relations, frequently using multiple resources, such as the possibilities offered by the distance learning environment and constantly interacting as part of the socio-cultural world. Given this relational perspective on learning, instrumental playing in a distance learning environment or by using playback programs should be considered as a specific cultural milieu through which students develop their understanding of what constitutes a gifted and creative interaction that is defined and validated in terms of the day-to-day practices and rituals of music culture. According to Ruokonen (2005), parents, teachers, and home and school environments seem to be the most important environmental factors in developing gifted and creative potential in music. The media, ICT and other communication skills have also been incorporated into arts education developmental programs in all participative countries and into distance learning, especially in Finland. Educators need to select the daily rituals and activities carefully so that students creatively learn to use and develop their skills and participate in practices which are consistent with the environmental structures and processes outside of schools (Ruokonen, 2005).

The aim of the project was to determine how the distance learning environment operates according to parents’, teachers’ and some children’s experiences after their first academic year of playing the
violin. The qualitative research data was collected through video group interviews with the parents and teachers from Finland (Helsinki and Rovaniemi), Denmark and Germany and through interviews with children from Finland. Group interviews were conducted with the participating groups from Germany and Denmark by using distance connection and video conferencing technology. In Finland, the groups were interviewed in live, face-to-face sessions. A violin teacher participated with four parents of 5-6-year-old children from Germany. The Danish group consisted of two violin teachers and four parents of 6-7-year-old children; two children were present in the discussion. One father also developed distance learning in Denmark. One teacher from Rovaniemi participated along with five parents and four 6-8-year-old children. Seven parents and six 6-7-year-old children from Helsinki participated in the interview session. In total, Professor Géza Szilvay, four violin teachers, 20 parents and 12 5-8-year-old children from three different countries participated. The three interview sessions were held during May and June 2013 (Ruokonen, Juntunen & Ruismäki, 2013).

All group interviews were video recorded, and the data has been analyzed using qualitative content analyses. The interview sessions were also documented for private online broadcasting. The three group interviews lasted 2 hours 49 minutes altogether.

According to the interview results, a distance learning environment worked very well for learning new instrument pedagogical skills as well as in violin playing. High quality instrumental pedagogy can be offered and learned easily around the world thanks to a distance learning environment. The main aim of the Minifiddlers distance learning program is learning to play the violin specifically by using the Colourstrings method. In this distance-learning process, the participants play a myriad of roles, all of which are essential for children who learn to play the violin. First, the expert-novice system was made possible through the distance learning environment. This environmental “suns” (see Piirto, 2002) or catalysts (Gagné, 2010) support the growth of early giftedness. Children as novice violin players benefitted from professional expert teaching from Professor Szilvay and their own local violin teacher. They also learned to practice daily with the support of their parents. Local violin teachers were already professionals in teaching the violin as an instrument, and within this distance-learning process they learned to use the Colourstrings method in their teaching. They wanted to develop their instrumental pedagogical knowledge from teaching novices via the Colourstrings method to teaching experts. To reach this goal, they received professional support and mentoring from Professor Szilvay who developed the method. Parents learned about how important their role is in their child’s learning process. Their acceptance, support and encouragement are valuable and create a good atmosphere and open joyful interaction among all international groups (Ruokonen, Juntunen & Ruismäki, 2013).
The participants’ experiences of distance learning were only positive. It gave learners an opportunity to participate in an international group and learn to play using the Colourstrings method directly from the method’s creator, Professor Géza Szilvay (Ruokonen, Juntunen & Ruismäki, 2013). It gave teachers a chance to learn a new instrument pedagogical method in a very practical manner. It gave all participants an international environment in which to share experiences and new solutions concerning violin pedagogy and the support of musically gifted children. According to Juntunen, Ruismäki, & Ruokonen (2011), when developing effective learning methods and educating children, it is essential to focus on both formal and informal learning and all the environmental catalysts that may be connected to the intrinsic motivation and the development of giftedness and creativity. To cultivate inspiring educational environments to support the development of creativity and giftedness, teachers need to explore new techniques to observe the development that is already occurring. According to parents, children enjoy distance learning sessions, and it encourages them to practice at home. Local teachers say that they have learned a lot about the Colourstrings method and musical interaction in distance learning settings.

International Minifiddlers promotes children’s culture and children playing music worldwide. The project offers music pedagogues around the world an opportunity to explore the Finnish high-standard Colourstrings-based musical education in detail. Through International Minifiddlers, a worldwide network of talented music pedagogues and young musicians can/could be created. The results also highlight just how important a good atmosphere, open and supportive interaction and the commitment of the adult participants are to a young child’s musical development and learning. According to Kruse et al. (2013), distance lessons may be a compelling phenomenon to monitor in the sphere of music teaching and learning as music education, applied music and technology continue to intersect and inform common practice.

Second case study: developing blended learning in teacher education music didactic studies

The second case study is connected to new experiments using online learning as a part of music didactics in Finnish teacher training. In early online learning approaches, an instructional model was
used according to blended learning settings (Graham, 2006) in which online tools were merely considered a means of practice.

The aim of the research was to discover and describe how new web-based learning environments are used in music learning in teacher education. However, recently instructional models have been updated with more interactive didactic methods based on socio-constructivism and collaborative activities. These paradigms respect the learner’s experience and stimulate participants’ divergent thinking. Previous research has also highlighted some relevant aspects of the online learning process related to pedagogy, didactic methods, online environments, tools, organization and creativity. And it has subsequently offered suggestions for designing high quality learning environments (Biasutti, 2015; Biasutti & EL-Deghaidy, 2012; 2014).

According to Oksanen (2012), the use of digital learning material in piano studio teaching reduced teacher centeredness and supported the students in reaching their goals, while the environment itself encouraged self-instruction and self-evaluation, thereby allowing the students to manage as accompanists in different situations. It was essential to differentiate parts of the learning materials during the lessons, as they were attended by students of varying skill levels and students from different courses. Student feedback has been positive. The opportunities for self-monitoring in the learning process were appreciated, and recording the students’ playing in a portfolio makes it possible to skip the traditional exam situation. Utilizing the portfolios for later evaluation also encourages students to compete with themselves and achieve good results. With the help of the students’ recordings, the development of their accompaniment skills can be tracked and, thus, easily and clearly demonstrated (Oksanen, 2012). The main strategies in teaching keyboard harmony in a digital environment are modelling, training, support, verbal and comparative reflection, and finally, phasing out the role of the teacher and the digital learning material. According to the action research made in Helsinki University, Department of Teacher education the combination of digital learning material and self-assessment of their portfolios fosters students’ mental training and feelings of success (Immonen, Oksanen, Ruokonen & Ruismäki, 2014)

During the last academic year, co-operation with Finnish companies (Rockway, 2016 and SongHi, 2016) has been developed so that student teachers can study autonomously in internet-based learning environments. They can use either the Rockway or the SongHi system to study music in game-based learning environments. More and more new technologies and internet-based learning environments are being used for learning music and create new blended learning environments in music education for teachers. Due to the enormous flexibility of digital music formats and the huge amount of available information, people’s access to music has changed. For example, instructional videos mainly featured famous musicians, offer guidelines in terms of performance and practice (see Ruismäki, 2012; 2013).
The possibility to study in the Rockway environment was introduced as an option for kindergarten student teachers at Helsinki University. The use was not obligatory. Student teachers were allowed to use Rockway free of cost for an entire academic year. Based on 100 student teachers’ feedback we can summarize: the self-determined e-learning environment was used by 56% of the students, 41% wanted to learn how to play a new instrument, such as the piano, ukulele or guitar, and 15% browsed the pages and studied some lessons, but not regularly. Most of those who used the e-learning environment were familiar with music and wanted to learn new techniques or how to play a new instrument. However, 14% of student teachers had never studied music and started to learn how to play by using the university’s pianos.

Figure 2. Rockway learning environment (Rockway 2016)

This illustrates how including the blended learning system in music didactic studies ensures that students learn to use Internet-based learning environments and also develop their musical skills (Hietanen, Ruokonen et al., 2016). According student teachers’ feedback, the blended strategies enhanced their engagement and music learning through online activities. Montgomery et al. (2015) note that a significant challenge facing the adoption of any digital innovation at undergraduate level is in the design of a pedagogy approach that provides adequate support for student engagement. It is perhaps the most important factor in determining successful learning for university students, regardless of the university program or instructional format (Trowler & Trowler, 2010; Ruismäki et al., 2012). Thus, success is not based on a particular program, but rather on student engagement and support. Following this, we can agree with Greher (2011), who said that intersection of the arts with
technology can provide educators with a focus that is more in tune with students’ lived experiences, providing a relevant context for the making of meaning. Yet the technological advances of the last few decades have done little to alter the pedagogical practice of most music teachers. Teaching with technology requires a shift in pedagogical practice from learning about technology to creating with technology.

Third case study: blended learning in the creative music learning process

The third case study concerned the experiences of a smaller group of students (N=16) who were improvising and composing their own music during their optional music course (5 cp). The research questions referred to the various learning experiences trainee teachers gained in studying music, especially group composing in a blended learning environment and how a blended learning environment can help music students in a creative learning process. The blended learning method used the rotation method in which students learned from a schedule of independent online study sessions in the Rockway music e-learning environment alternated with face-to-face classroom time. This concept can also be referred to as a hybrid learning environment, but in this article the term blended learning is used (Graham, 2006). Traditional face-to-face instruction involves interaction between a teacher and students who are in the same location, whereas technology-mediated instruction uses informal or online ICT to facilitate the learning experience and interactions without the need for the parties to have face-to-face contact. During the course, qualitative data was collected via group interviews and students’ reflective writings about their learning experiences were a source of data after the course. The data was analyzed by qualitative theory-connected content analysis. The major advantage that blended learning offered was an increased opportunity for independent and constructive learning. The experiences of the rotation model were positive and the teacher’s role was considered to be an important and helpful mentor for more independent learning (Ruokonen & Ruismäki, 2016).

In a minor 5cp music course (N=16), the e-learning environment was blended into the course program; thus, the students used it much more intensively than the student kindergarten teachers’ group (N=100). These 16 students were guided on how to use a blended learning environment in their group composition project, and according to the results collected, the blended learning environment worked especially well in both the creative group planning process and the creative production. This shows that including the blended learning system in music didactics studies ensures that all students learn to use internet-based learning environments to develop their musical skills. These results
confirm the significance of both face-to-face education and autonomous learning periods as important elements in music education (Hietanen, Ruokonen et al., 2016; Ruokonen & Ruismäki, 2016).

An important take-home from these studies is that the potential of new technology and self-determined learning environments has to be taken into consideration when designing new music courses. Blended learning is needed to engage all students in using the e-learning environment and to raise awareness of new learning environments and other possibilities for informal learning. According to our observations and discussions with students, the integration of face-to-face and online learning enhanced the classroom experience and extended students’ music learning via the innovative use of internet information and online lessons.

Students’ written comments detailed how the blended strategies not only enhanced their engagement and music learning through online activities, but also improved overall effectiveness and efficiency by reducing lecture time and allowing more time for group work to generate creative ideas. The music e-learning environment is also improved by peer interactions. Formal learning situations are more likely to emphasize the content of learning (usually through required assignments or activities) but peer-learning discussions enabled the students to focus on how they learned, rather than what they were learning (Reid & Duke, 2015). These peer interactions are also a means by which students are able to become “expert students” (Reid et al., 2011, p. 122) who are able to “broaden their conception of their discipline and learning in order to include an essential and personal connection over and above their engagement with the discipline itself”.

These experiences encourage us as teacher trainers to use more blended learning settings in future course planning. It is important to note that “creativity lives in freedom”, and there is not only one ‘right’ design for a blended learning environment. According to this small case study, online learning in music still needs classroom instruction and face-to-face support to best achieve the set learning goals, so the best solution for future learning in music lies in blended learning designs.

**Conclusions**

The three case studies presented in this chapter introduced and reflected on various styles of music learning and new learning environments. According to these case studies, the multidimensional form of knowledge (formal musical knowledge, informal musical knowledge, impressionistic musical knowledge and supervisory musical knowledge) supports student teachers’ abilities in ‘learning to learn’ music. As Elliott (1995, 2005) argues, the most important goal of music education is to give students opportunities for various experiences in different musical practices - “musicing” - including
musical performance, composition, improvisation, and conducting, all of which consistently embrace musical listening. He also underlines the importance of “musicianship approach”.

In one study, Albert (2015) aptly said that teachers and researchers should determine whether there are online graduate music education programs that have included applied lessons as part of their curricula, via either online delivery or traditional in-person means, and how effective they have been. Recently, music educators who teach privately have started using Skype™ and other Voice-Over-Internet Protocol (VOIP) services to teach private music lessons (see Rockway, 2016). Researchers could gather more detailed information on implementation, delivery processes and perceived effectiveness. Additionally, a survey or questionnaire could be designed to investigate the effectiveness of music education hybrid courses as a means of fulfilling students’ need to build relationships with faculty and fellow students, and increase contact time and learning materials.

Distance learning, the online learning environment and blended learning can well be used in music education provided that the technological facilities are to a high standard (see Jorgensen, 2014). Through International Minifiddlers distance learning, the intercultural knowledge and expertise (e.g. Colourstrings) can easily be disseminated all over the world.

Blended learning is an important way to teach and learn and it requires resources, new methods of instruction, course content development and university pedagogical knowledge (see also, Ruthmann et al., 2012). When university teaching and learning become increasingly digital and blended, new assessments will be needed to evaluate students’ learning and course participation. Traditional face-to-face contact and content is always precious in music education, but blended learning combined with individual choices and enrichment can make it more dynamic and effective for a learner. Teachers need high-speed internet connections and highly developed programs to be able to access online content quickly and easily in order to keep the dynamics of the classroom instruction flowing (see Biasutti, 2015).

According to these three case studies, we can say that new technology and environments work especially well in professional hands when teachers are helping learners to learn. Web-based learning works best when it is supported by teachers and connected to the contact lessons. These three studies serve as a starting point for researching and developing new possibilities and ways to learn music. The development of new technology along with online and distance learning programs in music will be a significant challenge in the future of music education. Educators, researchers, and educational policy makers can promote giftedness and creativity more equitably with respect to the local and cultural context, experiences, strengths or interests that are essential to lead to highly talented performance.
Web-based teaching and learning change pedagogy in a way that they emphasize the teacher’s role as an instructor or a guide. According to Ruippo (2015), in web-based teaching, empathy needs to be emphasized and video-based methods are natural tools for web-based teaching. One observation is that teacher training brings out silent knowledge and produces innovations. In the future it is possible that web-based teaching and learning will be such a natural part of learning that the distinction between face-to-face teaching and web-based teaching will be made redundant. Cyberspace offers invaluable, lifelong music learning opportunities within a community to anyone with a computer and an Internet connection (Waldron, 2009). Think of the possibilities.

New digital learning environments enrich learning experiences and in the best case can motivate deeper informal music learning (e.g. Yousician, 2016). Additionally, formal music learning benefits from informal and digital environments. To conclude, this study recommends that in the future, the interaction between formal and informal learning and rotation cycles with the optimal balance of face-to-face lessons and web-based learning should be more deeply researched.

References


Retrieved from http://sarestoakatemia.org/minifiddlers/


4. Faculty of Medicine as a mobile learning community
Eeva Pyörälä, Teemu Masalin and Heikki Hervonen
University of Helsinki

Abstract
An action research project described in this chapter examined the use of iPads and the innovative ways of integrating them into learning and teaching in the Faculty of Medicine at the University of Helsinki. The iPad project brought together students and experts in ICT and medical education. Longitudinal data were collected on 1st year student cohorts (176 in 2013 and 172 in 2014) to explore how students and teachers integrated mobile devices into learning and teaching in the context of medical education. We addressed the following research questions: (1) What type of support students and teachers required to effectively use mobile devices in learning? (2) How did the students and teachers incorporate iPads into learning and teaching activities? (3) How did the teachers produce new type of learning materials for the digital learning environment and mobile devices? (4) How did the students develop collaborative learning by using mobile devices and social media? The data consisted of web-based questionnaires, focus group interviews and observations. The main findings of the iPad research project were that mobile learning enhanced learning at several levels: Hands-on support for both students and teachers was established and instructional strategies in integrating iPads into PBL tutorials and virtual microscopy were developed. The project produced versatile digital triggers (e.g. e-books, videos) and high quality medical applications. Students learned new types of collaborative learning and networking. The iPad project actively developed good practices, positive shared experiences and promising research results in order to create a vivid mobile learning community in the Faculty of Medicine.

Introduction
The use of digital technology has rapidly expanded not only in our everyday life but also in healthcare and in patients' self-care. It is crucial for students that modern technology is actively incorporated into undergraduate medical education in order to educate capable and empowered professionals for future working life. The first-year students at the Faculty of Medicine at the
University of Helsinki have received iPads for academic use since 2013. In an action research project, we studied the ways in which students and teachers have integrated mobile devices into their learning and teaching. Our iPad project aims to collaboratively develop innovative study use of mobile devices and to further stimulate the use of new technology in medical education contexts (Jwayyed, Stiffler, Wilber, Southern, Weigand et al. 2011; Davies, Rafique, Vincent, Fairclough, Pacher et al., 2012; Archibald, Macdonald, Plante, Hogue & Fiallos, 2014; Boruff & Storie, 2014; Lumsden, Byrne-Davis, Mooney & Sandars, 2015; Patel, Green, Shahzad & Larkins, 2015).

Today, Finnish doctors and dentists work in a highly digitalized healthcare environment. For instance, the electronic health record (EHR) stores versatile data on patient’s medical history, and patients are able to access their own electronic health records and prescriptions on the My Kanta website (http://www.kanta.fi/en/omakanta). As future doctors, our students are change agents who have the potential to foster the use of digital technology and mobile devices in order to collaborate and communicate more effectively with patients. Effective doctor-patient communication facilitates the exchange of information, includes patients in decision making and is linked to patient satisfaction, compliance with treatment and fewer malpractice suits (Brown, Steward, & Ryan, 2003; Fong & Longnecher, 2010; Koponen, Pyörälä & Isotalus, 2014). The Internet as well as thousands of medical websites provides patients with a massive volume of health-related information. Patients search for information about diseases, symptoms and treatment (Masters, 2015), and use applications on their mobile devices to improve and monitor their own health. They form online health communities on social media in which they share information and experiences to supplement their encounters with healthcare providers (Rupert, Moulrie, Read, Amoozegar, Bornkessel et al., 2014; House, Borycki & Kushniruk, 2014 Helve, Kattelus, Norhomaa & Saarni, 2015). Healthcare professionals are faced with the challenge of developing new types of collaboration and communication with modern patients who are surrounded by an overwhelming amount of information, in a way that supports the patients’ care and wellbeing. Healthcare professionals have piloted social media sites for distributing health information to complement face-to-face encounters (Helve, 2014).

Young people who enter universities have grown up with the Internet, digital technologies and mobile devices as integral parts of their lives (Prensky, 2001, 2005; Jones, Ramanau, Cross & Healing, 2010; Margaryan, Littlejohn & Vojt, 2011; Hakkarainen, Hietajärvi, Alho, Lonka & Salmela-Aro, 2015). This generation is fluent in learning to use new technologies. Young people seek information and contents with mobile devices and are extensive users of the social media for
networking and communication (Sandars & Morrison, 2007). These digitally empowered learners prefer all their learning materials in electronic format and consume videos, interactive multimedia triggers and quizzes for stimulating their learning (Prober & Khan, 2013).

**Developing a mobile community of medical learners**

The Faculty of Medicine and the Meilahti campus library have been pioneers in digital learning at the University of Helsinki. The campus library has consistently developed and supported the use of digital platforms. Internet library services started in 1989 and a digital library for course materials (DiKK) was established in 1998. The library has also been a pioneer in providing e-books and journals (Englund, 2011, 2013, 2016). A huge step forwards in creating a full-scale digital learning environment in the Meilahti campus took place in 2013 when the Faculty of Medicine started to provide the first year students with iPads for their personal study use. The iPad project was funded during the first two years by the Jane and Aatos Erkko Foundation.

We began the mobile learning project by choosing the type of mobile device the faculty would supply students with. For that decision, we studied different mobile devices regarding their compatibility with interactive digital medical and biomedical textbooks. And we also checked which device had the widest range of digital application at the time. Furthermore, we conducted a literature review on the type of mobile devices to choose and discovered few reports from 2013 on the use of tablet computers as an active study tool in medicine, especially during the first years of study. Those few studies suggested the use of iPads (George, Dumenco, Doyle & Dollase, 2013; George, Dumenco, Dollase, Taylor, Wald et al., 2013; Robinson & Burk 2013). In 2013, these three criteria; compatibility with interactive e-books, high-quality applications and research-based information on the study use, were in favor of providing students with iPads (Romanov et al., 2013).

When the first cohort of students with iPads entered the faculty, students, teachers, representatives of the library, experts in e-learning and medical education formed an action study group to support and stimulate the use of mobile devices in learning and teaching activities and to foster research-based development of mobile learning in the Faculty. The Scholarship of Teaching and Learning (SoTL) endeavor contributed to our research project (Boyer, 1990; Shulman, 1993; Hutchings & Shulman, 1999). We formed an action research group which aims to improve mobile student
learning by doing research, relating this knowledge to research literature and communicating the results in faculty development activities, seminars, conferences in a peer-reviewed format at both the national and international level (Trigwell, Martin, Benjamin & Prosser, 2000; Kreber 2002). By sharing experiences, testing new ideas and collaboratively constructing new understanding and practices, we created a vivid mobile learning community in the Faculty of Medicine.

The first two study years in the Faculty of Medicine revolve around problem-based learning (PBL). The key learning principles of PBL are that learning is a constructive, self-directed, collaborative and contextual process (Dolmans, De Grave, Wolfhagen & van der Vleuten, 2005). Collaborative learning here refers to learning in which students interact and work together to reach a common learning goal and to construct a new level of understanding (Dillenbourg, Baker, Balye & O’Malley 1996; Van der Linden, Erkens, Schmidt & Renshaw, 2000). In this mobile learning project, we soon observed that students’ collaborative learning extended beyond problem-based tutorials and other face-to-face learning and teaching activities. Our students interacted and collaborated both face-to-face and online as an integral part of their learning. They were skilful in using new technology to engage in multiple conversations simultaneously (Stephens & Pantoja, 2016), and we wanted to understand students’ online collaboration practices and the ways in which such practices supported their learning.

Mobile learning is a phenomenon that constantly changes and evolves. It is affected by both the rapid technological advance and digitalization of society and learning itself, not only at the university but throughout the educational system as a whole. This exploratory research seeks to establish connections between mobile technology and learning activities in medical education (Cook, Bordage & Schmidt, 2008). The purpose of this article is to synthesize the research-based development process in which the iPad project collaboratively generated ways of integrating mobile devices into learning and teaching. We will address the following research questions:

- What type of support did students and teachers require in order to effectively using mobile devices in learning?
- How did the students and teachers incorporate iPads into learning and teaching activities?
- How did the teachers respond to the need to produce new types of learning materials fit for the digital learning environment and mobile devices?
Data and methods

The context of this study was the Faculty of Medicine at the University of Helsinki in Finland. Finnish degree programs in medicine and dentistry reward the titles of Licentiate of Medicine and Licentiate of Dentistry respectively. At the University of Helsinki, the first two years of study focused on biomedical studies and were the same for medical and dental students. The studies during these years were organized according to the seven-step method of problem-based learning (PBL), a student-centered, self-directed and collaborative learning approach, where the learning process is typically organized around small-group tutorial sessions (Norman & Schmidt, 1992; Dolmans et al., 2005; Dolmans & Schmidt, 2006). The learning process was divided into opening and reporting sessions and independent study between them (Schmidt 1983, 1993). In the third year of study, students continued their clinical studies separately in medical and dental units. There the programs included lectures, small-group teaching, skills lab exercises, bed-side/chair-side teaching and hands on clinical teaching and learning.

The target groups of this study were the two cohorts of medical and dental students who started their studies in 2013 and 2014 and were provided with iPads. All students in these cohorts were participants in the study. There was no control group in this study. In 2013, 124 medical and 52 dental students were admitted, and in 2014, 122 medical students and 50 dental students were admitted to the Faculty of Medicine after passing a demanding entrance examination. In 2013, just 8% of medicine applicants and 14% of those hoping to study dentistry were admitted. In 2014 the corresponding numbers were 8% and 13%. We examined the use of iPads in the learning and teaching of these 340 students and their teachers throughout their academic years from 2013 onwards.

An action research project was started in 2013 to examine the academic use of iPads and the innovative ways of integrating them into learning and teaching. Longitudinal data were collected on the student cohorts who started in 2013 and 2014. The data consisted of web-based questionnaires, focus group interviews and observations. The students were sent a web-based questionnaire
consisting of quantitative and qualitative questions on students' academic use of mobile devices, the challenges they faced, their need for support and the best ways to provide it, the applications they used when studying, the use of social media in their studies, and approaches to learning and self-efficacy beliefs. The response rates were high (from 74% to 86% for the 2013 cohort and from 85% to 87% for the 2014 cohort). Study data were also collected in focus group interviews and observations in learning activities such as in PBL tutorials and virtual microscopy. The informed consent of the participants was requested in the questionnaires and interviews.

Action research offered a model for this educational development project. Action research is participatory and collaborative. It is designed and carried out in partnership between the researchers and the participants to improve the educational practice (McNiff & Whitehead, 2011; Whitehead, 2009). Action research is an iterative process in which researchers and practitioners act together in a real-life context, identify problems, seek solutions and positive change, generate new understanding and practice-based theory of teaching and learning, and disseminate the results in the educational setting. The research project proceeded in developmental cycles. It started by recognizing problems and seeking solutions. The project advanced by collecting versatile data from the project participants, analyzing that data and bringing the new and improved knowledge and practice back to the educational setting where the elaborated activities are evaluated and further improved.

**Results**

The early student surveys and questionnaires in 2013 showed different profiles regarding the use of mobile devices, and in particular, in the academic use of mobile devices. 81% of students had a smartphone, 77% a laptop computer but only 21% of the first student cohort had a tablet computer in their personal possession. Students reported using mobile devices, in particular smartphones, for their everyday online information seeking, and for communicating with their peers on social media. Hardly any of the students had previously used any type of mobile device for academic purposes, even though 66% of the first study cohort had previously studied in another academic field. In open-ended questions students asked for support in the academic use of mobile devices.

The results of the study mirror the real-life development in the context of medical education. In the beginning of the action project, we focused on students’ acute problems and technical aspects of
mobile learning, such as the online coverage of the Internet for 170 students and technical problems. We collected a vast array of materials on the use of interactive e-books and the ways students preferred to take notes with the tablet computer. We sought solutions and disseminated the results to students and teachers. We soon moved on to integrating iPads into learning and teaching activities, such as problem-based tutorials, and we also turned our attention to seeking and producing fit-for-purpose digital learning materials and triggers. We observed that students had independently developed a new type of multilayered collaboration and communication as part of their learning processes. An important part of the research project was to share and disseminate the research results with all members of the academic community at faculty events and seminars.

The action research project advanced in the following developmental cycles (Figure 1). First, we developed hands-on support for both students and teachers and identified fit-for-purpose study applications. Secondly, we enhanced the integration of iPads into active instructional strategies such as PBL tutorials and virtual microscopy. Thirdly, we supported teachers in producing versatile digital triggers (e.g. e-books, videos) and identifying stimulating medical applications. Finally, we observed that students formed self-directed, multilayered groups both face-to-face and on social media to study collaboratively. In the following subchapters, we summarize what we could learn in the longitudinal action research.

**Figure 1. Cycles of action research based educational development**

**Versatile support and study applications**

To successfully implement the iPads into medical education, it was crucial to provide both students and teachers with comprehensive support. Support for teachers started in the spring of 2013, half a year before the students received their devices. Teachers were therefore given time to familiarize
themselves with the device and explore the applications that were installed in it in order to select the fit for purpose applications for the forthcoming study years. Teachers were given active support and training in the use of iPads with a focus on both the technological and educational aspects of the device. In the spring of 2013, they attended six training sessions and thereafter several hands-on training sessions and workshops were organized (Silenti & Masalin, 2014). To further lower the threshold for participating in training, so called pop-up trainings were introduced at the beginning of 2014 to make training sessions informal and flexible. Ever since, pop-up trainings have formed the basis for iPad support and training. They have been supplemented by local hands-on workshops organized throughout the campus.

The majority of the first cohort of students was used to smartphones, but only 21% of students had used a tablet computer at the beginning of their studies. To support the 176 incoming students from September 2013, an online self-study guide was created. Later on, it was extended to include instructional videos. As a part of a mandatory ICT course, all students attended an introductory lecture and a question time of iPad academic use. Students were offered further training in different formats, in popup training, in e-mail and in the Social media (e.g. Facebook, iMessages and Whatsapp Messenger).

The experiences of the first iPad student cohort were analyzed using web-based questionnaires and focus-group interviews, and further support for students was developed accordingly. The iPad study group discovered that there were substantial differences in the time span that was needed for students to adopt iPads in their study habits. Some students reported being competent in the academic use of the iPads without any delay, and some students took as long as eight weeks to learn to use iPads in their studies (Hervonen & Pyörälä, 2014, Masalin, Pyörälä, Romanov & Hervonen, 2015). This information prompted us to improve the iPad support for the next cohort.

The second student cohort in 2014 received their iPads a week before their first courses started, and they were offered versatile and tailored support. Thus, students were able to practice using their new mobile devices in the introductory course before the biomedical courses started. A students’ self-assessment survey was incorporated into the beginning and the end of the mandatory ICT course, and the course focused on the essential study-related mobile learning skills, such as taking
notes, annotating study materials, archiving notes and study materials as well as sharing documents (Masalin et al., 2015). According to students’ self-assessment, these skills improved throughout the course. The digital iPad guide and video library further supported students’ mobile learning skills. Students’ needs for training and support varied and, therefore, versatile training and question and answer sessions needed to be tailored for those who needed support. A few students reported no need for training, but most students needed some form of support, and those who needed support most wished that support would be delivered automatically.

“We were given sufficient training. All that involves the basic use (of iPad) was so thoroughly dealt with that thereafter we had no big gaps in the use of iPads.” (1st year medical student of the second cohort).

“My own generation is very handy with technical gadgets, so there was no point in organizing mandatory training on how to use the iPads. It’s good that you get advice, but it could be voluntary” (1st year medical student of the second cohort).

An important student innovation in the first study cohort was to pilot an iPad peer-tutor project (Silventoinen & Heinonen, 2013). Three second year students offered peer-to-peer support, produced iPad guides and sent the first year students e-mails with tips on using the iPads for academic purposes. This improved and intensified support had very positive results. The second cohort of students got to grips with the academic use of iPads in a considerably shorter period of time than the first cohort, and nearly all students reported a good or very good command of the academic use of iPads at the beginning of their studies (Heinonen, 2014). Even though the iPad peer tutoring project had very positive feedback from students, due to a shortage of resources, we had to merge the iPad peer tutoring and their materials into regular peer tutoring in the fall of 2015.

“The iPad tutors answered the questions very skilfully and patiently and, together with the written manual provided by the faculty, were the most important support in getting started with the iPad (I had never used an Apple product before). The tutors were also good at spontaneously giving valuable tips” (1st year medical student of the second cohort).
“The e-mail tips from the iPad tutors were the best [support for us]. I saved them and even re-read them. Also the meetings with them were good, if you needed to ask for something” (1st year medical student from the second cohort).

A new type of support, the so-called ‘iPad walk-in sessions’, was invented in the fall of 2015. The idea was to offer an option for students and teachers to walk in with their devices and ask for help. The goal was to provide support particularly for those who have difficulties getting started with their studies and using the new technology. The space used for the walk-ins was casual and the concept of walk-in sessions proved to be successful as a low-threshold support for both students and teachers.

Committed and versatile support and training in academic iPad use, peer-support and events on mobile learning were crucial for incorporating iPads into learning and teaching activities. Students value both low threshold support by IT experts and their peers. Support transcended boundaries between teachers and students: when necessary, students from the iPad cohorts offered teachers help in applying new technology in teaching activities.

**Integrating iPads into PBL tutorials and virtual microscopy**

During the first semester of the first student cohort in 2013, both students and teachers adopted tablet computers as an essential part of small-group learning in their biomedical studies. We quickly observed a dramatic change in problem-based tutorials (Masalin, Viranta-Kovanen & Hervonen, 2014; Sundvik, Masalin & Hervonen, 2014). Prior to the project, the tables in tutorials would be full of books, papers, printed study materials, handouts, heavy textbooks, notebooks and post it notes.

Students with iPads rapidly moved towards a paperless era (Hervonen, Englund, Masalin, Selänne & Viranta-Kovanen, 2014). All study materials, textbooks and printed course materials were provided in digital format. At first, the iPad cohort also used papers and post-it notes in problem-based tutorials. Students suggested trying a cloud-based collaborative whiteboard application (e.g. Baiboard) which enabled the tutorial group to create, elaborate, construct and save a shared document of each tutorial group work in a digital format. The students from the first study cohort described this in an interview in the following way:
Interviewee 3: And there (in PBL) we have this Baiboard and then we sort of throw them there....

Interviewee 2: Yeah, that’s practical.

Interviewee 3: Yeah, it’s really practical, that you can sort of, all can write and the secretary moves them (on the screen)...

Interviewer 1: Yeah.

Interviewee 3: And then forms a whole out of it, and adds pictures.

Interviewee 4: Yeah, and then you just take a Screenshot and that’s it, the whole thing is saved.

The learning spaces used for PBL tutorials were equipped with appropriate technical devices, high capacity wireless networks and projectors to support mobile learning. Tablet computers substituted all printed materials, textbooks, course materials - including PBL cases - papers for note-taking and post-it notes (Image 1). All learning materials were loaded in the digital learning environment, and the tutorial proceeded with a digital application. Students were glad to not have to carry heavy textbooks. Students of the first cohort described the benefit of having digital learning materials on their mobile devices in the following ways:

“You have nearly all the study materials for all the courses with you all the time” (1st year dental student from the first study cohort).

“You don’t have to carry a book with you, and you can use the time you travel and other types of spare time for studying” (1st year medical student from the first study cohort).

“You have lecture materials on the iPad, I hate printing for nothing” (1st year medical student from the first study cohort)
Having access to information anywhere and anytime had an impact on student learning and their participation in all learning encounters (Mauno, 2016). Students actively sought out information on the Internet, and instantly shared it online with their peers. Searching for information and sharing it with their peers became an essential part of small and large group learning, and students asked teachers more challenging and surprising questions.

Our promising experiences in developing teaching methods encouraged us to move away from traditional small-group learning arrangements and use a mobile-device-based virtual microscopy. The crowded computer classroom was closed, and learning spread throughout the campus and beyond. This gave an impetus to organize microscopy in histology in an innovative way. Originally, students had learned to study histology samples individually with traditional microscopes in laboratories, consulting a teacher when necessary. The next step was to use a computer-based virtual microscopy in an ICT classroom, and to study the samples in pairs. The course design was further developed to benefit mobile devices (Airaksinen, Hölttä-Vuori, Pyörälä & Hervonen, 2015). A group of thirty students, who were further divided into small groups of five, collaboratively studied virtual microscope images with iPads in a flat-floor classroom. Teachers observed that students immediately engaged in intensive group work, studied the specimens together while sharing and discussing their observations (Image 2). Virtual iPad-microscopy in small groups stimulated more vivid discussion and collaboration than ordinary microscopy or working in pairs in
an ICT classroom. As an added bonus, iPad-microscopy was no longer bound to any special type of learning space, such as a laboratory or an ICT classroom.

![Image 2. Virtual microscopy with iPads.](image)

**Digital triggers and medical applications**

Adopting an efficient way of taking notes with the iPads was the most important study skill related to the tablet computers. 33% of the students in the first cohort named it as the most important iPad related study skill after the first academic year. To study efficiently, students wanted to have learning materials in a digital format before the in-class learning and load them onto their devices. The easiest way to produce digital learning materials was to save and upload handouts in a PDF with one slide per page in an online learning environment (e.g. Moodle). During the lectures students took notes by directly annotating the digital study materials using a study application (e.g. Notability). They also included websites, pictures, mind maps and photos in their notes and shared them with their peers online using AirDrop or cloud services (e.g. Dropbox, Google drive), as described in the following extract.

“*You take notes with (notability), you write faster, and are able to combine pictures from inkling books and other learning materials from lectures*” (1st year medical student of the first study cohort)
Students with mobile devices challenged teachers to produce new types of digital learning materials. They encouraged the faculty to start using a digital course schedule and teachers to produce video clips and online quizzes. They also encouraged the faculty to use online tools for polls, voting and chats during lectures, to develop online examinations and to identify and recommend high-quality medical applications to students (Mauno 2016; Silventoinen & Heinonen; 2013, Heinonen, 2014; Tamminen, 2015; Joutsenvirta, 2013, 2016). Students recognized the new options mobile learning offered in terms of learning and teaching activities and suggested ways to adopt them in practice.

“Try voting during your lectures” (3rd year medical student of the first study cohort).

“In lectures all students have the device and are online, so (teachers) could be more interactive and ask for example some multiple-choice questions about the issue at hand” (3rd year medical student from the first study cohort).

“Examinations could be digital and everyone would take them with their own iPads or some other technology. Printed examination could be an alternative” (3rd year medical student from the first study cohort).

For the teachers, it was a major challenge to produce entirely new learning materials. However, there were programs and applications with which teachers could easily transform their existing learning materials into digital format and distribute these materials to students. For the iPad, there was a Mac-application called iBooks Author which made it relatively easy to create elegant digital books with interactive triggers for learning. These books could also be saved as PDF files and opened with any mobile device. In our research data, students gave very positive feedback on this type of learning material, and many students named e-books created by one of our anatomy teachers as the best learning material they had.

There were plenty of innovative medical applications which both students and teachers could use as a part of learning and teaching activities. Nearly all 1st year students with iPads purchased a 3D
anatomy application, which provided an entirely new perspective on studying human anatomy (Lewis, Burnett, Tunstall & Abrahams, 2014). This application allows students to rotate the body in any direction, observe the body as a whole or by organ systems, take structures away imitating dissection, isolate individual structures and observe them separately, to name just a few functions. It supports self-directed learning by providing tests and quizzes on anatomy (Hölttä-Vuori, 2015). The wide use of the anatomy application reflected the power of new types of learning materials and applications which invigorated students’ self-directed learning of anatomy, a fundamental discipline in both medicine and dentistry (Viranta-Kovanen, Laakkonen, Hervonen & Masalin, 2014).

Students and teachers learned to apply digital learning materials on the Internet in the first two academic years focusing on biomedicine. The beginning of the clinical study years was a watershed moment in the use of mobile devices. When the first cohort of students started clinical studies in their third academic year, the learning culture of students and that of clinical teachers collided. At the beginning, students of the first cohort were somewhat frustrated since few teachers adopted mobile devices in their study modules. Students suggested ways of easily implementing mobile learning in the existing modules. Some students wanted us to explore entirely new types of possibilities of online learning and to follow the example of massive open online courses.

“Clinical teachers could use iPads for voting, for drawing tasks embedded in the lecture materials and so forth. Sometimes it would be good if teachers remembered that we have the mobile devices and won’t print materials in vain” (3rd year dental student from the first study cohort)

“More dental applications. Videos online, now the videos can only be seen in the clinical skills lab” (3rd year dental student from the first study cohort).

“In lectures all students have the device and are online, so (teachers) could be more interactive and ask for example some multiple-choice questions about the issue at hand” (3rd year medical student from the first study cohort).
“Teachers could create new types of learning materials based on what the Internet enables instead of changing the existing materials into a digital format. For example, by being more creative in using video materials, applying online assignments and tests, I have used web-pages of the Khan Academy (mathematics, physics) and Duolingo (languages) for self-studying. These are good examples of entirely new kinds of methods and materials to support and motivate learning instead of just making videos of existing lectures and turning printed materials into a digital format”. (3rd year medical student from the first study cohort)

The iPad group encouraged and supported clinical teachers to prepare learning materials for a new type of learners. We organized events and versatile training for clinical teachers. Students suggested that clinical teachers should recommend high-quality clinical applications and requested more digital learning materials on clinical topics, such as videos and the aforementioned high-quality applications (Pyörälä et al., 2016). Soon, several clinical teachers started searching for videos on the Internet. In case no suitable ones were available, they started making videos by themselves. Teachers were provided with support in planning, making, editing and distributing videos, not just to assist teachers in these efforts but to make sure that the students would be able to watch the videos with mobile devices. These new types of learning materials could be used as triggers for learning to activate students’ prior knowledge and understanding and to stimulate their self-directed learning in a flipped learning type of course module (Prober & Khan, 2013; Pyörälä, 2014).

**Collaborative learning**

Today students have grown up with rapidly changing technology and the Internet. They are used to being online instantly and interacting and sharing their experiences, uploading photos and other materials to social media (Prensky, 2001, 2005; Sandars & Morrison, 2007; Jones, Ramanau, Cross & Healing, 2010; Margaryan et al., 2011; Hakkarainen et al., 2015). When we started the iPad study project, we soon realized that students also utilized their everyday online skills in their studies. They were skillfully engaged in multiple online conversations simultaneously (Stephens & Pantoja, 2016). They formed groups on social media and interacted and collaborated online to reach their mutual study goals (Dillenbourg et al., 1996; Van der Linden et al., 2000).
The student members of the iPad study group were active and innovative in supporting their peers, collaboratively seeking new ways of organizing their learning activities and sharing information online about useful practices and applications. In addition to stimulating formal learning activities, students generated a learning culture typical of their age. They regarded the Internet and their peers as important learning resources and formed online learning communities and networks to complement their face-to-face learning encounters (Sanders & Morrison, 2007). Their learning culture was characterized by instant online access to a variety of information sources and the sharing of information and materials with their peers using social networks, cloud services or AirDrop, a direct transfer between tablet computers (Pyörälä, Romanov, Masalin & Hervonen, 2015; Mauno, 2016).

Students were experienced social media users who multitasked by managing several activities, face-to-face groups and social media networks at the same time. Studies on classroom multitasking and maintaining multiple conversations raised the question of whether online communication channels increased students’ understanding and social support or distracted them from learning (Stephens & Pantoja, 2016). Our research project discovered that communication with mobile devices mostly stimulated their learning. Students had a multilayered system for sharing information and materials (Pyörälä et al., 2015). They used different groups, networks and sites for different purposes. They communicated on social media with the whole course, with problem-based tutorial groups and with small groups of friends. The online websites were used for academic purposes by communicating timetables, events and academic matters.

“I use Social media to ask for help, share files, arrange study dates and share study related despair (:D)” (3rd year medical student from the first study cohort).

“We (use social media) for sharing notes, we brainstorm and revise for the examinations” (3rd year dental student from the first study cohort)

“Social media is the most important information channel of the course” (3rd year medical student from the first study cohort)
In the focus-group interviews, students had a clear message to teachers. They did not want to become social network “friends” with their teachers nor did they want to have official social media accounts for the courses (Pyörälä et al., 2015). Being online in the classroom or when studying for an examination enabled students to communicate on social media for purposes other than academic ones. Some students expressed that it was a temptation they had to learn to control. The 1st study year cohort described it in the focus-group interviews in the following way:

*Interviewee 1: And then in a lecture, if the topic is boring, it’s kind of not at all difficult to have a look at Facebook.*

*Interviewee 7: It’s so easy that it makes it...*

*Interviewee 1: And you get stuck there.*

*Interviewee 7: And if you are reading a book with an iPad, it’s just a couple a clicks from Facebook (laughing).*

Sharing information and learning materials formed an important part of student online collaboration. Students used both their own notes and other students’ notes when studying. In their first academic year, 86% of the first study cohort and 76% of the second study cohort reported using their own study notes. Simultaneously, 66% of the first cohort and 63% of the second cohort used other student’s notes. Students hardly ever shared their own study notes with the whole class. Instead, they mostly shared notes with a small group of close friends. Anonymous high-quality study notes by more advanced students were distributed for the whole class.

Students willingly studied in small groups, especially before the examinations. During the final days before examinations, students constructed several types of groups, both face-to-face and online. In the focus-group interviews, students emphasized the value of collaborative revision. These groups were formed to reach a common goal: to pass the examination. Thus, the students did not form the groups to compete with each other, but rather they studied together to deepen their comprehension of the complex phenomena studied by asking questions, providing reasons, drawing pictures and mind maps, and explaining biomedical models and functions to each other. The
questionnaires and focus-group interviews revealed that most of the students (66% of the first cohort and 57% of the second) preferred studying with a group of close friends. However, in the interviews students described that the “last minute panic” brought forth also ad hoc groups which were formed haphazardly by posting an online open invitation for studying together and meeting at the learning center (Pyörälä et al., 2015).

The fact that students rejected the idea of ‘friending’ their teachers on social media and wished to avoid ‘official’ social media accounts for their courses (Pyörälä et al., 2015) was an important message for the teachers, who were pondering whether they should create a social media site for their courses. The students were content with the “official” digital learning environment for course materials and communication with teachers and course administrators, and preferred to organize their online communication themselves.

Students’ web-mediated collaborative learning was a multilayer compilation of different types of groups and networks sharing information and materials. Students’ online joint learning revealed that the new generation of students skillfully integrated their everyday online practices of interacting, sharing, grouping and networking into their studies in order to collaboratively reach the mutual study goals. Students expressed that their constant online presence in the classroom was mostly used for academic purposes, and therefore encouraged their learning and stimulated collaboration in studying. However, at times the multiple channels of communication proved to be a distraction to students.

Discussion

The goal of this article was to synthesize a large research-based educational development project on mobile learning in a medical education context. We addressed research questions concerning the support students and teachers required for effective use of mobile devices, the ways in which iPads were incorporated into learning and teaching activities, the challenges of providing digital and online learning materials fit for mobile devices, and finally the question concerning the students’ collaborative learning using mobile devices and social media. The iPad study group generated ways of integrating mobile devices into learning and teaching together with the first two student cohorts and teachers involved in their teaching and learning.
This research project revealed that both students and teachers required versatile support and training in incorporating iPads into their learning and teaching activities. Students were pleased to receive support both from the faculty and their peers (Masalin et al., 2015; Heinonen, 2014). Faculty events on mobile learning have served as a valuable tool to share experiences and communicate research results with faculty and students.

A literature review of technology-assisted medical education claimed that there was no “best method” or “best use” of new technology (Jwayyed, Stiffler, Wilber, Southern, Weigand, Bare & Gerson, 2011). Too often new technology was only used for online knowledge gain. Therefore, it was vitally important to develop, together with students and teachers, the ways in which mobile devices could be integrated into learning and teaching activities in our faculty. This participatory approach enabled us to try a cloud based collaborative whiteboard application in order to incorporate the devices into the learning steps of problem-based tutorials (Masalin et al, 2014; Wood, Woywodt, Pugh, Sampson & Madhavi, 2014). A new type of learning design was also developed in virtual microscopy in histology. There, students studied samples with mobile devices in small groups. This new way of studying histology stimulated interaction and collaboration between students, and permitted the learning activity to move away from laboratories or ICT classrooms (Airaksinen et al., 2015).

Students rapidly moved towards an entirely paperless era (Hervonen et al., 2014) and yearned to have all their learning materials in digital format. They appreciated the opportunity to have all their learning materials on one device, in order to be able to study anywhere, anytime, and to use their spare time for studying. The academic use of iPads required appropriate study applications (Masalin et al. 2015). Students wanted their teachers to identify and inform them of high-quality medical applications (Tamminen, 2015). They also wanted teachers use more online quizzes, tests and examinations (Mauno, 2016; Prober & Khan, 2013; Joutsenvirta, 2013, 2016).

Today, the Internet and social media are powerful learning resources in students’ learning culture (Prensky, 2001, 2005; Sandars & Morrison, 2007; Jones et al. 2010; Margaryan et al., 2011; Hakkarainen et al., 2015). Studies report that online communication with mobile devices in the
classroom is potentially beneficial to learning, but may also cause distraction (Stephens & Pantoja, 2016). Our research results on students’ online collaboration and communication were mostly very positive. Students shared information and study materials online with peers, and were experts in multilayered collaboration both on social media and face-to-face (Pyörälä et al., 2015, Mauno, 2016). Being online increased rather than decreased students’ collaboration. Students’ remained aware of the potentially distracting power of social media, especially in lectures and during long hours of studying for examinations.

The action research project started in the Faculty of Medicine in 2013, in an era when the literature on mobile learning in medicine was still limited and quite technical (Jwayyed et al., 2011; Luanrattana, Win, Fulcher & Iversson, 2012) or focused on clinical settings (Davies et al., 2012). George and his colleagues (2013a, 2013b) published a study about incorporating iPads into a preclinical curriculum. They discovered that the students recognized the value of iPads in medical education, but at the same time, they still used printed handout and books and were not satisfied with taking notes on iPads or with the medical applications available to them. We recognized these challenges at the beginning of the project when 1st year students started studying with iPads, and at the shift from preclinical to clinical study years. We tailored support for students and were amazed at how fast the students moved into entirely mobile learning ecology, transforming all their learning materials into digital format.

Our first cohort of students started their clinical studies, and we examined with great interest the research literature on mobile learning in clinical contexts. Manchester Medical School started an iPad project in 2011 and reported a versatile use of mobile devices in clinical settings. Students used iPads to take notes, use online medical resources, download multimedia, and collate personal electronic portfolios as well as student assessment and feedback (Lumsden et al., 2015). Tews and his colleagues (2011) discovered that medical students’ patient clinical skills improved with watching videos on mobile devices. An extensive Canadian survey indicated a widespread and regular use of smartphones and tablets in clinical settings for information searches, and thereby emphasized the significance of reliable information resources (Boruff & Storie, 2014). In the specialty of family medicine (Archibald et al, 2014), residents reported that iPads were valuable when searching for information and for detecting drug interactions but also pointed out that typing notes on a mobile device was not convenient. A study on the use of clinical decision tools in mobile
phones revealed an interesting cultural norm of not using mobile devices at patients’ bedsides (Patel et al., 2015). However, in the same study, patients were actually positive about doctors using mobile devices in patient care.

In the iPad study, we studied published research results on mobile learning in clinical settings and recognized the challenges students faced when they moved from the relatively homogenous preclinical studies to the heterogeneous clinical studies. By combining experiences from other research projects with our own, we have made a concerted effort to foster mobile learning in clinical settings (Pyörälä, Romanov, Hervonen, Merenmies, Englund et al., 2016). Students requested that clinical teachers digitalize their learning materials and share them online prior to learning activities. Students suggested that clinical teachers should find high-quality medical applications for academic use. The Students’ use of mobile devices also required attention. Following our research project, our recommendations are as follows: Students should be allowed to use mobile devices to search for information and to take study notes in the clinic. However, patient information should always be transferred to health records and deleted from personal devices. The use of mobile devices should not become a barrier between a doctor and a patient, but the new generation of doctors should find means of improving communication with patients and enhancing patient safety. Our research project monitored the use of mobile devices in a clinical context along with the student cohorts who participated in our study.

The strength of our study lay in the fact that we began our action research project at the beginning of the academic year with the very first group of students to be given iPads. We started by collecting longitudinal data from the first study cohorts and will continue to follow their learning throughout their academic years. We also constantly collaborated with the participants of the study, both students and teachers, who both proved to be innovative in generating new learning designs and materials for mobile devices. Thus far, we have yet to discover a comparably longitudinal and participatory study in the research literature.

There were certain limitations to this study. Our report concerned a large action research project with several subtopics, only a few of which were presented here. We chose this type of report in order to share our experiences and expertise on how this educational development project proceeded, to detail our strengths and weaknesses, and expand on what we have learned so far. We wished to stimulate and encourage those units which are at the outset of a similar project and enable them to learn from our experiences.
We addressed the question of credibility throughout the research process (Lincoln & Guba, 1985). Creswell recommended applying at least two strategies to test it (Cresswell, 2007). We used various research data and triangulated them to produce corroborating evidence. The main results presented here have been scrutinized by external peer reviewers in national and international seminars and conferences (Trigwell et al., 2000; Kreber, 2002). We constantly solicited the participants’ (i.e., the students’ and teachers’) views of the credibility of our findings by involving them in the evaluation of whether the results were credible or believable from their perspective. This so-called ‘member checking’ was considered as the most important way of addressing a study’s credibility (Lincoln & Guba, 1985).

Transferability refers to the extent to which the results of research can be generalized or transferred to other contexts or settings. To improve transferability, we provided contextual information about the research-based educational development project for the reader to evaluate whether our experiences can be transferred to their own setting (Shenton, 2004). We believed that our experiment of integrating iPads into student learning could be transferred not only to a medical context but also to other higher education contexts. We also believed that even though our study focused on one type of device (iPad), the results could be applicable to different kinds of mobile devices, such as tablet computers, smartphones, laptops, and future smart devices.

Sharing experiences and research results formed an important part of the iPad project. It was vitally important to be sensitive to the students’ needs. The student members of the iPad study group and all their peer discussions, both face-to-face and online, played a crucial role in our project. The iPad study group organized numerous faculty events, where teachers and students shared experiences for the benefit of the whole community (Shulman, 1993; Kreber 2002). This type of open communication diminished resistance among teachers. Along this process, we created a mobile learning community to collaboratively develop mobile learning in medicine.

Mobile devices provide access to an unlimited amount of information. This not only affects students and healthcare professionals, but also patients, who actively seek information online (Masters, 2015), use new technology to monitor their health and form online health communities on social media (Rupert et al., 2014; Helve et al., 2015; Househ et al., 2014). Health information on the
Internet has an impact on the communication and collaboration between patients and healthcare professionals (Murray, Lo, Pollack, Donelan, Catania et al., 2003). We are confident that our students, who have actively participated in incorporating mobile devices into their medical practice and are very much academically ‘online’, will be able to discover new ways of communicating and collaborating with patients of the digital era.

Acknowledgements

We wish to thank the Jane and Aatos Erkko Foundation for their substantial grant to the Faculty of Medicine that made the iPad project possible, Dean Risto Renkonen for his enthusiastic support for the mobile learning project, and Vice Dean of Education Anne Pitkäranta for her energy at the onset of the project. We wish to express our sincere gratitude to the iPad project group, Kalle Romanov, Jukka Englund, Taina Joutsenvirta, Suvi Viranta-Kovanen, Maria Sundvik, Kirsi Sainio, Antti Mauno, Leo Heinonen, Rosa Nyberg, Tero Tamminen and Jussi Merenmies for the joint adventure, and all the students and teachers who made it possible.

References


**List of Figures and Images**

Figure 1. Cycles of action research based development.

Image 1. Problem-based tutorial with iPads.

Image 2. Virtual microscopy with iPads.
5. E-Schoolbag Use in Chinese Primary Schools: Teachers’ Perspectives

Feng-Kuang Chiang, Shuhan Jiang, Mingze Sun and Yana Jiang
School of Educational Technology, Faculty of Education, Beijing Normal University, China

Abstract

In recent years, many scholars and educators have focused on the topic of how to teach using the eSchoolbag learning environment to improve the effectiveness of K-12 education in a meaningful and appropriate manner. Using the eSchoolbag, students work without piles of heavy books, but are still able to take notes and deal with graph work. An eSchoolbag is a multifunctional electronic learning environment. Our study intends to explore perspectives on using eSchoolbag in the classroom. 34 teachers from 4 eSchoolbag pilot schools teaching Chinese, Math, English and Science subjects in Shenzhen, China participated in this research. Focus-group interviews and questionnaire surveys were used in the study. The results of the study revealed that teachers’ attitudes underwent a shift from positive to negative after using the eSchoolbag in academic instruction. Finally, some suggestions for eSchoolbag pilot schools were proposed.

Introduction

The dramatic development of information communication technology (ICT) has changed the world. It is unsurprising that a large number of education researchers want to implement information technology into the current education system. School education must adapt to meet the challenges of this new century (Gut, 2011). ICT is so various that help it can be used in a multitude of roles within the educational environment. It can be used for instruction, to assist and as a cognitive tool (Ross, Morrison, and Lowther, 2010). By incorporating such technology into the teaching process, positive effects can be seen in areas such as cognitive skills, such as critical thinking (Yeh, 2009; Kong, 2014) and information literacy (Kong, 2014), and it can stimulate students’ motivation to study (Yang and Wu, 2012). Technology also appears impressive and magical, and can easily capture the attention of young children. Multimedia usually provides visually pleasing information, which can be helpful in memorization (Chambers et al., 2006). Thanks to ICT, not only have traditional teaching methods been transformed, but many original learning materials also have been developed into e-resources.
The prevalence of mobile devices contributes to the invention of new forms of interaction and class activities that may facilitate learning in a variety of ways. These electronic devices including eSchoolbags expand the learning context from the classroom to the outside world (Liu et al., 2008; Vavoula et al., 2009), help students to participate social learning (Liu & Kao, 2007; Roschelle, 2003; Zurita & Nussbaum, 2004), and contextualize their study experiences (Hsi, 2003; Vogel et al., 2010).

The sheer quantity of information can subject students to extreme academic pressure, and students have to carry bulky schoolbag everyday (Lasota, 2014). The initial invention of eSchoolbag sought to solve these two problems. Its further aim was to make studying and learning more effective and more efficient (Hennessy et al., 2007). Of course, it cannot be simplified as just one kind of electronic book. By using the eSchoolbag, students can do away with piles of heavy books, but are still able to take notes and deal with graph work. An eSchoolbag is multifunctional, just like an iPad, but its primary focus is academic. The usage of eSchoolbags fosters interactive communication in class. It helps teachers to build a vivid leaning context. In addition to that, it is so flexible and portable, so students can study wherever and whenever they want (Chang & Sheu, 2002). The eSchoolbag integrates different kinds of information, including learning resources and technological resources. The trend of maintaining a 1:1 ratio of eSchoolbags to students is not exclusive to Shanghai. This electronic device is considerably prevalent in elementary schools in Taiwan, and around East Asia (Chan, 2010). The eSchoolbag project and the research surrounding it have the potential to instigate an education revolution, which will usher in a brand new future. However, the development of the eSchoolbag currently faces stagnation (Wu et al., 2014). To prompt the eSchoolbag research into a new stage, it is imperative that we reflect on and analyze the current research. Problems and flaws should be discovered and eliminated, while the opinions of teachers and students should be accessed and acknowledged. Only by examining the current situation thoroughly can proper instructional methods be designed.

As it stands, Chinese schools and educators have managed to introduce eSchoolbag into many general courses. Educational circumstances have been improved to a great extent in terms of both hardware and software. The widespread intelligent terminal lowered the price of the digital device. The pad is more affordable for the general public and, consequently, it can be extensively implemented in teaching and learning. Naturally, the eSchoolbag boom in primary and secondary schools occurs in a one-on-one form (i.e., each student uses one eSchoolbag) in the developed cities like Beijing, Shanghai, Goangzhou, Shenzhen etc. Our longitudinal study conducted a project within four pilot primary schools, tracing teachers’ attitudes towards integrating eSchoolbags into
the normal curriculum from April 2012 to September 2013. A similar project was conducted in Hong Kong in 2002 (Li, 2003). However, the research in Hong Kong does not center upon teachers’ attitudes. Instead, that paper just discusses some examples from the teaching process in pilot schools, without concrete procedure or precise construction. This research may help to fill some of the remaining blanks in this field of research.

Before the 21st century, the effectiveness of computer-implemented education systems was widely regarded as facilitating the understanding process and improving the students’ learning motivation (Dori & Yochim, 1994; Hauben & Lehman, 1988; Lazarowitz & Huppert, 1993; Smith & Jones, 1989). However, the continuous and frequent technological developments render it difficult for teachers to keep up with new trends and update their knowledge (Dori, 1997). From the beginning of the new century, much research highlights that incorporating technology into education is, although creative and innovative, complicated and sophisticated (Mumtaz, 2000; Watson, 2001). Integrating technology into educational activities means that the fresh new hardware and software should be installed in the normal education surroundings. However, most teachers have never participated in systematic and long-term training in instructional technology skills (Olson, 2000). Not only do the instructors need to be adept at using various high-tech realia equipments but also they need to adapt their beliefs to the new surroundings and circumstances (Fullan, 2001). That is to say, simply improving the technological accessibility (e.g. increasing the number of facilities) without modifying instructors’ pedagogical beliefs would never lead to a real, digital change in education (Peggy et al., 2012).

Teachers’ attitudes towards integrating high-tech facilities (e.g. computers, iPads, and eSchoolbags) into education are critical for effective and efficient use of this educational technology (Teo, Lee & Chai, 2009). In a study performed to investigate teachers’ reactions to the electronic portfolio (EP), researchers found that those teachers who did not implement the device effectively endured significant technical obstacles and felt forced to transform the established instructional patterns. On the contrary, the teachers who had excellent performance in EP usage conveyed positive feelings, were supported by administrators and experienced improvement in their teaching activities. Furthermore, the flourishing trend of EP scaffolding software applied in pedagogical practices stimulates self-regulated learning, which in turn encourages more widespread EP usage. In this case, teachers would be more inspired to use EP in teaching when learning students would be more competent in self-management in study. (Meyer & Abrami, 2011)
Research Design

TAM Model

Naturally, a large number of researchers have strived to create and examine models that might be helpful in anticipating technology usage. Among all these models, the technology acceptance model (TAM) is more prevalent and the most universally accepted (Davis, 1989). Although there are many variables in TAM, the most important two are perceived usefulness (PU) and perceived ease of use (PE). TAM is demonstrated in Figure 1. TAM has been widely used to predict the usage of assorted kinds of technology by testing the users’ attitudes. In addition to the aforementioned variables, Teo, Lee and Chai (2009) also included the other relevant variables subjective norm (SN) and facilitating conditions (FC) in their study, which could also be referred to by subsequent studies. The original variables in the TAM were considered as a point of reference when analyzing the relationship between the educational effects of eSchoolbags and the attitudes towards them.

![Figure 1 TAM model (Davis, 1989)](image)

Participants

In total, 34 teachers from 4 eSchoolbag pilot schools teaching Chinese, Math, English and Science subjects in Shenzhen, China participated in this study.

Period

The research lasted for 1 year (2 semesters) including three investigations to explore the teachers’ attitude changes towards the eSchoolbag. In August 2012, at the beginning of the first semester, teachers’ attitudes towards the eSchoolbag before having used it were investigated through theme training and interviews. After one semester of using the eSchoolbag, at the end of the
first semester in December 2012, a focus-group interview and a questionnaire survey were conducted. At least 10 teachers participated in each interview, which lasted between 1 and 2 hours. 15 teachers took part in the first of the questionnaire surveys and 10 in the second. In September 2013, after two semesters of using the eSchoolbags, the interviews and the questionnaire were applied to keep track of teachers’ attitude towards eSchoolbags.

**Method**

Focus group interviews and questionnaire surveys were used in the research. The open-ended style of the interview questions aimed to enhance our understanding of the problems the pilot teachers’ encountered when using the eSchoolbag in their teaching. The process of the interview was recorded and transcribed in the form of a verbatim transcription. Based on the findings of the interviews, the questionnaire survey was designed to quickly understand the pilot teachers’ opinions on using the eSchoolbag in class in order to discover a solution to the problems the teachers raised.

This research uses a qualitative approach as its primary method and a descriptive and quantitative approach as its secondary one. First, the pilot teachers received thematic training and interview before using the eSchoolbag in the class. The content of the training and interviews was as follows.

- **Thematic training:** how to apply eSchoolbag in teaching, technology training, class management and the idea and teaching innovation, and discussion about the eSchoolbag itself and the integration of ICT into the theory and practice of teaching.
- **Focus interview:** discussion about the eSchoolbag, teachers’ doubts surrounding its use in their teaching, and their attitudes before the pilot.

After collection, a verbatim transcript of the interview data and a concept map of the teachers’ questions about eSchoolbag teaching were generated. We then conducted an analysis of the concept map which formed the basis of the questionnaire on teachers’ attitudes towards using the eSchoolbag in teaching. Afterwards, the questionnaire survey was used along with the focus interviews to investigate the teacher’s attitudes in both the first and second terms. This combination of qualitative and quantitative approaches led to a comprehensible discussion.

**Instruments and data analysis**
**eSchoolbag tool**

The software interface of the eSchoolbag is displayed in Figure 2. The left part contains information about students’ learning schedules. The middle part is used after class for students to review the course content. For instance, the “Personal Works” section is designed to collect students’ learning portfolio. “My Textbooks” and “Flaw Sweeper” are used for self-adjustment, while “Intelligent Learning” and “Tests” can provide students with much more detailed information and questions. Finally, the left part is possibly the most innovative as it aims to create an environment for student-to-student and student-to-teacher interactions through features such as Previewing, Practice, Group Discussion, Vote, Mind-map, and Class Resources.

![Figure 2. The software interface of eSchoolbag](image)

**Research tools**

A concept map and a 5-Point Likert scale questionnaire are featured in the research. The concept map was formed by collecting and summarizing the teachers’ opinions about using the eSchoolbag in their teaching, while each of the dimensions of the concept map were discussed among the front-line teachers and specialists and were modified by researchers several times. Based on the concept map, a questionnaire was formulated to further investigate teacher attitudes. The questionnaire used a 5-point Likert scale where 1 is the most negative, 5 is the most affirmative and 3 is ‘no opinion’. The reliability of Cronbach α to the first and the second questionnaire is 0.717 and 0.965 respectively.
The interview records were transcribed verbatim, then coded and subjected to conceptual analysis to form a concept map of attitudes towards the use of the eSchoolbag in teaching. The questionnaire survey used statistical analysis to support the findings of the interviews.

Three focus-group interviews were implemented to better understand teachers’ attitudes towards using the eSchoolbag. There were approximately fifteen teachers in each focus group, including four different kinds of course teachers and education researchers who were also involved in the project. In order to acquire more precise data, the entire interview process was recorded audiovisually and transcribed. The teachers’ conceptions were coded, and these transcripts were transformed into a concept map at the end of the process (see figure 3). This concept map was also the basis of the questionnaires given to teachers in the next phase of the study.

Figure 3. Concept map of teachers’ attitudes towards using eSchoolbag (Retrieved from Chiang & Xiong, 2013)

Research Findings

Qualitative analysis

The first focus-group interview. After the two training sessions on eSchoolbag, teachers took part in the first focus-group interview before formally using eSchoolbag for in-class instruction. The main goal of this interview was to discover the teachers’ attitudes towards this new mode of
teaching as well as any doubts they may have had regarding the application of eSchoolbag in class. The problems and results can be summarized as follows.

1. The management and use of eSchoolbag. Within this topic, teachers voiced concern over the fact that there are only two classes that use eSchoolbag in class, which will cause the students from other classes to feel curious about these devices. They also remarked that there is no place for students to store their eSchoolbags when they are not in the classroom, and that it is likely that the eSchoolbag will be accidentally destroyed by the students. Furthermore, large numbers of parents are reluctant to let their children use the eSchoolbags for long periods of time, because they are worried that these digital devices may have negative effects on the children’s eyesight and general physical well-being.

2. The problems of teaching. First of all, teachers are not familiar with eSchoolbag, which will make it difficult for them to use it correctly and proficiently in class. Many technical problems encountered when teaching are beyond their repairing capabilities. That makes it essential for the teachers to be well-trained in the use of the eSchoolbags before teaching. Secondly, teachers are obliged to design instructional resources on their own if the teaching materials offered by the eSchoolbag are not satisfactory or are unavailable, something which, of course, demands huge amounts of time and energy and poses a tremendous challenge to teachers. In addition, they worry that it will take them more time to check the students’ homework. True or false questions and multiple-choice questions can be corrected automatically by eSchoolbag, but teachers ought to spend more time on subjective (open-ended) questions, which is less efficient than paper homework.

3. The attitude of the teachers. In the beginning, the majority of the teachers held a positive attitude towards the application of new technology, believing that digital education will exert a positive influence on students and be a rich source of learning in the future. Nonetheless, a small number of teachers were suspicious of the eSchoolbag’s effect. In particular, some senior teachers claimed that technology had made education more complicated and that the students would be easily distracted by new things such as eSchoolbag. Several teachers also highlighted that some schools ceased using the eSchoolbag system after a while. Why would they have done this if eSchoolbag is truly beneficial to education? Teachers pointed out that the theoretical feasibility does not always guarantee satisfactory performance in reality.

*The second focus-group interview.* The second focus-group interview was conducted after the teachers had been using eSchoolbags for approximately one semester and sought to obtain teachers’
feedback about the usage of eSchoolbag. Below are some problems raised by the teachers during the interview.

1. The increasing pressure on teachers. Teachers claimed that due to the long time span between the training and the formal in-class use of eSchoolbag, they were “rusty” with the system at first and found lesson planning and checking students’ homework to be a big challenge. First, teachers had to select the most compatible and proper teaching materials from the vast array of resources provided by eSchoolbag. Furthermore, teachers usually took double the amount of time to correct students’ results than with paper-based homework due to the lack of standard answers. In addition, the evaluation method of some questions is confusing for students. For example, in one question students wrote three correct Chinese idioms out of four, but the teacher could only give the final mark as a whole, which meant that the students did not know which of the idioms they had completed incorrectly. Furthermore, teachers often experienced tiredness and dry eyes.

2. The difficulty of classroom management. The teachers reported that approximately two thirds of the students in class would follow the instructions. As for the students who misbehaved or had a strong sense of curiosity, they would be easily enticed by other information on the eSchoolbag and sometimes even delete the teaching system of eSchoolbag.

3. The imperfection of teaching resources. The teachers found that some exercises on eSchoolbag were ambiguous, which naturally means that students have difficulty to understand the questions. Apart from this, most of the teaching materials in eSchoolbag at present are simply scanned from textbooks without being supplemented by other instructional resources. Some teachers advised that some extra-curricular knowledge, Chinese for example, should be included in eSchoolbag as well.

The third focus-group interview. The final focus-group interview was conducted after the entire research project was completed. During this interview, teachers raised questions based on their experience of eSchoolbook-assisted teaching.

1. The technical issues. Teachers have faced all kinds of technical issues when using the multi-media devices. The display lacked clarity and the network was unstable. The eSchoolbag crashed easily, and the students usually could not receive massive information provided by the system. They also felt that the eSchoolbag had too many functional buttons which led to complications when teaching and had a negative impact on the teachers’ emotional state.

2. The problem of system resources. Teachers had to design their own teaching materials because of the inadequate resources provided by eSchoolbag. The resources supplied by eSchoolbag
lacked certain features and were not classified in a logical manner. Some resources contained errors, and eSchoolbag even provided the students with some pirated resources.

3. Side-effects of eSchoolbag. Students who were difficult to control could not resist the temptation of surfing the Internet or playing online games on eSchoolbag. Their parents were also worried about potential problems with their eyesight.

4. The combination of teaching and learning. Teachers expressed that there was less eye contact with students in class because they were all engrossed in eSchoolbag. Some teachers complained that the use of eSchoolbag did not complement their teaching style. The shortage of characteristic resources would sometimes interfere with classroom teaching.

Various kinds of problems were raised during the time the teachers’ were using eSchoolbag to assist their teaching, but overall the teachers concluded that the class efficiency was indeed improved. They also emphasized that it was very important school leaders support educational information technology system construction which is beneficial to both students and teachers. However, the question of whether using eSchoolbag can enhance teaching still rests on whether students achieve higher grades in exams, which means that the existing system of evaluation should be changed from score determinism to a multi-dimensional evaluation standard. It is not the total quantity, but rather the appropriate quantity and quality of resources available to teachers and students that really counts. Lastly, personalized training should also be carefully designed for teachers before they use eSchoolbag.

**Quantitative analysis**

There were two questionnaire surveys which were issued at two different times. The first surveys were designed and developed based on the concept map which was generated after the first interview. The second survey focused on the teachers’ attitude towards using tablet PCs. The two surveys were used to measure and trace the teachers’ attitudes in the pilot school. And the questionnaire employed the Likert scale.

**The first questionnaire survey**
There are seven dimensions to the first questionnaire: education system, eSchoolbag school management, teachers themselves, classroom teaching, students’ learning, use restrictions, and the eSchoolbag tool itself. 6 males and 9 females completed the first questionnaire survey. The results are shown below.

Table 1. The overall average

<table>
<thead>
<tr>
<th>Factor</th>
<th>Education system</th>
<th>eSchoolbag school management</th>
<th>Teachers’ professional development</th>
<th>Classroom teaching</th>
<th>Students’ learning</th>
<th>Restriction on use of eSchoolbag</th>
<th>Functions and resources of eSchoolbag</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN</td>
<td>3.19</td>
<td>3.52</td>
<td>3.47</td>
<td>3.39</td>
<td>3.30</td>
<td>3.29</td>
<td>3.06</td>
</tr>
<tr>
<td>SD</td>
<td>0.65</td>
<td>1.27</td>
<td>0.90</td>
<td>0.82</td>
<td>0.82</td>
<td>1.14</td>
<td>1.42</td>
</tr>
</tbody>
</table>

In Table 1, it can be seen that the eSchoolbag school management received the highest score (M=3.52). That is to say, the pilot school provided significant support for the eSchoolbag pilot scheme and communicated well with parents and teachers. Teachers’ professional development took the second highest score (M=3.47). Teachers believed that eSchoolbag could improve their IT literacy and promote the integration of ICT and subject teaching. The lowest score was awarded to the function of eSchoolbag (M=3.06). It was revealed that there is room for improvement and optimization regarding the teaching functions of the eSchoolbag.

The second questionnaire survey

There are five dimensions to the second questionnaire: students’ learning, classroom teaching, perceived ease of use, perceived usefulness and fears and concerns. 10 teachers completed the second questionnaire, 2 males and 8 are females. The results are presented in Table 2.
Fears and concerns received the highest score (M=3.4), which means that teachers were worried about the negative influence of mobile devices on the physical and mental health of students. Classroom teaching got the second highest score (M=3.02), suggesting that the teachers believed that the mobile devices had a positive effect on classroom teaching. The scores for students’ learning and perceived ease of use were lower; 2.69 and 2.6 respectively. Teachers claimed that eSchoolbag did not have an obvious influence on students’ learning nor was it easy to use. To conclude, teachers had some reservations concerning the usage of eSchoolbag, and they were reasonably sure that eSchoolbag had some unsatisfactory effects on students.

The dimensions of classroom teaching and students’ learning with the eSchoolbag were investigated in both questionnaires. Figure 3 shows that after one semester using the eSchoolbag, teachers’ attitudes towards their classroom teaching and the students’ learning both declined from the first semester to the second semester. The former experienced a small decrease from 3.45 to 3.11, indicating that attitudes towards in-class eSchoolbag use are less positive. The latter’s score drops from 3.02 to 2.68, showing that teachers' belief that eSchoolbag promotes students' learning is waning (See in Figure 4).

<table>
<thead>
<tr>
<th>Factors</th>
<th>Students’ learning</th>
<th>Classroom teaching</th>
<th>Perceived ease of use</th>
<th>Perceived usefulness</th>
<th>Fears and concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN</td>
<td>2.68</td>
<td>3.02</td>
<td>2.60</td>
<td>2.88</td>
<td>3.4</td>
</tr>
<tr>
<td>SD</td>
<td>0.93</td>
<td>0.80</td>
<td>0.94</td>
<td>0.89</td>
<td>1.05</td>
</tr>
</tbody>
</table>
Figure 4. The attitude changes concerning classroom teaching and students’ learning between two surveys.

In addition, a U-test was also conducted to analyze the change between the first survey and the second. According to Table 3, the teachers’ attitudes towards the eSchoolbag in students’ learning were more positive in the first survey than they were in the second, and this difference is highly significant (P=0.007<0.05). However, the difference in attitudes to classroom teaching shows no significance (P=0.51 > 0.05).

### Table 3. The U-test on Classroom teaching and Students’ learning

<table>
<thead>
<tr>
<th></th>
<th>Classroom teaching</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40</td>
<td>95</td>
<td>-1.953</td>
</tr>
<tr>
<td>F</td>
<td>Ma</td>
<td>Wil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>act</td>
<td>nn-</td>
<td>cox</td>
</tr>
<tr>
<td></td>
<td>rs</td>
<td>Whion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tney</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asymp. Sig. (2-sided)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exact Sig. [2*(1-tailed Sig.)]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Discussion

Common points between the qualitative and quantitative analyses

The findings of the qualitative and quantitative analyses above show some common points that reveal the change in teachers’ attitudes towards the use of eSchoolbags. First, teaching resources: in the interviews, many teachers expressed that the teaching resources of the eSchoolbag are not specialized enough, while in the first questionnaire, the resources category received the lowest score (M=3.06). Secondly, classroom teaching proved to be another point of overlap between the analyses. Teachers speculated during the interviews that students using eSchoolbags may become distracted by the software and resources on the devices that are unrelated to the class teaching and learning, that is, students might play on them instead of listening intently to the teacher. Classroom teaching got the lowest score in the second questionnaire (M=3.02). Thirdly, we can identify further parallels between the analyses in the areas of perceived ease of use (M=2.60) and usefulness (M=2.88). When using the eSchoolbags, teachers usually encountered some form of technical failure, such as network instability, failure to send messages, the device crashing and so on, which naturally made the class less efficient. Teachers who were interviewed argued that the usage of eSchoolbags not only failed to reduce the burden of teaching but actually had the opposite effect: it instead put them under more pressure when preparing for a class and correcting the students’ homework. The final commonality between the two analyses is the concerns and fears surrounding the use of eSchoolbags which got the highest negative score (M=3.4) (Table 2). Both the interview and questionnaire showed that teachers were worried that e-Schoolbags would weaken students' writing ability and be bad for students’ health and even cause them to become addicted to the games on the eSchoolbag.
Suggestions

Voluntary participation and multi-dimensional evaluation system

In China, teachers are usually designated to participate in research projects by school directors, and sometimes this participation is not voluntary. In this research, many teachers held negative opinions and had many concerns regarding the use of eSchoolbags, but there is a possibility that they are obliged to teach with eSchoolbag without any say in the matter. This factor can perhaps explain why they teachers’ attitudes continue to decline after one year of using the eSchoolbags. We would recommend that the school administration provide teachers with opportunities to choose projects freely instead of enforcing participation. Furthermore, it is likely that motivation in teaching and learning will decrease in the initial phase of use because of unfamiliarity with new technology. But this situation will improve along with the teachers and students’ increasing command of technology. A further suggestion is that the criteria of judging whether the eSchoolbag is valid should depend on the students’ grades. In this vein, we would recommend that a multi-dimensional evaluation system should be created including students’ learning motivation, information literacy and multivariate ability.

Individualized teacher training

It is difficult for senior teachers to implement new technology into their teaching due to their lack of information literacy. Trainers should, therefore, anticipate and introduce the problems the teachers might encounter and deliver the corresponding problem-solving measures. They could also develop video-based fragment training for teachers’ independent learning. Individualized training is necessary with the increasing academic use of tablets because different subject teachers and different schools might have different problems when they use the eSchoolbag system.

Targeted teaching resources

One of the advantages of the eSchoolbag is the abundance of teaching resources. However, most teachers indicated that the richness of eSchoolbag’s teaching resources needs to be improved. The proper quantity of teaching materials determines the quality of eSchoolbag. The resources provided by eSchoolbag must be selected carefully, and extracurricular books
should also be avoided. Moreover, teaching resources targeted for different subjects and knowledge points should be developed in order to satisfy different teachers’ requirements. Cognitive tools such as concept maps and digital story production could also be embedded into eSchoolbag to optimize the teaching and learning process. Developers could also consider building a resources-sharing-option into the cloud to ease the pressure on teachers’ to produce resources themselves.

**Technical support and service**

Teachers complained that the technical errors they encountered while teaching cannot be solved immediately, which might result in one of the negative factors that influenced teachers’ attitudes towards eSchoolbags. Therefore, companies that produce eSchoolbags must improve their technical support and consider dispatching technicians to pilot schools to ensure that technical errors can be solved promptly.

**Improvement of management regulations**

Following one year of eSchoolbag-assisted teaching, teachers remain concerned that students will use the tablets without limit after school. Parents are also worried about the negative effects of eSchoolbags. In order to solve these problems, every pilot class should be provided with an eSchoolbag charging cabinet. Relevant courses should be developed to teach students how to use their eSchoolbags correctly and safely. It is necessary that students develop good habits regarding their devices. Parents ought to properly supervise their children when they are using the eSchoolbag. Furthermore, the eSchoolbag system would benefit from an automatic power-down feature, for example it would turn itself off automatically at ten o’clock every night, as this would ensure that students can only use eSchoolbag during appropriate working hours.

**Conclusion**

To conclude, teachers primarily maintain negative attitudes towards eSchoolbag application in instruction. The limited degree of use of this innovative technology, the lack of experience in electronic portfolio (EP) implemented instruction and the deficiency of a proper teaching mode all
serve as barriers to effective eSchoolbag-led instruction. According to TAM (Teo, Lee & Chai, 2009), the perceived ease of use and perceived usefulness affect the ‘attitude towards using’. The ‘attitude towards using’ determines to some extent the behavioral intention to use, which eventually has direct impact on actual system use condition. It is widely acknowledged among teachers that using eSchoolbags actually puts more pressure on them. Moreover, it has no apparent influence on the study motivation, ability, cooperation, and progress of inquiry-based learning. Some teachers even reject the usage of eSchoolbags, implying they have a negative impact on class regulation and efficiency and may lead to students’ obsession with video games and weakness in handwriting. Also, the platform system, the hardware equipment and the educational resources are incomplete and inadequate and unable to support instruction. Furthermore, some technical issues cannot be solved immediately. Cumulatively, these factors have lead to repugnance towards eSchoolbags and the subsequent disappointing outcomes.

To deal with the aforementioned problems and change teachers’ attitudes, various measures are needed. The indispensable technology staff should always be available to tackle unpredictable incidents. Regarding the resources, an approval process is necessary to guarantee quality. Further to this, although the training programs that aid teachers in improving their technical competence are helpful, individualized and personalized training would be better. At the same time, teachers need to recognize the advantages of eSchoolbags and how tremendous their effect could be. It is also imperative that a new regulation system is established for the eSchoolbag environment to monitor the myopia rate among students. The schools themselves could involve experienced voluntary teachers and young teachers with an interest for technology in eSchoolbag-led instruction to overcome the obstacles posed by older, less technologically literate teachers. Lastly, the switch to a multi-dimensional evaluation system from the current single grading system would benefit both students and teachers.

**Acknowledgments**

Our work is supported by the Fundamental Research Funds for the Central Universities (705-105570GK), Beijing Social Science Foundation (14JYC027) and 2016 MOE Research Center for Online Education (2016YB112).

**References**


6. An E-learning Project for Language Instruction in China

Bao-Ping Li, Xiao-Qing Li and Lulu Sun

Faculty of Education, Beijing Normal University
*Tarkista onko viimeisin versio*

Abstract

This paper introduces an e-learning project focused on technology-enhanced language learning in primary and secondary schools in China. Over the course of 16 years, effective teaching and learning patterns using e-learning methods in the subjects of Chinese and English were established and applied to more than 400 schools all over China. The aim of the pedagogical model has been to build an e-learning environment using laptops or tablets as the basis for learning. This does not only help students to use the language in authentic circumstances but also to create, present, and share their work and thoughts in a convenient way. In the classroom, learning resources are abundant and curated; the quantity of students’ work is large, and their expression is profound. In addition, an online social network for thousands of teachers from different treatment schools was created. Through this network, teachers can accept remote training, design the curriculum cooperatively, and observe and evaluate other teacher’s classes in real time. Original materials such as learning resource platforms with evolutionary mechanisms, known as ‘Learning Cells’, and ‘Apps’ (Applications), for various learning activities on mobile devices were developed and provided to teachers and students. Sufficient evidence demonstrated that both the students’ native language and foreign language levels improved along with their ICT (Information and Communication Technology) skills. The teachers’ TPACK abilities (Technological Pedagogical and Content Knowledge) developed, and the gap in learning performance between rural and urban schools narrowed.

Keywords: Language learning; ICT in education; Teacher training; interactive learning environments

Introduction

Learning both Chinese and English is an important part of primary education in China. The students’ capability in the language will be of extreme significance to their studies, careers and even to their lives in general. However, since the 1990s, Chinese primary education has been inclined to
be exam-oriented, which has pushed the teaching mode of Chinese and English to a mechanized and standardized form. In Chinese classes, students are supposed to acquire words and skills in reading by rote, by mechanical imitation. This has not only prevented students from understanding and appreciating the language on a deeper level, but moreover their ability for observation, imagination and creativity is not fully developed. In English classes, reading and writing are stressed while listening and speaking are neglected. The accumulation of language knowledge takes priority over the development of integrative language abilities and cross-cultural awareness, which gives rise to almost non-existent sociability and the phenomenon of ‘Dumb English’. Dumb English refers to students who are not good at oral English; although they are able read English well, they cannot listen or speak fluently. This phenomenon has been widely criticized, and a curriculum reform in primary education is desperately needed.

Simultaneously, the rapid development and wide use of ICT in the educational field has been profoundly influencing the educational sphere. The Institute of Modern Educational Technology of BNU (Beijing Normal University) has implemented an e-learning project to promote language learning in primary and secondary schools since 2000. ICT (Information and Communication Technology) such as computers and wireless networks are used as tools of cognition, cooperation and communication to help students to learn and explore by themselves. Thus, the teacher-centered pedagogical model, the word-analysis-centered Chinese teaching concept, and the grammar-centered English teaching concept are altered. The project aims to improve the teaching quality of Chinese and English language courses to enhance students’ ability in word acquisition, reading and writing, to expand their capabilities in actual communicative situations and in doing so, effectively develop cross-cultural communication. In recent years, more and more primary and secondary schools have used tablets in their classes, so the project has also explored the language learning in the context of one-to-one digital learning environments.

**The model of language teaching based on e-learning**

No matter if mother tongue or foreign language, language learning is always a process of apprehension, internalizing, and using. Especially for primary school students, language learning has aroused much attention in many language learning studies, and both the instructors and students are looking for better models based on technologies and strategies.

At the apprehension stage of language learning, students must memorize and read basic word lists and grasp the use of significant grammar points. In China, teachers always teach vocabulary, especially English vocabulary, by simply drilling the students and having them memorize their
meanings. But to better apprehend new vocabulary, students need to be immersed in English words and grammar (Torres-Martinez, 2015). Compared with study-abroad learners and native speakers, non-native-speakers who study in their home country have fewer chances to practice, and therefore are arguably in more need of exposure to authentic English contexts. They also need to practice harder to retain new English words to achieve oral fluency and to be more effective and more curious when listening to words, speaking sentences, reading articles and writing papers (DeKeyser, 1991; Lafford, 2004; Segalowitz & Freed, 2004). However, studies suggest that vocabulary knowledge does not just have a great effect on the apprehension stage of language learning, it has also been found to predict reading comprehension (Hsueh-Chao & Nation, 2000; Laufer, 1992; Laufer & Ravenhorst-Kalovski, 2010) and listening comprehension (Staehr, 2009; van Zeeland & Schmitt, 2013) at the stage of internalization. For language learning, students (especially for young children) are not just memorizing the words and sentences from textbooks. Students need to integrate their pre-knowledge with post-knowledge (Wellman, 2004) and internalize what they learn, by, for example, using their own learning strategies (Oxford, 1994). Students who do not wish to simply memorize and analyze basic issues should pay more attention to language application, by, for example, writing essays and using the language actively in communication. To truly master a language and be able to solve linguistic problems in a second language as easily as in their mother tongue, students need to work with numerous literary texts in a short period of time and enhance their linguistic flexibility by employing strategies to find meaning (guessing, scanning, predicting) and to converse even when they don’t know all the relevant words (paraphrasing, gesturing) (Oxford, 1994). If students apply what they learn in their language learning classes, this may spark the desire to explore and understand more concepts. Teachers should therefore provide them with valuable experiences and opportunities for this application to improve their performance in each of the language learning phases: preparation, presentation, practice, evaluation and expansion (Bai, 2015).

The reality of language learning in China is that students are usually stuck to rigid material, and traditional teaching methods are focus much more on teaching than learning, resulting in the common situation where students are always very good at apprehension but weaker at internalization and use (He, Ma, 2005). In China, students start language learning with word lists that do not feature a meaningful context, and do so in a relatively low-tech classroom (no internet, tablets or PCs). The only learning resources on offer to students are books and some drilling materials. Furthermore, instructors usually check the outcome of language learning by testing, so repetition and memorization at the apprehension stage are the main methods to prepare students to handle standardized exams.

To solve these issues, Wellman (2004) recommends constant practice with one another as one key to learning new words and phrases at the apprehension stage. This is then followed by
communication through dialogues as part of the complex internalization and using process. In these dialogues, students are able to sum up all the language items, such as words, phrases and grammar, in a way that demonstrates their functionality. Cook (2007) thought that in modern language learning classrooms, technologies are partly replacing traditional rigid learning material, such as the substitution of non-contextual words lists with contextual word materials. Technology enables teachers to easily set up interesting circumstances for learners (Yoo, 2014) in which they can learn native speakers’ learning strategies more effectively. They can then apply those strategies in real life situations with people from different linguistic and cultural backgrounds (Jenkins, Cogo, & Dewey, 2011).

Above all, the opportunities for aural comprehension offered by technology could positively improve students’ listening competence. As Norris and Soloway (2004) stated, learning would change if everyone owned a computing device, similar to the fact that if everyone owned their own book instead of sharing with others. In the traditional Chinese classroom, one teacher has to teach at least 40 to 50 students on average at the same time. However, if each student had a digital learning device like a tablet, they could interact with the tablet and acquire learning resources from the tablet instead of from the teacher. This 1:1 student to device ratio could improve students’ speaking competence and provide them with opportunities to practice topics related to ‘real life’ situations. For example, contextual reading material offered by PCs, tablets or mobile phones could improve students’ reading competence; producing texts, handling feedback, and revising authentic work could likewise improve students’ writing competence. Technology has the potential to offer students authentic language experiences and feedback and to make language-learning feedback more immediate and more frequent. Feedback and records could be collected and stored digitally and reflect the trail of a student’s language-learning experience (McKay, 2010), and language teachers could teach more comprehensively and balance the three processes: apprehension, internalization and using.

**Mother-tongue learning supported by information technology: the instruction model of Chinese.**

Chinese psychologists have found that preschool children at the age of 5-6 have already mastered more than 3,500 words which are used in daily life. In the late 1990s, Chinese linguists found that children at this age can already understand and use many sentence patterns in Chinese (including complex interrogative sentences). Children have considerable capability in listening and speaking, which greatly reduces the difficulties they experience while learning words and sentence patterns (He, 2004).
Since language is the external expression of one’s thoughts, He and Wang (2013) stated that students should learn languages in authentic circumstances to carry out the language-application-centered pedagogical model. As children have established a solid foundation in pronunciation and meaning in their preschool years, their oral expression and intelligence help them compose complete and fluent articles when they are in first grade at primary school. As they have learnt Chinese phonetics, they can read extensively by themselves and even write sentences and essays combined with phonetics and characters by the computer.

Therefore, traditional instruction that splits literacy, reading and writing should be reformed. We should integrate the three instruction sessions and use this as an instructional model of Chinese language learning, delivering a trinity of literacy, reading and writing in the low and middle grades. With the help of ICT, teachers can utilize online multimedia education resources (most are riddles, stories, children’s songs, essays and fables which are interesting and include pictures, words and sound) to enhance this new integrated instructional model of Chinese language learning. The combination of ICT and a new integrated instructional model means that teachers can easily reach or even exceed the new curriculum’s recommended literacy and reading levels through extensive reading, sentence composition, children’s songs and essays in class, all without putting a further academic burden on the pupils. At the same time, the students’ ability to use the language and their intelligence will also be greatly improved.

According to the phased learning task\(^2\) of first language (L1) learning, the Chinese teaching mainly includes:

1. The literacy instruction model of the lower grade

   In the traditional literacy instruction in Chinese, the teacher usually picks out the new words for the students to memorize and arranges them so that they can better recognize and remember them. The students are supposed to mechanically memorize without any specific occasion, thus the dull process can hardly help them to understand. The literacy instruction model for the lower grades has integrated the three sessions, namely literacy, reading and writing into a trinity which will be practiced in class. This model divided a class into three parts. The first part involves teacher-centered learning for 20 minutes. In the second part the students complete the reading for 10 minutes, and the third part concludes the session with the 10 minute writing practice. As shown in Figure 1, the students can learn themselves with laptops or tablets to finish the reading and writing practice.

\(^2\) Chinese language learning is divided into different stages in primary schools, learning tasks for students in lower grades (Grade 1 and Grade 2) are mainly literacy-based, whereas in the higher grades reading and writing are the major tasks.
(2) The intensive reading instruction model in middle and senior grades

Reading is a process in which the students make use of the knowledge and experience they have gained to conduct multi-level interaction and meaning-establishment. Students are supposed to go beyond the text to understand the background of the articles, to comprehend the underlying ideas as well as to grasp the writing skills and expression style of the authors. As the leader of the teaching and learning in class, the teacher should guide the students to experience the process of reading by providing resources, tools and various activities. The ICT environment can provide abundant resources, effective platforms and procedural support for the students’ language sensibilities, along with encouraging students’ aesthetic appreciation of literature, language application, and the development of their reading abilities. Figure 2 shows that the development of students’ reading abilities consists of three progressive periods of understanding, aesthetics and application. These form the design theory for the intensive reading instruction model.

Figure 1: The procedure of the instruction model (in a tablet environment)*

Figure 2: The procedure of the development of students’ reading abilities
The critical factors of the intensive reading instruction model supported by information technology are “extending, typing, writing and understanding, and thinking” (He, 2005). Extending means that there should be an appropriate time frame in which students can read extensively with the help of technology. Typing refers to the importance of computer typing; the multimedia classroom is equipped so that computer typing can also serve as a cognitive tool for students. Writing involves the notion that computer writing practice should occur in the latter half of phonetic instruction. Understanding refers to the idea that in the teaching of symbols, words, sentences and paragraphs, the teacher should stress the reading comprehension of the article rather than spending too much time explaining the vocabulary. Thinking means that we should develop the students’ thinking ability, especially critical thinking and creative thinking, when stressing the importance of the language learning.

Second language learning supported by information technology: the instruction model of English

The traditional English teaching methods emphasize reading and writing, while linguistic communication is neglected. This paper raises the basic model of English teaching which centers on language sociability as shown in Figure 3 (the tablet environment is selected as an example).

Learning a second language is quite different from learning one’s mother tongue. According to He (2004), there is a rule that mutual language interaction with a real person is an essential condition for the learner to acquire the abilities of listening and speaking. Therefore, second language learning should center on language communication instead of grammatical analysis, word explanation, listening, reading or writing training. The instruction model of English contains the following three teaching sessions: the first session is a teacher-student dialogue guided by the teacher whether the aim is to learn new vocabulary or new sentence patterns. The teacher can dialogue with individual students or all the students. When dialoguing with individual students, a different strategy is used by the teacher. The dialogue with higher-ability students is always used as an example in class; while the dialogue with the students who need to improve is always used as a learning diagnosis and a consolidation exercise. The second session is to stress the dialogue between the students sitting side by side (the pair-dialogue can complement the teacher-guided dialogue). The third session is to stress the extensive reading. Two criteria should be met before achieving this: one is to provide interesting listening and reading material which is closely related to the content of the language textbooks; each
section in the textbook should be matched with 4~5 pieces of material (its quality and quantity should be guaranteed). The other is to make sure the students have sufficient time to listen to the material in the class by reasonable teaching design.

Simultaneously, five strategies such as listening, speaking, reciting, singing and role-playing are featured in the practice stages of second language learning. Listening refers to listening to children’s songs, stories, and jingles. Students can speak to the microphone in the tablet, record what they say and then play it back to listen to what they’ve said. The teacher should make full use of the multimedia technology to create an adequate listening environment. Speaking means that the teacher should utilize the Internet and face-to-face dialogue to encourage the students to speak; they can speak to themselves, talk in pairs or discuss in groups. Reciting refers to reciting children’s song, maxims, idioms or known passages. The students can spontaneously master the grammar and language sense when reciting. Singing can make the teaching content prosodic. This practice can not only create a relaxed class atmosphere to pique students’ interest, but it can also develop the students’ language sense while experiencing the beauty of artistry. Some of the teaching content is full of plots, so the teacher can ask the students to read and listen to the text, and then have them try playing the role with the textbooks closed. In this process, the students’ capabilities of expression and communication are further developed.
The implementation procedure of the project

Since the project started in 2000, the team has had approximately 16 years to explore and promote the language learning pedagogical model. The history and critical issues of the e-learning project are shown in Table 1.

Table 1: The critical issues of the project

<table>
<thead>
<tr>
<th>Time</th>
<th>Critical Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2000</td>
<td>The project was launched in Nanshan Experimental School in Nanshan district of Shenzhen. 80 students in two 1st grade classes joined the project in September 2000.</td>
</tr>
<tr>
<td>The end of</td>
<td>The number of Experimental Schools in Nanshan district expanded to 14.</td>
</tr>
<tr>
<td>2004</td>
<td></td>
</tr>
<tr>
<td>In 2007</td>
<td>The project was launched in Singapore. And it was comprehensively promoted locally and known as “Ten Point Chinese”.</td>
</tr>
<tr>
<td>Up to Jan,</td>
<td>28 experimental areas have been established in China so far, more than 400 middle and primary schools and more than 100,000 students have joined the project.</td>
</tr>
<tr>
<td>2016</td>
<td></td>
</tr>
</tbody>
</table>

Support for information technology in language teaching and learning often occurs in the Internet-accessed learning environment. The schools with technical devices can have students study in the multimedia classroom or in the one-to-one digital classroom, in which each student can have at least 1 digital device to help them learn. At first, the students mainly use laptops or the multimedia computer laboratory to study, but in recent years, more and more schools have started to use tablets in their teaching.

The project group has developed comprehensive digital resources for English and Chinese lessons from grade 1 to grade 9 in primary schools. The resources have covered all versions of textbooks in different areas of China. Moreover, the digital learning platform Vclass has been developed. Vclass is similar to the popular, much-used digital learning platform Black Board; it can support teachers in preparing their lesson online and in implementing interactive teaching and learning on the platform.
**Goal of the Project**

The goal of the project is threefold. Through the deep integration of information technology into the curriculum, the project hopes to, a) help the students recognize and remember 2500-3000 frequently-used Chinese words, b) to smoothly read common reading material and c) to compose a fluent article with 800-1000 words within 2 years after of attending school without surpassing the normal amount of class and schoolwork hours (the children aged 7 to 8 are supposed to already be able to read and write). This goal will be achieved within at least 10 semesters (when the children are in grade 5 or 6) according to the new curriculum standard (He, Ma, 2005; He, 2005). Compared with the traditional educational goals, this project shall improve the efficiency of the educational curriculum.

Through the English program of study in primary school, the students are supposed to make obvious progress in vocabulary, listening and expression. Within 4 to 6 years, we aim to help students mastering 3000 normally-used English words and to overcome their difficulties in listening, speaking, reading and writing. According to the newly-released curriculum standard, students who join the project in 1st grade can reach the 8th level in vocabulary, listening and speaking when they graduate from primary school. The 8th level is the equivalent to the level of a senior middle school graduate (He, 2014). Their performance in normal tests is better than that of students from the non-treatment class, and they are armed with the capacity for cross-cultural communication.

**The main process and work of the project**

In the implementation of the project, the following work sessions of work are included:

(1) The establishment of the e-learning environment

The school in the project should establish a one-to-one digital classroom which has access to the Internet or a campus network to obtain study resources for synchronized or desynchronized learning activities. The Vclass platform should be installed for online teaching and management purposes. A Learning Cell community will be established in this session to realize coordinative lesson-preparation, resource pushing and teachers’ remote training.

Learning Cell (http://lcell.bnu.edu.cn/) is an original learning resource platform. The resources on the platform are attached with tabs of semantic description, related learning activities, learning tool and interpersonal networks. The learning resource on the platform is open, generative, evolitional, and sociable. It supports information collection and online sharing in the process of
learning, which can effectively contribute to the students’ learning (Yu, Yang, Cheng & Wang 2015).

(2) TPACK training (Technological Pedagogical and Content Knowledge) capability for the teachers

Mishra and Koehler (2006) conceptualized technological pedagogical content knowledge (TPACK) as teachers’ know-how for drawing upon their technological knowledge, pedagogical knowledge and content knowledge to design ICT lessons. With the TPACK model, the project has formed a comprehensive capability training plan for the teachers’ digital teaching. The project has a 3 year cycle. The project will provide specific training content according to the level of the teachers’ digital teaching.

(3) The implementation of coordinative teaching research supported by the Learning Cell platform.

After understanding the instruction model in the training sessions, the project group will create an online learning community similar to a social network for every experimental area (or school) on the Learning Cell platform. Instruction plans and learning resources are created and shared as well as collaboratively revised in the learning community. The project will provide instruction guidance and present teaching resources to the teacher through the community. Remote coordinative instruction design will also be organized to help the teachers to master the language teaching skills supported by information technology. Teachers can prepare their lessons coordinately to design high quality digital instructions. In this coordination, all the teachers have established an interpersonal network. They can meet the experts in this field which will be beneficial to their professional development.

(4) The implementation of the curriculum and targeted guidance of class observation and assessment.

Once the coordinative lesson preparation is completed, the teachers communicate with local researchers, principals and the teachers from experimental schools in the form of an open class or seminar. The project will instruct the teachers to observe classes in the experimental school, and they have the opportunity to communicate with the teachers face to face after class. As the number of experimental schools increases, the project groups will organize cross-region and cross-school class observations to carry out continuous teaching research. The field class can be a link to the remote coordinative teaching research and communication. Teachers’ understanding of the teaching concepts, models and methods in the experimental schools will be improved through collective lesson preparation, class observations, group discussion, comments from program members, and class assessment by the representatives among the teachers, by the researchers and by the heads of certain programs.
Research questions

This study aims to verify the effectiveness of the pedagogical model in language learning. Based on the goals of the project, the research questions are:

1. Whether the students have reached the target level of literacy in advance after one year of the experiment?
2. By teaching and learning with the language-application-centered pedagogical model, are there any differences in Chinese and English language abilities between the test students and control students?

Research method and tools

Research method

The case study method has been adopted in this research. From all the areas and schools which have joined the project, we selected the project in Q County in the Hebei Province as the case. Q is a Manchu autonomous county located in a rural area. The teaching quality is relatively inferior to that in the urban environment, and the teaching resources are rather poor. The school of this kind has its own typicality and particularity.

Research tools

This research on language ability mainly focuses on the number of recognized characters, the reading ability and the writing ability of learners. We use the 3108 Chinese characters in the Chinese primary school curriculum standard as the material to test how many characters students can recognize. The project has also developed a Chinese language proficiency exam to test the students’ literacy, reading comprehension and writing abilities. The paper has been tested with internal consistency reliability; the coefficient of the whole Cronbach's $\alpha$ is 0.73, which is a high reliability. Our project also uses the English language proficiency test paper to examine the students’ abilities in listening and writing.

Research on language ability: case study of Q County

The process of the research

Since 2011, 174 English and Chinese teachers from 32 primary schools have participated in this experiment. Among them, all the students from the First Experimental Primary School and the Second Experimental Primary School have participated in the project. Until June 2014, 4218 students had participated in the project over a total of three terms. They had used these models in their language
learning continuously for three years. During these three years, 21 activities including surveys, teacher training, class observations and assessments and learning tests for the students were organized. There were 180 class observations in total.

The project group has established a study community on the Learning Cell platform. In the community, the schools are organized into online teaching and research groups, each of which contains 5 to 8 people. Here, the teachers are supposed to participate in the online teaching research activities according to the plans. They submit and update the instruction design plans on the platform and give feedback each month to the e-learning project manager group on the online instruction research. Those online collaborations are becoming routine works gradually. At the end of each month, a typical class was demonstrated for observation and assessment. Experts from BNU went to the schools to instruct the teachers who joined the program through the class observation.

In the class observation, the experts from BNU observed and recorded their observations very carefully; after the class, they communicated with the teachers. The class teacher shared his or her reflections on the lesson and the experts shared their recommendations. Finally, the experts gave advice on the education instruction, including the highlights and areas for improvement of the observed class. The experts were also on hand to help resolve any instruction-related problems the teachers may have had.

**The results**

(1) The results of the number of recognized characters

As the one-year experiment ended, the project group organized a test for all the 2nd and 3rd grade students on the number of characters they could recognize. In the test, the 3108 Chinese characters in the Chinese primary school curriculum standard were used as the material. The students were asked to recognize them one by one. The results of the test are shown in Table 2:

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>The average amount of recognized characters in grade 2</th>
<th>The average amount of recognized characters in grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>The First Primary School in Q county</td>
<td>779</td>
<td>2826</td>
<td>3024</td>
</tr>
<tr>
<td>The Second Primary School in Q county</td>
<td>500</td>
<td>2422</td>
<td>2899</td>
</tr>
<tr>
<td>Rural treatment school</td>
<td>129</td>
<td>2232</td>
<td>2810</td>
</tr>
</tbody>
</table>
The curriculum standard -- 1600-1800 2200-2500

From the test results, we can see that the average amount of recognized characters among the 2nd grade students in the rural treatment school is 2232, while that of the 2nd grade students in the rural control school is 1956. The treatment school is higher by 276. The average amount of recognized characters among the 2nd grade students in the treatment class of the First Primary School in Q County is 2826, while that of the Second Primary School is 2422.

After a year of learning, the average amount of recognized characters among the 3rd grade students in the rural treatment class is 2810, while in the rural control class that number is 2462. The experimental class is higher by 348. The average amount of recognized characters among the 3rd grade students in the treatment class of the First Primary School in Q County is 3024, while that of the Second Primary School is 2899.

(2) The results of the language ability

The test on Chinese language ability mainly included the students’ abilities in literacy, reading and writing. The literacy test aimed to test the flexible application of the character pronunciation and the character pattern. The score of this section was out of a total of 40 points. The reading ability section featured two articles between 200 to 300 characters of different styles and with different difficulties to test the students’ reading apprehension. The score of this section was out of a total of 30 points. In the writing ability test section, students were supposed to complete a composition and present it as an imaginative story. The score of this section was out of a total of 30 points. Students were given 50 minutes for the literacy and reading abilities test, and 30 minutes for the writing ability test. The test lasted for 80 minutes in total.

The results of the test are shown in Table 3. Table 4 illustrates that there is a significant difference between the rural treatment and control classes in terms of both recognized characters and their literacy, reading and writing abilities. This indicates that the students in the treatment schools have made great progress in the Chinese language, especially in writing.

<table>
<thead>
<tr>
<th>Rural control school</th>
<th>233</th>
<th>1956</th>
<th>2462</th>
</tr>
</thead>
<tbody>
<tr>
<td>The curriculum standard</td>
<td>--</td>
<td>1600-1800</td>
<td>2200-2500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th>Characters and words</th>
<th>Reading</th>
<th>Writing</th>
<th>Points in total</th>
</tr>
</thead>
<tbody>
<tr>
<td>The first Primary School in Q county</td>
<td>779</td>
<td>36.21</td>
<td>24.32</td>
<td>24.80</td>
</tr>
</tbody>
</table>
The Second Primary School in Q county
Rural treatment school
Rural control school

<table>
<thead>
<tr>
<th></th>
<th>Treatment class</th>
<th>Control class</th>
<th>T Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academic performance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characters and words</td>
<td>34.33±4.01</td>
<td>29.80±3.03</td>
<td>1.82*</td>
</tr>
<tr>
<td>Reading</td>
<td>23.00±2.00</td>
<td>19.60±4.10</td>
<td>1.32*</td>
</tr>
<tr>
<td>Writing</td>
<td>23.67±1.53</td>
<td>19.31±2.96</td>
<td>2.67**</td>
</tr>
<tr>
<td>Points in total</td>
<td>81.00±6.25</td>
<td>69.71±4.00</td>
<td>3.10**</td>
</tr>
</tbody>
</table>

The English language ability test sheet contained two parts, a listening section and a writing test with a total of 60 points available. The results are shown in Table 5.

Table 5: The test outcome of English as an independent sample (M±SD)

<table>
<thead>
<tr>
<th></th>
<th>Treatment class</th>
<th>Control class</th>
<th>T Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academic performance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listening</td>
<td>26.72±2.69</td>
<td>17.85±3.53</td>
<td>4.63***</td>
</tr>
<tr>
<td>Writing test</td>
<td>25.62±2.06</td>
<td>18.68±2.07</td>
<td>5.38***</td>
</tr>
<tr>
<td>Points in total</td>
<td>53.65±5.50</td>
<td>36.55±5.07</td>
<td>5.21***</td>
</tr>
</tbody>
</table>

The average score of the students in the rural treatment class is higher than that of the rural
control class, which shows that the English pedagogical model has the potential to greatly improve students' English ability.

**Discussion**

The instruction model has carried out a language-application-centered pedagogical thought. Teachers need to change their learning behavior in their classes and reduce the time allocated for rote learning. Now, in both English and Chinese lessons, teachers always take the last 10 minutes practice section seriously by expanding students’ reading or writing skills, or asking students to produce individual and interactive stories by using tablets or other devices. Compared with the traditional language pedagogical model, new models pay more attention to expression and communication, which helps the teaching and learning process become more active and interactive for all parties involved. Students no longer follow the teachers to mindlessly repeat words and sentences over and over again, instead, they read, listen and write within a clear context which is provided and elaborated by language teachers. Students learn the language in an authentic context, which not only leads them to the internalization phase of language learning, but also enables them to understand and experience how the characters, words, and sentences can be used in real life.

There are some differences between Chinese and English learning. The learning activities in Chinese classes emphasize students' reading and writing. Students need to read more extensive materials in addition to their textbooks as well as complete some imitation writing tasks. As Chinese is their L1, students already had enough vocabulary and language skills to understand and express themselves before they came to school; what they lack at this stage is literacy ability. In traditional classes, literacy is often divorced from an authentic context, resulting in a lack of meaningful understanding. In a similar manner, reading and writing training only occurs in high grades in primary schools, which restricts students’ ability to use their native language. The language-application-centered Chinese instruction model avoids the shortcomings of traditional learning so that the students who join the project can reach literacy targets early, and achieve great progress in their Chinese language ability, especially in reading and writing.

English is a second language; some students have not studied English before primary school. Due to the lack of opportunities to use the language, and the lack of cultural background, students have difficulties understanding English. The English instruction model focuses on communication in language learning, plenty of oral and listening training has been done in class. Multimedia materials are used to create English cultural contexts which compensate for the lack of authenticity in second language learning. In the study, students who joined the project demonstrate a significant superiority
in listening and writing when compared with the students who did not participate. The English instruction model also promotes the students’ intercultural communicative competence, consisting of cultural knowledge and culture awareness (Wang, Yu, 2014). It is conducive to the development of students’ 21st century skills in an age of globalization.

However, fulfilling the pedagogical model is not easy in the classroom, as the individual needs of each student are highlighted when the unified guidance from the teacher was reduced. The e-learning project is supposed to provide realistic, native-speaker models of the language in a variety of media, offer a language learning curriculum, and record what the student has done along with an overall evaluation (Warschauer, Healey, 1998). In the project, one-to-one learning environments were constructed with the help of laptops and tablets. These learning environments fulfill the need for individual development of each child. As the medium of intelligent one-to-one learning, laptops and tablets have enriched information resources and break the traditional form of teaching. Thanks to this technology, each student in the classroom can choose a learning resource that meets their needs in an almost tailor-made fashion, and read, express and share it with their peers. Students are engaged in cooperation and communication with the teacher and their peers through ICT used within the language-application-centered pedagogical model.

It is worth adding that the project always tries to help students who cannot afford such advanced ICT devices, because in China the level of education development is unbalanced between urban and rural areas. The project tries to bridge this gap by properly integrating the technology and instructional activities. The key issue for the success of the project is to apply the language-application-centered pedagogical theory in different technological environments. The students can access the internet to search for reading material or communicate with someone – even a native speaker - outside the classroom in a one-to-one learning environment. In rural areas, even without any digital technology, students still could access various reading resources from printed material provided by the project. The active and individual learning activities thus guarantee that students in rural areas have the possibility to reach a similar level of achievement as the urban students.

Conclusion

The results demonstrate that, after three years of the project experiment, Q County students in Chinese and English have made significant academic progress. The 2nd grade students in the treatment schools approached or even exceeded the curriculum requirements for 3rd or 4th grade students. The number of characters they could recognize reached 3000 when in 3rd grade. The students from the
treatment class recognized more characters than the students from the rural control class. The latter reached the standard amount of recognized characters for the primary period. The goal of the project has been successfully met.

In the project, the results on Chinese language ability demonstrate that, like the English class, the students in the project are better than the non-project students in literacy, reading and writing. In the English class, ICT was involved in the students’ language communication and provided learning material and a means of communication for the students. It strengthened the students’ oral expression and listening practice, and improved their sense of language. In both the Chinese class and the English class, there is a significant difference between the treatment class and the control class, which indicates that the instructional model centered on language application has clearly demonstrated its powerfully positive effect.

**Future works**

In this project we just focused on one specific case, and in the future we would like to gather more schools and historical data to analyze, and, thus, provide more reliable evidence to evaluate the outcome of the project.

**Acknowledgements**

We would like to thank the great team led by Professor Kekang He and Professor Shengquan Yu for their fantastic support. We are also grateful to the members of this project: Juan Wu, Ning Ma and Ling Chen who offered the precious material and resources.

**Reference**


7. A study on the online learning behaviors of secondary school students

Xiaomeng Wu

Graduate School of Education, Peking University, Beijing, China

Abstract

The study investigates the characteristic differences among student learning behavior patterns and explores the existence of behavioral differences in terms of grade and gender. The actions of 110,156 secondary school students in an online learning environment were documented in a log file and statistically analyzed. The results reveal that 5936 students participated in some online learning activities. Among these students, three distinct patterns are discerned: active learning participants, socially active participants and less active participants. Comparison between genders reflects no significant difference in learning behaviors. Comparison between grade groups indicates that 7th grade students tend to learn for longer periods of time than older students, while 7th and 8th grade students tend to participate in more social activities than 9th grade students. Our conclusion indicates that although educators have developed a huge online learning resource, it is necessary to encourage young students to use this resource effectively.

Introduction

Starting with the Open Educational Resource movement, there has been tremendous growth in online open learning resources for self-regulated study. Imitating the Khan courses, Chinese teachers in primary and secondary schools developed a kind of online learning resource called “micro-lessons”. They are short videos approximately 8 to 10 minutes in length. Each focuses on one knowledge point taken from textbooks, such as “addition under 10”. Invested in by the educational government and corporations, these micro-lessons have accumulated quickly over the past 2 to 3 years. The underlying assumption of developing micro-lessons is that this kind of short and highly-focused educational resource will be consciously and conveniently used by students after school to review the target knowledge in order to improve their performance. Some developers even expect that this kind of resource could replace extracurricular training institutes.

Earlier research on the use of educational resources has demonstrated that students do not access resources frequently (Wang, Liu & Zhu, 2013; Chen, Weng, 2014). According to a survey conducted by CNNIC (China Internet Network Information Center), the main online activities of
middle school students are real-time communication, entertainment and web surfing. Students spend little time learning online (CNNIC, 2013), which suggests the danger that the utilization of online educational resources may not be efficient. Therefore, there is still doubt regarding the benefits of the massive development of micro-lessons.

This research stems from the conviction that a better understanding of learners will improve the efficiency of the utilization of online educational resources. By describing and analyzing the online behaviors of pupils, this research aims to provide suggestions for educational resource designers and policy makers.

**Purpose of the Study and Research Questions**

The purpose of this study was to describe the online behavior of school students. This behavior was examined within an online learning environment which was designed for the students to complete micro-lessons, conduct virtual scientific experiments and participate in some online social activities. A log file was used for data analysis. The results of the study provide a better understanding of the online behavior patterns of school students in China.

Learning in an online environment is obviously different from the traditional face-to-face classroom, especially when the learning is not obligatory. The designers and policy makers refuse to speculate on the students’ online behaviors according to their performance in the traditional classrooms. The question remains, therefore, as to what the students do in an online environment? In order to address this problem, two main issues need to be resolved, namely (1) what do the students do online, and is there any characteristic difference among students’ learning behavior patterns in the online learning situation? And, (2) are there any significant differences according to gender and grade?

**Students’ online learning behavior literature review**

Liang, Wang and Hung (2008) used the two-stage cluster analysis method to explore the identification and classification of the learning behavior patterns of school students according to the six variables of Study, Handbook, Exercise & Test, Project, Social Corner, and Access Time. They found three distinct patterns among the students: Active Participants (31.6%), Enthusiastic
Participants (5.0%), and Lower Participants (63.3%). Enthusiastic Participants seemed to be interested in Social Corner activities and visited each forum an average of three times more than the total mean value of the students. They were spontaneously involved in learning and almost all completed the online tasks on schedule every time. Active Participants were interested and involved in online learning with the assistance of their parents. Their variables values were all higher than the others students’ mean values, excluding the Handbook ratio. They were less involved in the Handbook activities. Lower Participants constituted the largest group. All variables for this cluster were lower than all the mean values of the students. Most of the Lower Participants seemed only interested in the Handbook activities (Liang, Wang & Hung, 2008).

Ben-Zadok, Leiba and Nachmias (2010) compared learning behaviors in an online science learning environment – in school vs. at home - and explored the existence of some behavioral differences in terms of age and gender. They found that students who learned at home tended to spend more time learning but at a slower pace. And their scores were higher on tests than students who learned in school. Comparison between age groups indicated that younger students tended to learn for longer periods of time, at a slower pace, and complete fewer activities than older students. Comparison between genders, on the other hand, reflected similar learning behaviors for boys and girls (Ben-Zadok, Leiba, & Nachmias, 2010).

Chinese scholars Duan, Guo and Zhao (2007) carried out a survey on online learning among middle school students. They used six variables: attention, self-control, motivation, emotion, learning habits and computer capability to explore the online learning of middle school students. The survey showed that most of the students had adapted to studying online, although approximately 30% of the students had some problems concerning the variables of attention, self-control, motivation, emotion when they studied online. The result also showed that there was no significant difference between boys and girls in terms of self-control, emotion and learning habits, but they demonstrated a significant difference concerning the variables of attention, motivation and computer capability (Duan, Guo & Zhao, 2007). Another survey, which focused on high school students, reported that 96.7% of the students studied online just because their teacher asked them to do so. Only 10% of the students felt confident in staying focused on the online study tasks (Hu, Wang, 2013)
Methodology

The online learning environment

The online learning environment, the subject of our research, is a part of the educational innovation of a local education bureau in south-east China. Hoping to cultivate self-regulated online learning among school students, the local educational bureau developed the website Qingguo Online (http://www.qingguo.me/) in July, 2014. This online learning environment aims to provide a vast array of learning resources to support students’ home study. The website features micro-lessons and virtual scientific experiments classified according grade and subject. The content of these micro-lessons and virtual experiments are limited to topics from the 7th grade curriculum through to the 9th. The website also has a question and answer forum to encourage discussion among students on learning content. The website is arranged for teachers to answer students’ questions online. Besides learning resources, the website provides a personal cyber-space for users to introduce themselves, and the young students can be “board master” and establish a discussion board according their hobbies. The website is accessible for all secondary students in public schools, and students log on the website using their school ID. Although Qingguo has been broadcasted to every secondary school, online learning is voluntary. We are interested in the following aspects: how many students participated in the learning activities voluntarily in this online learning environment established by the local education government; what they do online, and are there any characteristic differences among student learning behavior patterns in this online learning situation.

Participants

The participants in this study were secondary students in public schools. The total number of participants was 110,157. All of them were able to visit the online learning environment with their school ID.

Data was collected during the second semester of a school year, from February 2 to July 10, 2015. Among the 110,157 middle school students, the number of students who completed at least one online activity of their own accord was 9413 (8.5%). Among this group of students, 5936 visited the online learning materials, such as micro-lessons and virtual scientific experiments, while the others preferred the social value of the website. Since this study focused on online learning behaviors, the data of those 5936 students were analyzed.
Data collection and analysis

Traditional research methods such as questionnaires or observations based on self-reports and traditional observations are practically impossible with such a large number of subjects. However, an analysis of log files provides an opportunity to learn about the behaviors of a large population of students and collect data on their actual behavior in a non-intrusive way (Ben-Zadok, Leiba, & Nachmias, 2010).

The system profile of each student included categories such as school name, grade, gender, time spent watching micro-lessons, time spent doing virtual scientific experiments, time spent asking or answering questions, amount of participation in virtual communities, and the number of documents in their personal space. These categories were used as variables for analyzing student learning behavior in this study, and they are described briefly as follows.

1. Lessons Studied: recorded the total number of times each student accessed the micro-lessons. Math, Physics, Chemistry, Chinese, English, and Biology all have micro-lessons which can be studied by students.

2. Virtual Experiment: recorded the total number of times each student completed a virtual scientific experiment. Physics and Chemistry have virtual experiments.

3. Interaction: recorded the total number of times each student asked or answered study questions on the discussion boards.

4. Social Activity: recorded the total number of virtual communities which a student had organized or participated in.
(5) *Self-Presentation:* recorded the total number of documents which a student presents in his/her personal space.

To address the first research question of the study, the K-Means cluster analysis method was used to group the behavior of students. The Independent Sample t-Test was used to explore the significant differences in the online activities of boys and girls and a one-way ANOVA was performed to determine the differences between students according to their grade to answer research question 2.

**Findings**

*Analysis of the learning material studied by the students*

The assumption about the Qingguo online learning environment was that learning material would be learned by the students of their own initiative if there were enough resources and if they were of a high enough quality. The local education bureau designed this website to assist after school study, especially when the students needed to preview or review their lessons. But the students who had actually studied on Qingguo were few according to the statistics showed in Fig.1. It was necessary to investigate the online learning – or lack of – in more detail.

The study chose Math as the subject of analysis because Math is a subject that all the grades have. Qingguo provided Math micro-lessons for the students to learn online. These micro-lessons were organized into categories according to grade and semester. Each semester included about 20 to 30 micro-lessons. Table 1 showed the mean value of the number of micro-lessons which were watched by students of different grades. Although there were 20 to 30 micro-lessons for each semester, the average number of times lessons were watched was low.

Table 1. Number of times Math micro-lessons were watched among different grades

<table>
<thead>
<tr>
<th>grade</th>
<th>7th grade micro-lessons</th>
<th>8th grade micro-lessons</th>
<th>9th grade micro-lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st sem</td>
<td>2nd sem</td>
<td>1st sem</td>
</tr>
<tr>
<td>7th</td>
<td>N</td>
<td>Valid</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td>2918</td>
<td>2918</td>
<td>2918</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean</td>
<td>2.12</td>
<td>4.40</td>
<td>.48</td>
</tr>
</tbody>
</table>
The data showed that the students from each grade mainly studied the micro-lessons of their current semester. For example, as the data was collected during the second semester of school year; (7th grade - 2nd semester) M = 4.4, (8th grade – 2nd semester) M = 2.70, (9th grade – 2nd semester) M = 1.23. These mean values were the highest ones compared to the other semesters. Students also reviewed some knowledge points from the previous semester. For example, (7th grade – 1st semester) M = 2.12, (8th grade – 1st semester) M = 0.56, (9th grade – 1st semester) M = 1.09. Some students did study some micro-lessons from other grades, for example, grade 8 watched lessons from grade 7, but the mean value for this was much lower (M=0.53 or M=0.12).

**Learning Behavior in terms of Gender**

Comparison in terms of gender by the mean value of the variables Lesson Study, Virtual Experiment, Interaction, Social Activity, Self-Presentation, which were defined above as describing the behavior of the students, indicated slight differences between boys and girls. Table 2 shows that the boys (M=36.9416) took part in more social activities than girls (M=23.7700). But the independent sample t-Test showed that there was no significant difference in online behaviors between boys and girls (Table. 3).

Table 2 Comparison between boys and girls by the average variables
<table>
<thead>
<tr>
<th></th>
<th>Girl=0 (N=3113)</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boy=1 (N=2823)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lessons Studied</td>
<td>0</td>
<td>7.44</td>
<td>12.83</td>
</tr>
<tr>
<td>Virtual Experiment</td>
<td>0</td>
<td>.51</td>
<td>1.79</td>
</tr>
<tr>
<td>Interaction</td>
<td>0</td>
<td>6.81</td>
<td>29.06</td>
</tr>
<tr>
<td>Social Activity</td>
<td>0</td>
<td>23.77</td>
<td>181.80</td>
</tr>
<tr>
<td>Self-Presentation</td>
<td>0</td>
<td>28.34</td>
<td>79.48</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>17.11</td>
<td>76.43</td>
</tr>
</tbody>
</table>

Table 3 The results of Independent Samples t-Test on gender

<table>
<thead>
<tr>
<th></th>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Lessons studied</td>
<td>Equal variances assumed</td>
<td>3.850</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
<td></td>
</tr>
<tr>
<td>Virtual Experience</td>
<td>Equal variances assumed</td>
<td>11.477</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
<td></td>
</tr>
</tbody>
</table>
Table. 4 Multiple Comparisons of grades

<table>
<thead>
<tr>
<th>Dep. Variable grade</th>
<th>(I) grade (J)</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lessons Studied</td>
<td>7 8</td>
<td>2.524*</td>
<td>.371</td>
</tr>
<tr>
<td></td>
<td>7 9</td>
<td>2.090*</td>
<td>.575</td>
</tr>
<tr>
<td></td>
<td>8 9</td>
<td>-0.4341</td>
<td>.588</td>
</tr>
<tr>
<td></td>
<td>7 8</td>
<td>-0.091</td>
<td>.052</td>
</tr>
</tbody>
</table>

1.1 Learning Behavior Between Different Grades

Comparison of the five variables across grades revealed some significant differences. Using LSD (Least Significant Difference) for multiple comparisons showed that 7th grade students differed significantly from 8th and 9th grade students regarding micro-lesson watching. The 7th grade differed significantly from the 9th grade in interaction and social activities. The 8th grade differed significantly from the 9th also in terms of social activities. There was no significant difference in doing virtual science experiments and self-presentation among grade groups.
1.2 Identification of the Online Learning Behavior Pattern

Based on the five variables of Lessons Studied, Virtual Experiment, Interaction, Social Activity, Self-Presentation, this study intended to find the learning behavior patterns among students using the Qingguo online learning environment and to describe the characteristic differences among these patterns. A correlation among variables was found by Pearson’s product-moment correlation. The data reduction process was executed using factor analysis. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett’s Test of Sphericity (BTS) are applied to the data prior to factor extraction to ensure that the characteristics of the data set are suitable for exploratory factor analysis. In this study, KMO was .638, above the minimum value of .5, and BTS was significant, \( \chi^2 = 8244.889, p < .05 \), supporting the factor analysis (Xue, 2010). Factor analysis was conducted with all 5 variables by principal component analysis. Two components were extracted; learning activities and social activities. The total variance explained was 65.933%.

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sum of Squared loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
</tr>
<tr>
<td>1</td>
<td>2.231</td>
<td>44.616</td>
</tr>
<tr>
<td>2</td>
<td>1.066</td>
<td>21.318</td>
</tr>
<tr>
<td>3</td>
<td>.873</td>
<td>17.453</td>
</tr>
<tr>
<td>4</td>
<td>.644</td>
<td>12.887</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the .05 level.
Table. 6 Component Matrixes

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lessons studied</td>
<td>.322</td>
<td>.605</td>
</tr>
<tr>
<td>Virtual experiment</td>
<td>.115</td>
<td>.812</td>
</tr>
<tr>
<td>Interaction</td>
<td>.908</td>
<td>-.117</td>
</tr>
<tr>
<td>Social activities</td>
<td>.698</td>
<td>-.131</td>
</tr>
<tr>
<td>Self-presentation</td>
<td>.896</td>
<td>-.101</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis

a. 2 components were extracted.

The K-Means cluster analysis method was used to group the behavior of students into three patterns. Table 7 presents the descriptive statistics for students’ profiles and the number of cases in each cluster.

Table. 7 Final Cluster Centers

<table>
<thead>
<tr>
<th>Cluster</th>
<th>1(N=38)</th>
<th>2(N=5643)</th>
<th>3(N=255)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning activities</td>
<td>9.240</td>
<td>-.086</td>
<td>.529</td>
</tr>
<tr>
<td>Social activities</td>
<td>-1.355</td>
<td>-.151</td>
<td>3.547</td>
</tr>
</tbody>
</table>

The three clusters were named Active Learning Participants, Less Active Participants, and Socially Active Participants. The characteristics of each cluster are detailed below.

(1) Cluster 1: Active Learning Participants

Thirty eight students (0.64%) were grouped into this cluster. This cluster was named Active Learning Participants due to the fact that their learning activities value was much higher than the others students’ mean values. That said, the Active Learning Participants actually seemed less involved in the social activities. The minus value (e.g. -1.355) meant that such students had a lower mean value for the participation in social activities in the online environment than the mean value of all students.

(2) Cluster 2: Less Active Participants
5643 students (95.1%) were grouped into this cluster, which was the largest group. All the variable values of this cluster were lower than mean values of other students. This cluster was named as *Less Active Participants* because of their lower level of participation.

(3) Cluster 3: *Socially Active Participants*

There were 255 students (4.3%) grouped into this cluster. This cluster was named *Socially Active Participants* because all the social activity variable values were higher than for the other two groups.

2. Conclusion and Discussion

This study investigated how many students voluntarily took part in the learning activities offered by an online learning environment established by the education government, what they did online, and if there were any characteristic differences among their online learning behavior patterns. The serious issue revealed by the study was that although the online learning resources were abundant, the target students’ usage was limited. The proportion of the students who actually learned online was only about 5%, and most of them were less active participants. The researchers of this study investigated the content of the learning resources deeply and found that the content of these micro-lessons were just the same as the classroom teaching. This perhaps suggests why the students had little interest in the micro-lessons; they simply repeated what students had already learned in the classroom. And this study suggests that learners’ needs should be carefully analyzed before developing the learning resources.

Various studies have explored the role of gender difference in online learning. The results of such research have been far from consistent. Some researchers have found that boys tend to use computers more frequently, have more positive self-efficacy and stronger value beliefs about computers compared to girls (Hakkarainen et al., 2000; Vekiri & Chronaki, 2008). Other research has revealed that girls tend to consume more online content than boys and read more messages in discussion groups (Leiba & Nachmias, 2006). In the Qingguo online learning environment examined in this study, boys and girls showed generally similar behaviors in terms of lessons studied, doing virtual experiments, asking and answering questions and presenting themselves in their space. Boys participated in more social activities such as managing or being part of virtual communities. However, the analysis showed no significant difference in their online behaviors in
term of gender. This result is in line with the study Ben-Zadok and her colleagues conducted on elementary schools in Israel (Ben-Zadok, Leiba, & Nachmias.,2010).

Comparison between grade groups with regard to online learning behaviors revealed that young students participated in more learning activities than their older counterparts. Of the three grades, 9th grade students were less involved in online learning than the other two grade groups. One suggestion is that 9th grade students have to take entry examinations for high school in China, and the heavy academic burden that accompanies this could mean that they have less time to study online. Another supposition is that the online resources are not very useful for 9th grade students to review their classes and prepare for the entry examination.

One of the implications of this result is that the massive investment in accumulating learning resources will not lead students to automatically use online learning facilities. The secondary school students in China have not yet formed the online, at-home study habits. Not only do they need to be motivated, encouraged, and stimulated, but they also need direction. Perhaps blended learning is a good start to guide the students in their online studying. The result of this study also implicates that many students see the online environment as a social place. They enjoy communicating online with others regarding study problems or topics that interest them. Perhaps the designers of the learning environment should develop some learning activities based on social learning theory to animate the group of Socially Active Participants to study online.

As the local department of education is consistently improving the Qingguo online learning environment and continues to advocate online learning, future research will investigate students’ online learning behavior in a more in-depth manner and try to find a pedagogy model that can integrate online learning into classroom learning.

References


PART 2. Personalized learning support in digitalized era

Finnish digital learning support for children with learning difficulties in Mathematics

Pirjo Aunio, Special Education, University of Helsinki

Abstract

The aim of this chapter is to describe the research and developmental work that has been done in Finland on designing evidence-based Web services for educators related to mathematical learning difficulties, assessment and interventions. The two Web services (LukiMat and ThinkMath) have been developed by two different, but related, research teams at the Niilo Mäki Institute (University of Jyväskylä) and the University of Helsinki. Together, the two evidence-based Web services include the knowledge base, assessment batteries and intervention tools to be used in relation to mathematical learning difficulties in the age group 5-10 years. The materials encourage educators to provide educational support for children according to the Responsiveness to Intervention model.

Key words: evidence-based, early identification, learning difficulties, low performance, mathematics
Introduction

The demand to bring technology to schools and early childhood education settings has been rising in most societies, supported by the idea that it will provide children with the possibility to learn important working life skills early on. However, we actually know rather little as to whether technology is really able to enhance academic learning in schools. In the field of mathematical skills learning, systematic literature reviews related to the effectiveness of computer-assisted-interventions (CAI) report significant but declining effects from 1985 up to today (see review Räsänen 2015). In these CAI-reviews, most of the technological solutions are designed for students of various achievement levels to use (e.g., Cheung & Slavin, 2013; Harskamp, 2015, Slavin & Lake 2008; Slavin, Lake & Groff, 2009). However, general educational meta-analysis (Hattie, 2008) has demonstrated that educators’ impact on students’ learning is also crucial. In this light, the notion of technological solutions supporting educators in increasing their pedagogical and subject knowledge becomes particularly interesting. International development in (special) education and its Finnish counterpart share main characteristics, thus a brief overview of international development is given before elaborating on the Finnish educational context.

Responsiveness to Intervention practice in supporting children with learning difficulties

At the beginning of the 21st century in the United States and Europe, the way to approach individuals with learning difficulties started to change. The focus shifted from diagnosing the individual in clinical settings to viewing individuals’ learning as part of his or her learning context and emphasizing the early identification of learning difficulties to provide early interventions (i.e., Responsiveness to Intervention, RtI) (Hallahan, Pullen & Ward, 2013). Responsiveness to Intervention is a pedagogical problem solving model, whose most important goal is to provide all children the most efficient instruction and intervention according to their needs (Jimerson et al., 2007). The instruction and support are divided into levels, which are often three levels of support: Tier 1, Tier 2 and Tier 3 (Riley-Tillman & Burns, 2009), but other tier systems also exist (Fuchs, Fuchs & Schumacher, 2011). Increasing levels means that the focus becomes more individualized, the support becomes more intensified and the support is provided over a longer period of time (Riccomini & Smith, 2011). RtI practice has increased the need for evidence-based tools that identify children who are at risk of learning difficulties and support those who struggle with learning.
Learning difficulties in mathematics

In the literature, there are several different terms used in relation to learning difficulties in mathematics, such as low performance in mathematics, learning difficulties in mathematics, mathematical learning disability, dyscalculia, mathematics disorder and many more. These various terms refer to different definitions (e.g., in terms of various cut-off scores) and different origins of the problems ranging from neurological dysfunctions to inappropriate opportunities to learn and practice mathematical skills (e.g., SES) (Mazzocco, 2009). Geary (2013), for instance, suggests that children who score at or below the 10th percentile on standardized mathematics achievement tests for at least two consecutive academic years are categorized as having an MLD (Mathematical learning disability) in research studies. He further suggests that all children scoring between the 11th and 25th percentiles, inclusive, across two consecutive years are classed as LA (Low Achievers). In addition, it is important to understand that mathematics performance, also at the lower end, is a continuum; there is no strict point where the problem starts. From an educational perspective, the vital message from educational intervention studies is that all these persons benefit from good quality education; for some this means more intense and longer periods of extra educational support, but practicing and teaching is still beneficial.

Evidence-based assessment tools

The Responsiveness to Intervention model not only emphasizes the research evidence on interventions used by educators, but it also highlights the assessment batteries educators employ to identify those in need of extra support, and children’s’ learning should be traced in an evidence-based intervention process. This has resulted in an increase in developmental work concerning the assessment batteries used by educators, especially in the United States (e.g., Geary, Bailey & Hoard 2009; Seethaler & Fuchs, 2011).

Evidence-based intervention programs

Previous research shows that research-based intervention programs that are provided with care and whose effectiveness has been investigated produce better learning results in the classroom than non-research based interventions (e.g., Jacob & Parkinson, 2015; Slavin & Lake, 2008; Swanson et al., 2011). One way to measure the effectiveness of the intervention is to study the learning process (i.e., achievement) of the children. A systematic way of assessing and monitoring children’s learning
during intervention is especially important when we need to know how well the intervention is able to support the child’s learning (Jimerson, Burns & VanDerHeyden, 2007). Intervention programs are often developed by using intervention research design. Thus, the concept of “intervention” can be used in reference to both an intervention program and a research methodology, which can cause some confusion among students and researchers. The recommended intervention research design includes a pretest (i.e., baseline measurement) and immediate and delayed post-test measurements. The intervention and control group design allows researchers and teachers to compare whether the children receiving the planned instruction (i.e., intervention program) develop faster than their peers who are not in receipt of extra support. When is it possible to say that an intervention program is effective? This is again an issue where researcher’s conceptions differ from one another. In general, it is possible to say that an intervention program is effective if the children with low performance or learning difficulties progress better than their control peers. Better still would be a result that shows children with low performances are able to maintain their head start compared with the control group even after the intervention phase has ended. Finally, the most optimal result would – in addition to the aforementioned effects – be achieved when the low-performing children closed the gap with their average performing peers. It is the researchers’ task to explain these possibilities to educators who need to make decisions related to how to support the children with learning difficulties. This kind of decision-making rests at the heart of the RtI approach at schools (Jimerson Burns & Van Der Heyden, 2007).

**Finnish evidence-based Web services for educators**

In Finland there has been a positive tendency over the last 10 years to boost teachers’ levels of knowledge concerning individual learning differences in early reading and mathematical skills. The emphasis has been mainly on the early identification of learning difficulties and early intervention, with the aim of moving towards the Responsiveness to Intervention model and general (Tier 1), intensified (Tier 2) and special educational support (Tier 3) in the national education system (National core curriculum for basic education (2014/2016). This kind of educational change brought a need for evidence-based knowledge and tools, also seen internationally (Ansari, 2015). The nationwide attempts in the field of early mathematics funded by the National Ministry of Education and Culture have been focused on producing evidence-based knowledge for educators and providing them with assessment tools and intervention programs to be used with children struggling with learning. The author has been part of two teams that have designed two Web services for educators, namely LukiMat (www.lukimat.fi) and ThinkMath (http://blogs.helsinki.fi/thinkmath/in-english/), both
funded by the National Ministry of Education and Culture. In this chapter, the research work done in developing these two web services will be discussed.

**LukiMat Web service**

The design process of the LukiMat started at the University of Jyväskylä and Niilo Mäki Institute in 2006. LukiMat contains three parts: reading, mathematics and learning assessment learning. All parts focus on basic skills for children aged 5-10 years.

The mathematics part has been developed to serve both Finnish and Swedish speaking educators and children in Finland. It features a knowledge base for parents and educators about mathematical skills development, mathematical learning difficulties, assessment and educational interventions. The mathematics knowledge base development relied on a systematic literature review. For instance, we provided educators with a core factor model of the mathematical skills that develop in children aged 5-8 years (Aunio & Räsänen, 2015). This model was based on a systematic literature review of longitudinal studies investigating mathematical development in this age group. In addition, we analyzed the assessment batteries designed for identifying the children with potential learning difficulties in mathematics. The purpose of the model was twofold; first, it aimed to present educators with an overview of the most important skills that develop in early childhood, and secondly, it sought to make educators aware of the individual differences in early mathematical skills development.

Assessment batteries for the identification of children with learning difficulties in mathematics in kindergarten, first and second grade were designed in relation to learning assessment. The screening materials focus on core skill factors: symbolic- and non-symbolic number sense, understanding mathematical relations; counting skills and basic skills in arithmetic. There are three scales to be completed three times a year with children: at the beginning of the school year (August-September), in the middle of the school year (November-December) and at the end of the school year (April-May). The series are built so that the autumn scale features the most items and the mid and end of year scales feature comparatively fewer items. For instance, in the kindergarten scale there are 48 items at the beginning of the school year, 25 in the middle and 27 at the end. The number of children participating in the Finnish norm collection is presented in Table 1, along with reliability information.

Table 1. Participants and reliability of Finnish norm studies
The study with Swedish speaking Finnish children featured a total of 1,139 children (587 girls and 552 boys) and reported good internal consistency and developmentally relevant factor structure (e.g. Hellstrand, Aunio, Korhonen, Räsänen & Linnanmäki, 2014; Hellstrand, Aunio, Korhonen, Räsänen & Linnanmäki, manuscript in process).

In the LukiMat Web service, there are two evidence-based computer games in which children can practice their early mathematical skills. The first, Number Race (Wilson, Dehaene, Pinel, Revkin & Cohen, 2006; Wilson, Dehaene, Dubois & Fayol 2009; Wilson, Revkin, Cohen, Cohen & Dehaene, 2006) is based on the idea that number skills develop from approximate representations of magnitudes, and these representations are connected to numbers with the help of counting. The second game, GraphoGame Math, was originally designed as part of the GraphoGame project at the University of Jyväskylä, Finland (Richardson & Lyytinen, 2014). The foundations of GraphoGame Math stem from the notion that learning the correspondences between small sets of objects and numbers helps the child to discover the numerical relationships in arithmetic. Research has demonstrated that both games have positive effects on children with learning difficulties in mathematics (Räsänen, Salminen,
Wilson, Aunio & Dehaene, 2009; Salminen, Koponen, Leskinen, Poikkeus & Aro, 2015; Salminen, Koponen, Räsänen & Aro, 2015).

**ThinkMath**

The design process of the ThinkMath Web service began at the University of Helsinki in 2011. It provides educators with hands-on intervention materials to be used with children who have problems with learning early mathematical skills. The Web service focuses on children aged 5-8 years. The fundamental idea behind this Web service was that educators also needed evidence-based materials for offline use, as there was a significant lack of computer devices for young children to use in early childhood settings or in early primary school grades. As a result, the Web service delivers intervention materials and knowledge to educators.

In the ThinkMath Web service, there is a knowledgebase with evidence-based information concerning (1) mathematical skills development and learning difficulties, (2) thinking skills development, (3) motivational issues related to learning, (4) executive functions relevance for learning, and (5) (special) educational interventions. The Material section offers group-based intervention materials for practicing mathematical and thinking skills.

In the ThinkMath mathematical skills intervention programs, explicit teaching was one of the main guidelines along with several ways to practice the skills in focus (e.g., Gersten et al., 2008; 2009). In line with these recommendations, each lesson consists of a teacher-guided activity to model a new mathematical learning concept or strategy as well as guided and peer activities (e.g., hands-on activities with manipulatives, or card and board games based on the current topic). At the end of the lesson, there is a short, paper-and-pencil individual activity. Another general feature is that mathematical ideas are represented following the concrete, representational and abstract levels, thus giving meaning to abstract concepts by using visual representations (e.g. cubes, bundles of sticks, dot cards structured in tens and hundreds) (e.g., Mononen, 2014). The teacher manual includes 12-15 lesson plans of 35–45 minutes each. The lesson plans include specific instructions for teachers to follow in each activity. The manipulatives are made of low cost, everyday materials found in every classroom, combined with printable materials (e.g., dot and place value cards) included in the manual.

During the development of the intervention materials, authors worked closely with educators and investigated the effects of these intervention programs on low-performing children through quasi-experimental, pre-post measurement with intervention and control groups. These studies
demonstrated some positive signs in children with low performances learning (Leijo, Aunio & Mononen, in revision; Mononen & Aunio, 2014; Mononen & Aunio, submitted).

One of these studies was the second grade intervention study (Mononen & Aunio 2014) which featured 88 second graders (M age 8 years and 2 months) from four classes in schools located in two southern Finnish cities. Their mathematical skills were measured with the Assessment of Mathematics Skill in the Second Grade (AMS-2) (Aunio & Mononen 2012a). It is a paper-and-pencil test and measures (1) the number of forward and backwards word sequence skills, (2) numerical relational skills associated with base 10 and place value knowledge, (3) addition and subtraction word problems, (4) multi-digit addition and subtraction calculations with number symbols, all within a 1-1000 range and (5) addition and subtraction facts in the 1-20 range (40 items, 2 minutes’ time). Children’s thinking skills were assessed using the Assessment of Thinking Skills in the Second Grade (Hotulainen, Mononen & Aunio, 2012a). It measures two types of inductive reasoning (Klauer 1989): comparing properties and comparing relations. Reading comprehension and fluency skills were measured using a standardized reading test for primary grades (Lindeman 2005). The intervention program used in this study was Improving Mathematics Skills in the Second Grade (Mononen and Aunio, 2010). It aims to practice number word sequence skills, counting and conceptual place value knowledge in the 1-1000 range and following the guidelines of explicit instructions. Mathematical skills were measured three times: shortly before the intervention (September), immediately following the intervention (in December) and three months after the intervention (in March). The thinking and reading skills were assessed at the first of the three time points. The intervention phase lasted 6 weeks, and there were two 45-minute intervention sessions per week. There were 5-6 children in the intervention groups. The preliminary analysis revealed that there was no difference between low performance children in the control and intervention groups in terms of their thinking and reading skills. The results demonstrated that the low-performing intervention group made significant improvements in mathematics (whole scale \( z=-2.94, p=0.001 \); addition facts \( z=-2.50, p=0.001 \), and subtraction facts \( z=-2.94, p=0.001 \)) but did not show significantly better scores compared to the low-performing control group (\( p>0.05 \)). In addition, neither the intervention children nor the control children were able to perform at the same level of their peers following the intervention phase (\( H (df=2) = 43.444*** \)). One interesting detail is that after the intensified instruction, children’s’ fluency in addition and subtraction actually decreased among the intervention group. Although there were no tremendously scientifically significant results, there was a trend to be seen that when children with low mathematical skills received extra support, their skills developed, but when the intensified instruction ended so did the development of their skills. This was especially true of arithmetical
fluency skills. In a kindergarten intervention study (Leijo, Aunio & Mononen, in revision) the children in the low-performing group were studied in more detail. The children in this group were children whose math performances were below the 10th percentile (i.e., very low performing, n=20), and children whose mathematical performances lay between the 11th and 25th percentiles (i.e., low performing, n=18). The results were collected with a scale (Aunio & Mononen, 2012b) measuring mathematical relational skills, number-word-sequence skills and counting skills which showed that the number children who reached an average level of performance at the post-test stage was higher among the group of children with low performance (67%) versus those with very low performance (35%) (Mononen, Tapola & Aunio, 2015). In addition to focusing on mathematical performance during ThinkMath interventions, studies have also targeted children’s interest in mathematics. One such example is a first grade intervention study (Mononen & Aunio, submitted) that tracked children’s interest in mathematics (Tapola, Mononen & Aunio, 2014). 98 first grade students (mean age 7 years 3 months) participated in this study. They were divided into three groups: a low-performing intervention group (children scoring lower than the 25th percentile in math measurement participating in ThinkMath intensified instruction, n=18), a low-performing control group (children scoring lower than the 25th percentile participating regular school activities, n=10) and children with average performance (children scoring higher than the 25th percentile participating regular school activities, n=70). The children’s interests were measured with a short questionnaire (5 questions) that the children answered by marking the smiley faces (5-point likert scale) most suitable for him/her. This questionnaire was completed at the pre-test and immediate post-test stages. The results showed that interest in mathematics increased more among the low-performing intervention group than among the low-performing or average performing control groups (F(2,66)=2.98, p=.05, η² = .07) (Tapola et al., 2014). Interventions are not only an important form of support for low-performing children’s mathematics skills, but they also stimulate their interest in mathematics, which in turn has been found to be relevant to future math learning (Viljaranta et al., 2014). A related study shows that at the kindergarten stage, individual differences in children’s skills cannot be attributed to their parent’s education or values regarding mathematics (Aunio, Tapola, Mononen & Niemivirta, in press).

ThinkMath’s thinking skills materials are called Improving Thinking skills (ITS) and are suitable for low-performing children aged 5-8 years. The materials were designed according to the principles of two thinking skills programs, namely the Cognitive Acceleration Program (Adey & Shayer 1994; Adey 2008) and Cognitive Training for Children I (Klauer, 1989; Klauer & Phye 2008). The interventions consist of a series of activities designed to provide age-appropriate problems,
accompanied by a sturdy lesson structure. The lessons are designed in a way that offers opportunities for social construction and metacognition. The programs for each age group include 12 activities as well as one introductory lesson to orient the children on the working methods used in the activities.

In a recent study, Hotulainen, Mononen and Aunio (2016) reported the effects of ThinkMath Thinking program designed for low-achieving first graders. In this study, the children were divided into three groups: the low-achieving intervention group (performing below -1.0 SD in pre-test Assessment of Thinking Skills in the First Grade (Hotulainen, Mononen & Aunio, 2012b) n=9, receiving intensified instruction), the low-achieving control group (performing below -1.0 SD in pre-test Assessment of Thinking Skills in the First Grade (Hotulainen et al., 2012b) n=18, receiving regular instruction), and the average-performing group (performing above -1.0 SD in pre-test Assessment of Thinking Skills in the First Grade (Hotulainen et al., 2012b) n=122, receiving regular instruction). The analysis showed that there was a significant difference between the groups in their Thinking Skills scores during the intervention phase (F2, 148)=17.05 p<0.001; post hoc comparison revealed that the low-achieving intervention group had better gains in the post-test stage than the low-achieving control group (p<0.001, gain ES 0.86) (Hotulainen et al., 2016).

In relation to the issues surrounding ThinkMath, we conducted a pilot study on low-performing young children playing math games as part of their average day in early childhood (Aunio, Mononen & Hakala, in process). This study has shown some promising signs for the research area of game-based math learning for young low-performing children.

One of the essential future challenges for intervention research is to find out how to maintain the upward learning trend after the intervention phase has reached its end. A decline in skills after the conclusion of the intervention phase is a common phenomenon in intervention studies conducted in a school context (Aunio, Hautamäki & Van Luit, 2005). One future possibility is that after the intervention phase children continue to practice the skills they have acquired in a digital learning environment, which would potentially provide enough support to maintain their upwards learning trajectory.

**Conclusion**

The work on the LukiMat and ThinkMath projects have not only shown that it is possible to develop
evidence-based materials and that educators appreciate them, but also that Web services are a very efficient way to deliver such information and materials. Valid and reliable assessment materials for the identification of children with low performance or potential learning difficulties are important to prevent learning problems from worsening. Even though it is challenging to obtain significant and lasting learning effects with intervention studies in natural educational settings, these studies are essential in providing educators with evidence-based materials. In line with this, there is an international collaboration with South African and Norwegian researchers to develop ThinkMath intervention materials for different educational settings.

The field of (special) education research still has several unsolved and interesting challenges concerning mathematical learning difficulties and the Responsiveness to Intervention approach. For example, researchers are still looking for the best way to identify children with a potential risk of mathematical learning difficulties. However, digitalized assessment environments may go some way to solving some of these challenges, for instance by providing assistance in analyzing test results. In addition, researchers need to determine the best way to provide extra (special educational) support for those with low performance. We can conclude that digital learning environments provide various possibilities for intervention, but the evaluation work has only just begun.

References


Aunio, P., Mononen R., & Hakala, M. Lola’s World educational game’s effects in low performing children’s mathematical skills – an intervention study in preschool setting. Manuscript in process.


Leijo, S., Mononen, R. & Aunio, P. *Matemaattisten taitojen harjoittelun vaikutukset matematiikan taidoitaan heikkojen esiopetusikäisten lasten osaamiseen (The effects of mathematical intervention on low performing children’s performance in kindergarten).* In revision.


Kristiina Kumpulainen, University of Helsinki

Tarja-Riitta Hurme, University of Turku

Abstract

This chapter is based upon the argument that not only are digital technologies and media still under-utilized in supporting hospitalized children’s learning and well-being, but moreover, the understanding of their potential and meaning in this context is under-researched and
under-theorized. Through cultural-historical theorizing on tool-mediation in human agency, learning, and development, and the Self-Determination Theory (SDT) of motivation and optimal functioning, we will review and examine current research on how digital technologies and media interact with hospitalized children’s agency and learning opportunities, entailing a sense of autonomy, competence, and relatedness. We conclude that while there are promising findings on how digital technologies can connect children to their family, school, and peers, more attention needs to be given to the relevant sociocultural contexts and practices in the use of digital technologies and media to understand and support hospitalized children’s agency and empowerment in their healing and learning.

**Keywords:** hospital education, digital technologies and media, agency, learning, well-being, cultural-historical approach, self-determination theory

**Introduction**

It is commonly recognized that hospitalized children and young people are at an increased risk of academic and psychosocial difficulties. Although learning and academic achievement are not typically perceived as priorities for hospitalized children (Wilkie, 2014), research suggests that opportunities for educational experiences can contribute to children’s healing, learning, and overall well-being (Hopkins, et al., 2014; Jackson, 2012; Martinez & Ercikan, 2009; Yates, 2012). Educational opportunities, such as taking part in the school’s activities, can serve as an anchor of connection between hospitalized children and the world beyond the hospital and as a small continuation of their everyday life. This also enables them to interact with peers, family members, teachers, and other important people while in the hospital. The lack of opportunities for social interaction and educational stimulation reinforces feelings of stress and anxiety, which are likely to interfere with the child’s ability to cope with his or her illness, learning, and future (Martinez & Ercikan, 2009).

Today’s health care, including hospital education, is in turmoil both in Finland and at a global level (Shaw & McCabe, 2007). Recent developments in the provision of health care and the demands set forth by economic efficiency are shaping the conditions and modes of hospital services. In education, changes in hospital services are evidenced by a rapid pace of transition in children’s learning journeys from the hospital to regular schools and back. Likewise, the rate of children attending hospital education has accelerated. A review of Finnish hospital education covering 24 hospital schools and approximately 3,000 children underscores the urgent need for the development of new solutions for hospital education that can ensure children’s rights to quality learning experiences, regardless of their health condition or hospital-school setting.
In the Finnish health care and education system, hospitalized children are not dependent on the teachers’ good will but have a right to high-quality educational opportunities. According to the Constitution of Finland, everyone is to be treated equally. No one may, without a valid reason, be treated differently from other people on grounds of sex, age, origin, health, disability or any other reason. Everyone also has the right to free basic education. Everyone is guaranteed an equal opportunity to receive an education in accordance with their abilities and special needs to develop themselves.

According to the Finnish Basic Education Act (628/1998), formal education must comply with the national core curriculum. Instruction is to be organized to meet learners’ age level and abilities, so as to promote their healthy growth and development. Instruction is to be conducted in cooperation with young people’s homes. The National Core Curriculum for Pre-school and Basic Education is concerned with the education of children and young people from six to sixteen years of age, and is the national framework used as the basis for drawing up local curricula. Education providers are responsible for preparing and developing local curricula. Municipalities are responsible for providing early childhood education and care, pre-primary education and basic education to all children residing in the area. This responsibility for organizing educational opportunities also applies to children who are hospitalized.

The advantages of using various technologies for overcoming hospitalized children’s isolation and creating educational opportunities are increasingly recognized. New tools and applications are being developed to extend young patients’ opportunities for social connection and to meet their learning needs. The importance of these efforts were also affirmed in the first Finnish national report on using digital technologies to support hospitalized children’s schooling and the schooling of children who live abroad (Hurme & Laamanen, 2014). The study was conducted via online surveys and thematic interviews. 11 children, 15 parents/guardians, and 22 teachers participated. Thematic interviews were conducted with 8 parents and 8 teachers selected on the basis of their responses to the online survey. Fifteen of the teachers who participated in the study had experience in facilitating the education of sick children via distance teaching.

The report by Hurme and Laamanen (2014) demonstrates that Finnish teachers, parents, and children all emphasized the important and empowering role of maintaining social relationships and connections when a child falls ill and is hospitalized. The report also reveals that the Finnish teachers felt accountable for arranging educational opportunities for every child
regardless of their health condition. This commitment is demonstrated by one of the interviewed teachers, who said that “every student is a member of my class and it’s my responsibility to organize learning situations in which the hospitalized child could participate.” In addition, the teachers stressed that avoiding isolation would be one way to decrease the sick child’s risk of stress and depression. In the interviews, the teachers reported several different types of pedagogical arrangements they had used to provide technology-supported education for the hospitalized children or housebound young patients. These arrangements are highlighted in Table 1.

Table 1. Examples of pedagogical arrangements for hospitalized and housebound children in Finland

<table>
<thead>
<tr>
<th>Situation</th>
<th>Technical solution</th>
<th>Arrangements for distance learning</th>
<th>Application to classroom teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-year-old child, cancer</td>
<td>Webmeeting equipment: a computer with a video camera and microphone.</td>
<td>No specific timetable, online connection available throughout the school day; online connection was used if the child’s condition allowed it.</td>
<td>The whole class was involved and after 2 weeks, the students were used to webmeetings and they took care of setting up the connection. One camera followed the teacher and the other camera recorded classroom activities; a computer screen was situated so that the child was seen by the other students.</td>
</tr>
<tr>
<td>10-year-old child, cancer</td>
<td>Adobe Connect web-conferencing system.</td>
<td>No specific timetable, online connection available throughout the school day; online connection was used if the child’s health condition allowed it. Participation in group work, and in other classroom activities; discussion with classmates during breaks</td>
<td>Synchronous connection and distance education became a natural part of classroom activities. Classmates took care of setting up a connection. A computer screen was situated so that the child was seen by the other students.</td>
</tr>
<tr>
<td>Under 12-year-old child, psychiatric diagnosis</td>
<td>Adobe Connect</td>
<td>Web-based course for language learning 2 hours a week if possible; working with the workbook, discussion with other participants, and familiarization with the culture.</td>
<td>Online together with a hospital teacher or therapist. Parental permission granted for participating and using the video camera during synchronous learning.</td>
</tr>
<tr>
<td>15-year-old child, isolated due to risk of infection</td>
<td>Adobe Connect web-conferencing system.</td>
<td>Arts &amp; Design course, communication with the teacher either through AC or by phone in case of technical problems. In addition, classmate interaction through mobile technologies. The course assignments were redesigned as homework.</td>
<td>It was not possible to arrange a distance education because of the coinciding schedules of lessons and medical treatments.</td>
</tr>
</tbody>
</table>

Similarly, Finnish parents reported that for the hospitalized child, it is essential to avoid social isolation and to keep up with classmates and school by using digital solutions. The parents also felt that having an online connection to the school made it easier for the child to return to school, as classmates were aware of what had happened, because the sick child had already discussed his or her illness online. Moreover, the possibility of access to school from home or the hospital encouraged adolescents to complete their schooling at the same time as their peers and to continue studying. This seemed to make them feel more confident and optimistic about their future.

Overall, the findings from the Finnish study resonated with the global research literature. In their systematic evaluation of existing research on the use of new technologies among hospitalized youths, Maor & Mitchem (2015) conclude that, in general, using technologies supported young people’s potential for learning and well-being and improved connectivity with their school. Yet, they also remark on the scarcity of research in this area. Moreover, their review of the research highlights the need to better address the social contexts and practices in which
technologies are used in order to take full advantage of their potential for the hospitalized child’s learning, healing, and overall quality of life.

This chapter follows existing research findings and argues that not only are new technologies and media still under-utilized in supporting hospitalized children’s learning and well-being but that understanding their role and meaning in this context lacks research and is under-theorized. Drawing on cultural-historical theorizing about tool-mediation in human learning and development and the Self-Determination Theory (SDT) of motivation and optimal functioning, we will review and examine current research on what is known about the ways in which digital technologies and media interact with hospitalized children’s agency and learning opportunities, entailing a sense of autonomy, competence, and relatedness. We hold that this framing is necessary if we want to understand and enhance hospitalized children’s healing and learning via new technologies and media as sociocultural, tool-mediated practices.

Agency and Learning

The conceptual framing to research and understand the influence of new technologies and media on hospitalized children’s agency and learning draws on cultural-historical theorizing on tool-mediation in human agency, learning, and development as well as on Self-Determination Theory (SDT) of motivation and optimal functioning. We regard these two theories as complementary. On the one hand, cultural-historical theorizing brings insights into conceptualizing human agency, learning, and development as socially and culturally embedded and tool-mediated (Vygotsky, 1978, 1987), while on the other, SDT offers insights into explaining the meaning of intrinsic and extrinsic sources of motivation in an individual’s cognitive and social development (Ryan & Deci, 2000). The role of the individual actor in human learning and development that SDT brings into the fore is often overlooked in cultural-historical theorizing (Stetsenko, 2008). SDT also focuses on how social and cultural factors interact with people’s sense of volition and initiative in addition to their well-being and the quality of their performance. According to SDT, social conditions supporting the individual’s experience of autonomy, competence, and relatedness foster the most volitional and high-quality forms of motivation and engagement for activities, including enhanced performance, persistence, and creativity. Moreover, SDT proposes that the degree to which any of these three psychological needs is unsupported or thwarted within a social context will have a detrimental impact on an individual’s wellness in that setting.

In our framework, we regard the three psychological needs — autonomy, competence, and relatedness — addressed by SDT as integral elements of human agency that are pivotal for human learning, development, and well-being. Agency, that is, pursuing intentional actions and is
typically attached to human motivation, will, resilience, intentionality, choice, initiative, and efficacy (see, e.g., Emirbayer & Mische, 1998; Holland, Lachicotte, Skinner, & Cain, 1998). Research has demonstrated that experiences of agency are crucial protective elements mediating children’s learning and well-being, also in the hospital context (Shaw & McCabe, 2006; see also Kim-Cohen, Moffit, Caspi, & Taylor, 2004; Luther & Zelazo, 2003; Puroila, Estola, & Syrjälä, 2012; McLaughlin, 2008; Sellman, 2009; Weare, 2010). These arguments are also supported by research on efficacy that shows that while children are able to act in evocative and proactive ways to shape their environments, they also make themselves more resilient (Kim-Cohen et al., 2004).

However, to help children become more agentive and resilient, they need agentic experiences: the things they do and ideas they produce need to be respected and recognized, and they have some impact on their lives. To become an agent, one must be treated as if one can do something of one’s own volition (Emirbayer & Mische, 1998; Kumpulainen, Lipponen, Hilppö, & Mikkola, 2013).

In cultural-historical theorizing, agency is conceptualized as an ongoing process that is contextually and historically situated, occasional, multi-faceted, relational, and transitory (Edwards, 2007; Schwartz & Okita, 2009; Virkkunen, 2006). The socio-cultural framework, thus, foregrounds agency as a social construct that is born out in context. Accordingly, we conceptualize agency as socially constructed, which is the result of a dynamic interaction between the individual’s life history, prior experiences, and the social context in a given activity (Valsiner, 1998). We, therefore, hold a view that there is a relational interdependence between human agency and social context.

According to the cultural-historical framework, human interactions with each other and with the world, including their agency, are mediated through the cultural symbol systems and artifacts we use. Here, cultural artifacts, such as digital tools, have a special meaning: They are resources that mediate our thinking and acting (Vygotsky, 1978, 1987). Hence, it is not just knowledge that is constructed in tool-mediated social interactions and practices; humans, their identities, and their sense of agency are social constructions, too (Packer & Goicoechea, 2000). The mediating role of technologies in promoting human agency, learning, and development is explained in cultural-historical theorizing via the notion of double stimulation (Vygotsky, 1978). In double stimulation, an external tool is used for intentional and voluntary problem-solving activities. As Vygotsky (1978, p. 73) maintains: “The development and use of artificial stimuli play an auxiliary role that permits human beings to master their own behavior, at first by external means and later by more complex inner operations.” In other words, to redefine situations and to control their own actions, people develop and use external artifacts to master and transform the contexts in which they act” (Virkkunen, 2006).
Altogether, our conceptual framework underscores the importance of human agency in tool-mediated interactions with the world. It is these agentive interactions that can contribute to a hospitalized individual’s healing, learning, and well-being. The social contexts of the hospital, young patients’ health conditions, and their treatments further challenge children’s opportunities for agency. Therefore, it becomes pivotal to understand not only how young patients can perceive themselves as autonomous, competent, and relevant in the sociocultural context of the children’s hospital, but also the role new technologies and media play within this social context.

Next, we will turn to reviewing recent research studies on the use of digital technologies and media to promote hospitalized children’s social connections, learning, and well-being. In our reflections, we point out the ways in which these studies address hospitalized children’s agency and learning opportunities with a specific focus on children’s opportunities to develop their sense of autonomy, competence, and relevance.

Our review was guided by the following questions:

- How does current research on the use of digital technologies and media address hospitalized children’s agency and learning?
- What is currently known about the ways in which digital technologies and media can enhance hospitalized children’s agency and learning?

The selection of research studies for our review was guided by our goal to understand how digital technologies and media have already been utilized with hospitalized youths, what research questions and conceptual framings steered the studies, and what research outcomes were reported. To be included in the review, publications needed to meet the following criteria: (a) report empirical studies or reviews of empirical studies; (b) involve the use of digital technologies and media in support of hospitalized young patients; (c) target hospitalized children and adolescents; and (d) target learning or the enhancement of the social and emotional well-being of hospitalized youths. Our selection of studies focused primarily on literature spanning the previous decade, with an emphasis on recent empirical research. Our search utilized ERIC, Proquest, Health & Medical Complete and Google Scholar databases. These key articles on which our literature review is based are listed in the references.

Digital Technologies and Media in the Children’s Hospital: Insights from Online Research Environments and Virtual Communities
Digital technologies are increasingly used to overcome the social isolation of hospitalized children and youths, and to increase the amount of opportunities for educational experiences young patients. The review research of Maor and Mitchem (2015) evaluated existing research on the use of digital technologies for communication and educational purposes, and considered how they interacted with the well-being of hospitalized children and youths. Covering 14 research articles published in the last decade, the review sheds light on the innovative technological tools and practices developed for children and young people in hospitals. Many of these solutions consisted of an electronic network that enabled the formation of online communities where hospitalized children could search for, meet, and interact with other young patients, their classmates, peers, and family members as well as teachers and health professionals through videoconferencing, chat rooms, email, and games (see e.g., Battles & Wiener, 2002; Hazzard, Celano, Collins, & Markov, 2002; Holden, Bearison, Rode, Rosenberg, & Fishman, 1999; Nicholas, Darch, McNeill, Brister, O’Leary, Berlin, & Roller, 2007; Nicholas, Picone, Vigneux, McCormick, Mantulak, McClure, & MacCulloch, 2009). For example, Zora, a web-based virtual community, includes instant chat and a three-dimensional, multi-user environment in which participants can design and build a virtual city and participate in e-mentorship (e.g., Bers, 2009; Bers, Beals, Chau, Satoh, Blume, DeMaso, & Gonzalez-Heydrich, 2010; Cantrell, Fischer, Bouzaher, & Bers, 2010).

Maor and Mitchem (2015) also describe the technologies and mobile apps that supported ambient social presence and bidirectional interaction among hospitalized children, their teachers, classmates, and families. For example, in the Presence App, all participants can engage in interactions with one another, and share photos and documents across the hospital, school, and home (Wadley, Vetere, Hopkins, Green, & Kulik, 2014). Another tool called The Bednet allows young patients to follow their class from their home or the hospital, interact with one another, post pictures and documents, scan and send documents, and use a webcam (Zhu & Van Winkel, 2014a; Zhu & Van Winkel, 2014b). Likewise, Pebbles is a video-mediated communication system that transmits live audiovisual data between the classroom and the hospital/home. While interacting with Pebbles, hospitalized children can use a videogame controller to adjust their view of the classroom and call for the teacher (Hazzard, et al., 2002).

**Digital Games**

Digital games and gaming environments, such as virtual communities or social videogames, are being increasingly developed and used to maintain and enhance hospitalized children’s social relationships and collaboration with their classmates (e.g., González-González, Toledo-Delgado, Collazos-Ordoñez, & González-Sánchez, 2014). Social videogames reportedly
foster peer interaction among children and young people, reduce isolation, and increase hospitalized children’s motivation surrounding learning activities (González & Toledo, 2011). One example of the digital, multi-user, game-based learning environment is the Kala Forest system (Chin & Tsuei, 2014) in which a child can play, learns, and interact with other players and thus develop their sense of agency. The research results of the Kala Forest system application showed that the parents were delighted with their children’s use of the digital game, since it encouraged their child to focus on issues other than illness, helped to develop their own skills and competence in using technological tools, and enabled them to have fun. The game playing provided a tool for active engagement which was seen as beneficial for maintaining and developing the child’s agency (Chin & Tsuei, 2014).

The 3D-learning game SAVEH Project (González, Toledo, Alayon, Muñoz, & Meneses, 2011) was designed to support communication and positive interdependence of players (González-González et al., 2014). The game consisted of different stages which were reached based on the success gained at previous levels. The previous levels could not be performed if all participants in the team did not reach specific goals and tasks: for example, each player had an avatar, and the avatar had certain skills that would benefit the group’s goal. The experiences of the SAVEH Project (González-González et al., 2014) as well as the experiences of gaming in classroom settings show that digital tools can support hospitalized children’s learning, including the development of technical and social skills. Moreover, the gaming experiences can also be utilized in real world situations (González-González & Blanco-Izquierdo, 2012).

**Robots**

Although in Finland, robots are a novelty in most children’s hospitals and classrooms; worldwide, there is emerging research evidence on the use of robots as teachers, and for therapeutic and educational purposes (Sharkey, 2016). Existing research has demonstrated the potential of robots in supporting hospitalized children’s healing and learning, especially children with physical disabilities, through play and play-like activities (for a review, see van den Heuvel, Lexis, Gelderblom, Jansens, & de Witte, 2015). Animal-like robots, such as Probo (see Goris, Saldien, Vanderniepen, & Lefeber, 2009), with washable fur and thus without hygiene problems, are designed to comfort hospitalized children through play. These robots have been designed to imitate human gestures, respond to certain actions, and/or perform programmed tasks. However, a true challenge in robot development has been how to enable a robot to process more complex information related to understanding a human’s reactions and emotions, and interacting with real people in real time (Belpaeme, Baxter, Read, Wood, Cuay’ahuitl, Kiefer, et al., 2012).
One innovative project targeting a more naturalistic robot is ALIZ-E (Belpaeme et al., 2012). It was developed for child patients to have long-term social interaction with a robot during hospitalized periods. During a hospital stay, a child can play games and do quiz activities with the robot by using language as the primary interaction channel. In the “SandTray” game, a large touch screen is used to facilitate the interaction between the child and the robot, which avoids the physical constraints of a turn-based game and allows equal participation of the child and the robot. Belpaeme and colleagues (2012) report that the use of robots motivates the child when the robot adapts its behavior; however, the limitations of the robot’s functions can also cause the child to lose interest quite quickly.

Many robots play the role of a caregiver, although it would be beneficial for the child’s agency if he/she could teach or take care of the robot his/herself. Tanaka and Matsuzoe (2012) have suggested that a robot could be seen as a care-receiver and children could learn English verbs better by teaching a robot. The care-receiving robot was teleoperated by one of the researchers outside the classroom. In their study, 3-6-year-olds Japanese private school children (n=17) played a verb-learning game with a care-receiver robot and an adult. An adult first modeled how to play the game and how to teach the robot. The adult was continuously present when the children played the game and tried to teach the robot to pick up the right object. The robot also interacted with the child by calling his or her name and shaking hands. The results of the study showed that the children tended to take the robot by the hand and teach it step by step, or they used gestures and vocal instructions to make the robot understand. In addition, the results demonstrated that playing with the robot was not only beneficial for children’s English verb learning, but it also promoted spontaneous learning. However, Tanaka and Matsuzoe (2012) argued that the limited learning capacity of the robot caused some children to become frustrated or irritated. This demonstrated that discovering the appropriate learning dynamics of care-receiving robots would benefit the human-robot interaction research field.

A telepresence robot can also be used to connect classrooms in different locations. In Tanaka, Takahashi, Matsuzoe, Tazawa, and Morita’s 2013 study, Japanese and Australian children operated a telepresence robot to interact with each other during an English class as well as in physical exercises. The results of the study showed that controlling the robot made the children more engaged in interaction compared to taking part in a Skype session. The researchers and developers found the use of a child-operated telepresence robot system useful and effective in distant communication, especially to support foreign language learning. Their future plan is to prototype telepresence robot systems in daily educational activities (Tanaka et al., 2013). In summary, robots seem to hold much potential for enhancing hospitalized children’s agency and
learning, for instance, a hospitalized child could have more agency in his or her own classroom by operating a telepresence robot.

**Makerspaces**

Our final example of the latest uses of new technologies and media in children’s hospitals is situated within the context of “makerspaces.” Makerspaces are socio-material environments in which participants can use equipment, such as 3D printers, laser cutters, and e-textiles, for the design and production of digital artifacts, texts, and other products to solve challenges that they have identified in their lives (Peppler, Halverson, & Kafai, in press).

Makerspaces at the children’s hospital are aimed at encouraging children’s sense of curiosity in setting up and pursuing personal goals via invention. They also support children in feeling more agentive in taking charge of their environment as well as of their own learning and well-being (Krishnan, 2015). Here, the aim is to enhance children’s agency by facilitating their creative use of various technologies as they engage in socially shared activities. Overall, makerspaces resonate with those efforts that advocate the importance of turning the hospital into a compensatory and positive place that offers socially and intellectually stimulating experiences for children and adults, and a new empowering role to the young patient (Schmidt, 1997).

Although research in the uptake of makerspaces in hospitals is at present very scarce, there are some encouraging results on the potential of makerspaces in promoting social interaction, increasing young patients’ physical mobility, creating a sense of control, and positively affecting the moods of chronically ill children. In his research, Krishnan (2015) designed a mobile makerspace for a children’s hospital in order to examine how it enhanced young patients’ agency and identity in learning. The idea of the mobile makerspace was to overcome the challenge of having one physical location for people’s hands-on design work. Instead, the mobile makerspace can be brought into patients’ rooms and left there for use throughout the entire duration of the patient’s treatment. In his research, Krishnan was keen to understand how hospitalized children interacted with the makerspace and its resources to pursue personal goals. In addition, he examined how the mobile makerspace functioned as a therapeutic socio-material environment in the existing hospital routines, roles, and expectations.

The findings of Krishnan’s (2015) study indicate that young patients’ engagement in the mobile makerspace positively contributed to their physical health, that is, it increased their mobility. He also found that patients recruited and negotiated a wide range of resources (conceptual, material, and social) to pursue their personal goals in their design and making processes with the makerspace. Patients’ orientations to interacting with the makerspace were characterized by
different motives and working processes, such as whether patients preferred to include other people in the design process or whether they preferred to pursue their work independently, and whether their working approaches were predominantly systematic or rested on trial-and-error discoveries. This study also highlighted the fact that young patients’ flexibly adapted the makerspace into their existing hospital routines. For example, they explored the makerspace materials during their daily treatments, brainstorming ideas, and discussing their design processes with their respiratory therapists. Children interacted with various people such as the hospital doctors, nurses, therapists, visitors, and hallway traffic to share and seek feedback about their designs, and sometimes just to receive positive attention. Hospital routines inspired many of the designs that the children created such as the nightline creation that employed electroluminescent lights to guide nurses. Conversely, young patients also harnessed the makerspace to transform and even disrupt their regular hospital routines, roles, and expectations. For example, some used their inventions to challenge privacy invasions and to improve the quality of their hospital stay experience. In addition to that, they used their inventions to “leave” the room virtually when hospital rules forbade them from interacting with other patients and even to play pranks and jokes on nurses. Overall, makerspaces appear to create a socio-material context in which young people can negotiate a balance between their lives as young adolescents and their lives as young patients subject to the constraints of life in the hospital (Krishnan, 2015).

Summary of Research: What do we know and what do we not know?

Our overview of recent research clearly demonstrates the potential digital technologies and media hold for creating rich and varied opportunities for hospitalized children’s educational opportunities and for connecting these young patients with their school, peers, family members, professionals, and other relevant communities. By examining recent studies dealing with online virtual communities, digital games, robots, and hospital makerspaces, we identified uses and practices that gave indications of their potential to enhance hospitalized children’s agency and learning, including a sense of autonomy, competence, and relevance. It can be concluded that digital technologies and media can contribute to reducing the social exclusion of vulnerable youths as well as serve varied learning and well-being needs. These findings give an important impetus for developing children’s learning in the healthcare environment throughout the world. At the same time, our overview highlights the serious gaps and limitations in current research. For example, little attention has been paid to researching sociocultural contexts and practices in which the use of digital technologies and media are embedded, and how these mediate hospitalized children’s agency and learning. Yet, digital technologies are not used in a vacuum but
are always situated in specific social contexts. Children’s hospitals and schools have their own practices, norms, values, and rules that position young patients in certain ways. Without the knowledge of these sociocultural contexts and their practices, it is impossible to generate an in-depth understanding of how and under which conditions digital technologies and media might enhance hospitalized children’s agency and learning. Furthermore, in addition to researching individual children, it is important to pay attention to how social practices in the children’s hospital develop and potentially change as the result of these new tool-mediated practices. It is not just children and their agency and learning that may potentially change as the result of the use of digital technologies but also the social practices and contexts they themselves develop. Cultural-historical theorizing as well as the Self-Determination Theory (SDT) of human motivation and optimal functioning provides a suitable framework and relevant concepts to address such research topics in the future.

At present, research in the field appears to be very much technology-driven, as studies concentrate extensively on reporting technological developments rather than educational and/or sociocultural issues. So far, little attention has been awarded to educational arrangements and social practices, and how these co-create and challenge opportunities for learning and well-being at the level of the individual patients and other actors as well as on social and cultural planes. Likewise, little attention is given to technological difficulties and challenges such as low transmission, difficulty connecting, audio and video challenges, and software problems as well as the digital competences required from both young patients and supportive adults and peers (Ellis et al., 2013). For hospital education to be successful, it is necessary that there is a working model for successful collaboration between the education provider, the hospital, and other relevant stakeholders, including the child. Multiprofessional collaboration is pivotal for ensuring that young patients are connected to learning and well-being across institutional boundaries. Moreover, attention needs to be given to support the professional development of teachers and hospital professionals to better address young patients’ learning and well-being through digital technologies and media. These arguments were supported by the outcomes of the Finnish survey, where, in addition to technological challenges, teachers expressed their incompetency with the pedagogical usage of digital learning tools and environments (Hurme & Laamanen, 2014).

Current research also overlooks the voice of hospitalized children regarding their own motives, needs, and experiences when using digital technologies and media, and how this interacts with their sense of agency and learning. The child’s perspective should be taken into account more deeply not only in terms of user experiences but also in terms of gaining an understanding of how young patients see themselves and their agency. Do they feel that they have control and influence
over their lives both in and outside of the hospital? What meaning do digital technologies carry for them and their sense of agency? Consequently, children’s voices and agency should be actively recognized in the co-creation processes of educational and healthcare services. We hold that recognizing children’s voices and perspectives on matters relevant to their lives increases their sense of belonging, trust, and community, and, hence creates fertile conditions for their learning and well-being (Kumpulainen, et al., 2013).

There are also methodological challenges and limitations that many research studies carry with them. At present, studies are by and large limited in size and time. That is, existing research studies include few individuals, and the timeline for data collection is short. The ethically sensitive context of the children’s hospital calls for sophisticated and advanced research designs and methodologies. For example, in one case (Hurme & Laamanen, 2014), a seriously ill child was first very excited about the digital connection to her school, but as her illness became worse, the connection reminded the child of all the things she was being excluded from. The child’s mother described the situation as follows: “It [distance education] was a great thing until she got tired of it. I think it was at the time she started to struggle when she realized this nightmare never ends, and she was not able to turn back to a normal life and she drifted further and further and away. I think she got tired of things reminding her that she was sick and unable to live a normal life.” In the interview, the mother reported that the digital connection to the school was not used after her daughter became tired of it. In another case, adolescent patients felt uncomfortable being visible online because of certain physical changes caused by medical treatments, and some of these students were more willing to interact online only with their teacher. All these examples point to the complexity of the research context of the children’s hospital that calls for the utmost sensitivity and ethical responsibility on the part of the researchers.

Conclusion

As our review of existing research in the field clearly demonstrates, digital technologies and media have the potential to enhance the agency and learning of hospitalized children. Yet, this potential is not adequately researched nor understood. In more concrete terms, our analysis shows that the use of digital technologies in children’s learning in hospital environments has been technology-driven, instead of focusing on children’s learning processes and motivation, their learning communities, educational arrangements and social practices. Consequently, the key message of this article for future research is to focus more on hospitalized children’s multifaceted learning opportunities in sociocultural contexts and not merely on technologies or applications. More attention needs to be
given to sociocultural contexts and the usage of new technologies and media to support hospitalized children’s agency and empowerment in their healing and learning. Hence, further research and development is necessary. The important topics for further research and development entail:

- researching and developing a “connected model” for children’s agency and learning in hospital education that accounts for engaging, self-fulfilling, and transformative experiences in which every child with varying needs and health conditions feels agentive, competent, connected, valued, and trusted (Kumpulainen & Sefton-Green, 2014; Kumpulainen, et al., 2013). Here, research also needs to address how children and young people themselves could be involved in developing new forms of learning in hospital environment;

- researching and developing innovative pedagogies and digital solutions for children’s connected learning and well-being in and out of hospitals (Kumpulainen & Mikkola, 2015; Mikkola, & Kumpulainen, 2016; Rajala, Kumpulainen, Hilppö, Paananen, & Lipponen, 2016). Here, digital technologies and media need to enhance engagement and self-expression and increase accessibility to knowledge and learning experiences. Furthermore they need to expand social supports for learning and well-being as well as diversity and capacity building and increase interaction between children and their communities in and outside the hospital;

- researching and enhancing the professional development of the healthcare and teaching professionals to better address multiprofessional collaboration and the use of digital technologies to support children’s connected learning and well-being; and

- co-configuring educational and healthcare services into a dynamic unity in which the two services can transformative intersect and address the diverse learning and well-being needs of hospitalized children.

In sum, our chapter addresses a pressing societal challenge surrounding the quality and nature of children’s hospital services with a specific focus on the role of digital technologies and media in supporting hospitalized children’s agency and learning. Our starting point for stressing the importance of such research knowledge rests on the Finnish principle that every child should have equal rights to high-quality health care and educational opportunities regardless of their health condition, age, region, or socio-economic background. Inequality and marginalization in the lives of the young patients can lead to serious negative multiplicative effects; the economic, social, and human costs are considerable, both for the individual and for society as a whole.

According to this vision, we contend that children have a fundamental right to educational experiences and to maintain their social and educational connections when confronted with illness. We envision a children’s hospital that is an exciting and uplifting place for children’s
healing and learning. As a consequence, it is important that children’s transitions between the hospital, the school, and home are as seamless as possible by creating inspiring educational and technological solutions that keep children holistically connected to various learning environments, their peers, and communities (Kumpulainen & Sefton-Green, 2014). Moreover, we emphasize co-configured health care and education services, innovative learning environments and pedagogies enriched by digital learning solutions as well as children’s active agency in their learning, development, and well-being. Here, the democratizing potential of digital networks and online resources becomes pivotal in expanding the entry points and pathways to hospitalized children’s agency and learning.

References


10. Game-based Inquiry Learning: Design and Application

Yu Jiang¹, Lu Zhang², Junjie Shang² and Morris Siu Yung Jong ³

1. National Center for Educational Technology, Beijing, 100031;

2. Peking University, Graduate School of Education, Department of Educational Technology, Beijing 100871;

3. The Chinese University of Hong Kong, Center for the Advancement of Information Technology in Education, Hong Kong 999077)

Abstract

This chapter aims to explore the application model, application strategy, and application effect of educational games in inquiry learning. Based on the literature review and theory analysis, a game-based inquiry learning model has been constructed. With this learning model, using the educational game “Farmtasia II”, which was created by the Center for the Advancement of Information Technology in Education, at the Chinese University of Hong Kong, researchers developed the
“Farmtasia” inquiry learning curriculum and conducted an empirical study in a high school. The result shows that this game-based inquiry learning model definitely helps expanding the advantages of educational games, and cultivates students’ inquiry learning ability.

**Key words:** Educational Game, Inquiry Learning, Learning Experience, Learning Model, Farmtasia

**Background**

Nowadays, the significance of inquiry learning has been widely acknowledged. The term inquiry learning refers to how, based on their interests and with the teachers’ instruction, students can find a research topic fitting to their experiences with nature, society and life, and use it to gain knowledge, apply knowledge and solve problems (Guo, 2001). Inquiry-based learning can be applied in science education, and it entails the joint involvement of learners in scientific activities such as searching for literature, formulating hypotheses, and gathering and interpreting scientific data (Mäkitalo-Sieg, Kohnle, & Fischer, 2011). Computer-supported inquiry learning environments essentially enable students to learn science by doing science, offering resources to develop a deep understanding of domain knowledge (Mulder, Lazonder, & de Jong, 2011).

Although the new Chinese curriculum reform has rendered inquiry learning an independent course in school, the essence of this course is still a type of inquiry learning activity based on certain topics and projects. This inquiry learning activity is characterized by the following features: open problem, authenticity, progressive solution and developmental evaluation. Inquiry learning emphasizes the learning experiences in a real context. But considering the students’ safety issues and other conditions, inquiry learning activities have many limitations. Although information technology skills are regarded as having great importance in inquiry learning processes, the typical situation is that even though students are encouraged to efficiently utilize the online resources and cooperate online, they seldom come up with ideas independently. Instead they roughly copy and paste information from websites. As a result, their problem solving abilities are not developed to any significant extent (Li, 2003).

Since the 1980s, scholars have studied the educational significance of online games. Their exponential popularity in recent years has made people aware of the huge influence that games can exert on teenagers, causing more scholars to devote their research attentions to the educational function of games, with impressive results (Yun, Jiang, & Li, 2010). Although some scholars believe that there are many obstacles facing the acceptance of playing games in formal classes (Shang, Jong, & Jiang , 2011), others regard online games as sources of attractive virtual learning contexts, in which students can gain learning experiences in the gamified virtual environment.
(Cheung et al., 2008). According to a survey among principals from the developed areas of south China (Shang & Jiang, 2010), 82.5% of the principals believe that educational games show considerable potential in an integrated practical curriculum. Above all, the authors believe that the application of educational games in inquiry learning courses can make it easier for schools to accept using games in general teaching. This paper uses inquiry learning as its theoretical base, integrates the game-based learning approaches, and develops the game-based inquiry learning model. With this model and the educational game “Farmtasia II”, which was created by the Center for the Advancement of Information Technology in Education, at the Chinese University of Hong Kong, a game-based inquiry curriculum was developed and its effect was empirically studied.

**Inquiry learning**

Inquiry learning can be defined as an approach that involves the process of exploring the natural world. In their search for new understanding, students are able to ask questions, make and test their discoveries; in inquiry learning environments, students take the initiative in the learning process and realistic material should be offered in a naturally collaborative setting (de Jong, 2006). Furthermore, inquiry learning is also taken as a student-centered form of learning, in which students become deeply involved in the construction of knowledge through building hypotheses, gathering evidence and interpreting results (Mäkitalo-Siegl, Kohnle, & Fischer, 2011). Students who learned through an inquiry-based mobile learning approach achieved better learning outcomes and had a smaller cognitive load than those who learned through a traditional approach (Hwang, Wu, Zhuang, & Huang, 2013).

In 1964, Professor Schwab from the University of Chicago and Professor Ausubel from New York University first adopted the term “inquiry learning”, and Schwab (1970) pointed out the seven steps of this scientific method: 1) raise a question; 2) collect information that helps to answer the question; 3) refine the question; 4) define the necessary information needed for problem solving; 5) make experiment plans to gather data; 6) gather data through experiments; 7) data analysis. Inquiry learning is differentiated from the traditional instruction approach, which keeps far away from the exploration of natural phenomena and concentrates on conveying pre-drawn conclusions. However, inquiry learning encourages learners to be involved in the exploration process, practice scientific inquiry skills and develop their interest in science (Xu, 2002; Zhong, 2008), all of which is characteristic of problem solving, progressive solution and open problems (Yu, 2004).

**Cases of using educational games in inquiry learning**
“The promise offered by inquiry learning is tempered by the problems students typically experience when using this approach”, and some supportive cognitive tools with computer simulations may offer a solution (de Jong, 2006). Online games can provide the requirements of the ideal learning environments and can present students’ with engaging learning experiences (Kiili, 2005). Educational games have demonstrated great potential concerning integration with inquiry learning. Usually, 2D or 3D digital games create relatively complex settings, and the task mechanism and human-computer interaction of the large-scale online role-play games can meet all the requirements of constructivism learning (Dickey, 2007). Games can provide a virtual environment as the learning context. In addition, players can interact and communicate with each other, and finish the inquiry activity by taking the necessary steps during the playing process. Furthermore, games can also help to establish a fictitious learning context, the elements of which can be added or deleted accordingly. In addition to these strengths, games can also activate players’ motivation to participate, which is crucial, as active participation is the prerequisite of successful inquiry learning. Given this, it is perhaps unsurprising that many scholars have already conducted research on inquiry learning by using games:

Squire (2004) utilized a digital game “Civilization III” to improve the problem solving and cooperation abilities of students in 4th and 9th grade. The experiment lasted for eighteen days, and the instruction process was as follows: 1) establish a connection between the game and the class content; 2) instruct students to play the game; 3) organize activities with certain targets and create inquiry communities; 4) re-play the game and try new strategies; 5) game over, and students reflect on and summarize the process under the teachers’ guidance, and make presentations.

Lee created the VISOLE (Virtual Interactive Student-Oriented Learning Environment) learning model, on which the digital game Farmtasia I was based and applied in many courses. The VISOLE learning model consists of three steps: 1) scaffolded learning period; 2) game-based learning period; 3) reflection and summary. Actually, the third step is also intertwined with the second (Cheung et al., 2008).

Dede et al. developed the multi-user virtual environment (MUVE) “RiverCity” for experiment studies in high school science lessons. The study consists of eight steps: 1) make observations; 2) raise questions; 3) gather information from the virtual library and talk with people; 4) collect data with instruments and make analyses and explanations; 5) make hypotheses and study plans; 6) gather more evidence based on the hypotheses and the interaction with the virtual players; 7) get the results, explain and reflect; 8) discuss and communicate in class (Ketelhut, 2006).
The three cases above are the typical cases for applying games in inquiry learning. These cases emphasize reflection and the connection between the game and the teaching content as well as the teachers’ role in the learning process. In these three cases, though digital games provide the virtual learning environment and bring an element of fun, the inquiry learning process in games has not been specifically designed. For example, the learning process in the case of RiverCity is still a linear process, and the spiral escalation process is not highlighted.

**Game-based inquiry learning model**

Based on the previous discussion and studies, we have developed a game-based inquiry learning model. This model is based on inquiry learning theory and utilizes games as the main learning environment for scientific inquiry learning. The aim is to develop students’ study interests, cultivate their scientific inquiry abilities and enhance cooperative learning.

**Game-based inquiry learning process**

The game-based inquiry learning process is presented in Figure 1.

![Game-based Inquiry Learning Model](image)

Fig. 1. Game-based Inquiry Learning Model.

Game-based inquiry learning consists of three stages: independent study, cooperative inquiry learning, and reflection and summary.

**Independent study.** This is the fundamental stage and is also crucial to the learning process as a whole. Learning the relevant knowledge and how to manage the game is the main task in this stage. Students gain knowledge through independent reading and rudimental game attempts.
Teachers try to connect the game to the learning content, point out the learning targets, and activate the learning motivation.

Cooperative inquiry learning. Students form groups and determine inquiry questions. The game provides a learning environment for inquiry learning: the whole process begins with some specific experiences (game experiences). Through observations of and reflections on certain concepts, students design an preliminary experiment plan to test their previous understanding; the continuous attempts are necessary to refine the experiment plan.

Students are under teachers’ instruction in this process and follow scientific inquiry procedures: they raise questions, determine topics, raise hypotheses, make experiment plans, test their hypotheses, observe and reflect and finally summarise the experience. Teachers are not only responsible for providing instructions for scientific inquiry methods but also for supporting the group cooperation.

Reflection and summary. With teacher guidance, students discuss and summarize their game experiences and make inquiry reports to share with other students.

Reflection is required during each stage. The second and third steps proceed in groups. Although we differentiate the three stages, they are not isolated from one another. For example, in the cooperative inquiry learning phase, students should also study independently and may also work with group members to achieve “learn by doing” objectives.

Features of the Game-based Inquiry learning model

(1) Games help to activate learning motivation. Bruner et al. believe that learning should be achieved through active inner motivation, therefore the activation of motivation is very crucial. Research shows that games help to create a “flow” learning experiences, in which students become immersed in their learning and participate significantly (Ketelhut, 2006). The GIL model takes the game as the main environment to support learning, the catalyst for students’ learning motivation, and a way of maintaining said motivation, all of which is greatly beneficial for inquiry learning.

(2) GIL places emphasis on the function of real context for knowledge construction. Some scholars hold the opinion that learning tasks should be completed in relatively real contexts, as it invokes more active participation in interactive learning (He, Zheng, & Xie, 2002). GIL encourages students to raise and solve problems in real contexts offered by the virtual environment.
(3) Cooperative learning is highlighted. Peer communication can help generate a comprehensive and precise understanding of knowledge. Cooperation is encouraged, as tasks are completed in groups, which benefits the construction of knowledge and value development. In fact, the problems in the online games are relatively complex, and as a result, group work is required to solve the problem, which enhances the cognitive communication and cooperation (Tao, 2010).

(4) Independent study is required. He, Zheng and Xie (2002) claim that the design of independent study should encourage students to use their initiative when learning. In this way, students can develop their own understanding of the surroundings and find solutions to problems independently. GIL also features a blog section and alternative inquiry questions to support students’ independent study.

(5) Reflection is emphasized in game-based learning. Many scholars believe that the reflection and summary stages during and after the game can guarantee successful learning (Crookall, 1992). Reflection causes students to realize that game playing is also a learning activity.

(6) Games function as a “virtual laboratory” because for each specific inquiry question, GIL follows Kolb’s ideas about experiential learning (Shi & Wang, 2009; Kolb, 1984) as well as the basic process of inquiry learning (making observations, raising question, formulating hypotheses, proposing a plan, conducting experiments, reflecting on and summarizing the experience). However, in the learning process as a whole, inquiry learning provides a main structure, and games exist as the “virtual laboratory” for inquiry learning. Students formulate their hypotheses and design their experiment, then seek answers in the virtual learning environment. Discussions also encourage critical thinking.

(7) The GIL model highlights the learning experiences that students can gain during the learning process, and games provide an ideal learning context to offer more of these opportunities. Experiential learning theory stresses the importance of direct experience and reflective observations as well as of the continuous nature of learning and appropriate feedback (Kiili, 2005). Furthermore, experiential learning has a strong connection with constructivism and situated learning theory, according to which the best way of learning is to gain knowledge in an authentic context. Through continuous participation and with the instruction of experts, the novices can also become experts (Lave & Wenger, 1991).

Above all, the game-based inquiry learning model actually constructs a student-oriented inquiry learning environment, and supports learning with interactive and encouraging game activities. According to Spires and Lester’s pilot study (2016), game-based learning environments
not only increase student engagement but also positively impact content knowledge of scientific topics and problem-solving skills.

**Game-based inquiry learning curriculum**

We developed a game-based inquiry learning curriculum using the game-based inquiry learning model and Farmtasia II (www.farmtasia.com).

**Course introduction**

The objective of this course is to cultivate and develop junior high school students’ scientific inquiry ability and cooperative ability in an inquiry learning environment. This program consists of eight lessons, with the first and second designated as the independent learning period, during which students receive instructions about the inquiry learning process and its methods, and they familiarize themselves with the online blog. During the second stage, in the third lesson, students are assigned to different groups according to their questions, and they make decisions about the inquiry topic; in the fourth lesson, each group continues their inquiry learning. In the fifth session, teachers comment on the students’ blogs and online discussions and provide instructions on how to assemble research reports and assessment strategies. In the sixth lesson, students are able to refine their inquiry learning outcomes. The seventh and eighth lessons are for reflection and summary, during which each group reports their inquiry findings and presents their inquiry reports, and teachers also participate to contribute the refinement of inquiry reports. Of the eight lessons, the first, third, fifth and eighth are for group learning and discussion, and the second, fourth, sixth and seventh are for independent learning.

**Farmtasia II**

Farmtasia II combines knowledge from different subjects, such as agriculture, geography, economics, and sociology. Players enter a virtual world where they play role of farm owners who must manage their own farm.

When the students first have access to this game, they are assigned a “practice island” where they complete small tasks and practice the basic skills of planting and animal feeding. When their ranking reaches five, players can buy a piece of land in one of 230 cities from all over the world, and begin to design and manage their farms according to the different climates, plants and animals. Players can also interact and form groups to explore the new land.

Features of Farmtasia II:
(1) Simulated authenticity: first, the in-game environment (climate and weather) is designed according to the nine climate types all over the world, including real precipitation and temperature. The growth condition of the plants and animals in the game is also in line with that in the real world, including nitrogen, phosphorus, potassium, water and pH levels. The growth target of plants can be reached through the number of plants and their growth progress, and that of animals can be reached by giving them water and food, cleaning them and letting them graze. This simulated authenticity makes scientific inquiry possible.

(2) Scientific experiment supports: when the players determine the location of their farm, with the fixed geographic and climate situation (may change with seasons), soil, plantation and animals can be influenced by fertilizing and watering. These measures provide opportunities for inquiry experiments, and students can alter the conditions based on their own ideas to test their hypotheses. For example, if students want to examine how nitrogen influences plant growth, they can observe the growth situation of the plants fertilized with non-urea material or urea material.

(3) Cooperation supports: in essence, Farmtasia II is an online game and it can support online communication. Players can also make friends, send messages, and even invite others to visit their farms.

Other tools and resources

In addition to the game environment, this course also provides students with cognition tools and learning resources:

(1) A handbook for independent study. We prepare a handbook consisting of four chapters for players to introduce the game and how to play it, along with the relevant geographical, agricultural, economic and environmental knowledge. Moreover, this handbook provides website links for students to improve their subject knowledge; students also have subject knowledge brochures.

(2) Scaffolding and blogs to support reflection. This curriculum provides scaffolding questions to encourage reflection. By raising questions, students are inspired to search for the reasons behind their mistakes and explore the right strategy, and their interests are developed in order to achieve the objectives. Scaffolding questions mainly aim to spark reflection upon their behavior and their plan and to encourage students to post their ideas on their blogs.

(3) Peer communication and a forum. Researchers have created a discussion forum, and group members are distributed in different communities, where they can share their experiences and ask questions. At the same time, students also have some group discussions to share ideas.
A reference book for teachers. In order to help teachers gain a better understanding of the theory and methods of game-based inquiry learning, researchers have compiled a reference book for teachers to support their teaching. This book contains the theory explanation and specific cases.

Table 1. Learning tools and resources

<table>
<thead>
<tr>
<th></th>
<th>Tools and resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>students</td>
<td>Information resources (knowledge website links and books)</td>
</tr>
<tr>
<td></td>
<td>Knowledge scaffolding (reflection and report samples)</td>
</tr>
<tr>
<td></td>
<td>Discussion and cooperation (blogs and instant communication)</td>
</tr>
<tr>
<td></td>
<td>Questions column</td>
</tr>
<tr>
<td>teachers</td>
<td>A reference book</td>
</tr>
<tr>
<td></td>
<td>Game management tool*</td>
</tr>
</tbody>
</table>

Note: * is the management tool for teachers. When teachers log in, they can set the log in time of students, create the password for students’ accounts, and monitor and observe what is going on.

_Inquiry questions and samples_

In a student-oriented learning environment, learners try to solve problems in cases and projects, and the questions raised are interesting and attractive. In the GIL model, the inquiry questions are very important, as these are the guarantee for active inquiry learning. Of course, GIL encourages students to raise inquiry questions of their own accord. However, in order to instruct students on how to learn effectively, this curriculum also offers inquiry questions for students, for example:

Inquiry question: “Most crops must be planted in soil because nitrogen, phosphorus and potassium can support the growth of crops. Among these three substances, which one is the most important? Or all of them are important?”

First, each group chooses an inquiry question and after reflecting on their previous experiences and referring to some learning materials, they form their own hypothesis: “nitrogen is the most important fertilizer” or “all of them are important”. Students can also share their knowledge and ideas in discussion forum.
Next, students conduct their experiments. Under the group leader’s coordination, students design an experiment plan in groups. The group leader assigns each group member different kinds of fertilizers. Meanwhile, they are given the same seeds and grow these plants in the same climate and time period to test the hypothesis.

After the experiment, if the result contradicts their hypothesis, students can also refine their hypothesis and the experiment plans. In this stage, online and offline discussions and instructions from teachers can improve the learning process. Later, each group completes an experiment report to present their scientific findings.

**Research on game-based inquiry curriculum**

The target group was made up of students from a 7th grade class, and this research lasted for half a month. The research design and research findings are described in the following section.

**Research design**

The purpose of this study was to examine the effect of the curriculum and to observe teachers’ and students’ responses towards this learning model.

Considering the complexity and the realistic constraints, this study adopted the quasi-experiment research method and uses surveys, observations and interviews.

The study tool includes Farmtasia II, quizzes and surveys. The total score of the pre-test and post-test was 30, and the test consisted of multiple choice questions, gapfills and essay questions. All of the questions were created by researchers and teachers and were examined by teachers. The response survey for students comprised six parts: relevant basic information, attitudes towards learning methods, response to the learning material, students’ responses to teachers and group learning, opinions on the in-game learning behavior and the learning model. All the questions were presented with a Likert scale.

The 52 participants were in grade seven, half boys and half girls, and their average age was 12. These participants began the group inquiry study at the beginning of the semester. Groups were formed according to their scores and willingness to participate, and each group had 4-5 members. Boys and girls were equally assigned. Based on Papastergiou’s study, the learning results that boys
and girls achieved through the use of the game did not differ significantly, and boys and girls were equally motivated (2009b).

The entire experiment lasted for half a month. The pre-test of knowledge was made first; eight lessons were taught over two weeks; observation and interviews were also made during this time, and post-tests and questionnaires were also administered after the course had finished.

In addition to the data from knowledge tests, questionnaires, observations and interviews, this experiment also utilized certain features of Farmtasia II to record the playing time of students, and collect the reflection journals, discussion posts, and the final inquiry reports. We collected 50 valid pre-tests and post-tests, 51 valid questionnaires and 50 valid game records. After a basic analysis, 49 valid samples were determined, among which 24 were from boys and 25 from girls. The amount of the valid samples comprises 94.3% of the total amount. The data analysis is made based on the data from the 49 valid samples by SPSS 17.0.

**Research results**

The following analysis mainly focuses on the knowledge tests and questionnaires and integrates the information obtained from observations and interviews.

(1) Knowledge tests

Pre-tests and post-tests were looked through by teachers, and the average score of each section and the average of the total score are presented in the Table 2. The pre-test and the post-test were two different tests.

<table>
<thead>
<tr>
<th></th>
<th>Multiple choice</th>
<th>gapfills</th>
<th>Essay question</th>
<th>Overall average</th>
<th>Overall standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>5</td>
<td>9.71</td>
<td>3.45</td>
<td>18.16</td>
<td>5.301</td>
</tr>
<tr>
<td>Posttest</td>
<td>6.57</td>
<td>6.04</td>
<td>2.53</td>
<td>15.14</td>
<td>2.993</td>
</tr>
</tbody>
</table>

Teachers said that the post-test was more difficult than the pre-test, hence the decline in the average score. In terms of the overall average score, the post-test score is 3.02 less than the pre-test
score, but the standard deviation decreases, which means that the post-test scores are more uniformed.

In order to learn more about the effect of this learning model, researchers divided the samples into two parts; a high-achieving group was made up of the top 11 students (scores ranking from 23 to 26), and a low-achieving group included the bottom 10 students (scores ranking from 7 to 13). The finding indicate a significant change of the overall scores of the high-achieving and low-achieving groups (P<0.01). The average score of the high-achieving group declined by 7.73, and that of lower-scoring group increased by 2.60. This shows that this learning model is more effective for low-achieving students.

(2) Degree of satisfaction with this learning model

In general, students felt satisfied with this learning model. 61.2% and 27.1% of the students choose “strongly agree” and “agree”, and nobody chose “disagree” or “strongly disagree”.

In addition, 86.7% of the students believed that this learning model can connect knowledge and real-life experiences. In this way, memory will last much longer, and knowledge can be more easily understood. But with regard as to whether this learning model can improve their scores, only 40% of the students felt this was possible, which corresponds with the results of the post-test. There is no strong correlation between students enjoying the game and positive attitudes toward this learning model, but there is a positive correlation between satisfaction with the game and with this learning model.

(3) Understanding scientific inquiry

The objectives of inquiry learning include the development of basic inquiry abilities, the construction of general science knowledge, the development of intuitive, innovative and logical thinking (Papastergiou, 2009 a,b). This study focused on inquiry ability and the ability to raise questions and critical thinking. According to the on-site observations, most students engaged actively in discussion and hypothesis formulation and tried to test their hypotheses in game. According to the survey, 77.6% of the students agreed that “this learning model helps to raise more questions”; 71.4% of the students think that they can find evidence for a hypothesis and approximately 90% of the students believe that this learning model can help them to master the science inquiry method.

In addition, 90% of the students agreed or strongly agreed with the statement that they like scientific inquiry; 85.5% of the students believe that scientific inquiry is important; less than 10% of
the students hold the opinion that “scientific inquiry is boring”. Although we are not completely sure if this learning model makes a difference, interviews, reflection diaries and forum posts also support the idea that this learning model definitely exerts a positive influence on their consciousness of science inquiry and the ability development. A teacher commented that the “game offers students a simulated learning context, in which students have the opportunity to gain experiences and find questions”. One student remarked after finishing the curriculum “I still have lots of questions to answer”. Above all, the positive effect of this learning model on developing interest in scientific inquiry is obvious.

(4) Comments upon learning support tools

There are five questions in the questionnaires for students to examine their comments on learning support tools, and the reliability coefficient is 0.723. Eight questions for teachers and group learning, and the reliability coefficient is 0.829.

We also found that students made positive comments on the learning support tools. More than 90% of the students believe that blogs, forums, game instruction brochures and reflection scaffolding are beneficial. They made more positive comments about the online tools (blogs and forums) than the paper tools (reflection diary, reflection questions and game instruction brochure). According to the correlation analysis, the degree of students’ satisfaction has a positive relationship to the learning support tools, especially with the blog system and reflection questions.

Conclusion and discussion

This learning model has remarkable effects

The analysis above shows that the game-based inquiry learning model does in fact have remarkable effects on learning. First, compared with traditional books, games can arouse students’ interest in learning more easily. Second, this learning model effectively improves cooperative learning and encourages students to cooperate with each other. Third, in this learning model, most students can master scientific inquiry procedures and methods, especially the ability to criticize and raise questions. Fourth, this learning model brings added benefits to low-achieving students.

However, according to the analysis, this learning model does not make a significant contribution to raising test scores, which also conforms to Shang’s research findings (Shang, Jong, Lee, & Lee, 2008 a,b). Such a large-scale online game can make changes to students’ ability development and emotional attitudes and values, but makes little difference in gaining knowledge.
It is important to consider that game-based inquiry learning is a novelty, which perhaps should not be evaluated by traditional methods. Engagement is also an important aspect of game-based learning. A study quasi-experimental study found that there were significant differences in the participants’ engagement while interfacing with the video games to learn genetics knowledge (Annetta, Minogue, Holmes, & Cheng, 2009).

Perhaps the most interesting outcome of our study is the fact that this learning model makes more of a difference to students who have poor performance. The test scores of low-achieving students were obviously raised, and those students felt more confident about this learning model, and felt a sense of achievement. Perhaps this learning model can activate their learning motivation, and weaken their sense of disadvantage. This learning model can also provide them with the same learning opportunities, which make them feel confident and improve their test performance. But for students whose scores are relatively high, they probably already possessed the learning motivation, and their perceived learning efficiency is lower. Although such problems exist, high-achieving students can still benefit from this learning model. A study found that although some excellent students felt hesitant to acknowledge the efficiency of this learning model, it still improved their performance and their abilities (Shang, Jong, Lee, & Lee, 2008b). Despite these benefits, the acceptance of video games in classrooms remains a complicated issue. According to another study, students’ preference for using video games is influenced by a number of factors: the perception of usefulness, ease of use, learning opportunities, and personal experiences with video games in general (Bourgonjon, Valcke, Soetaert, & Schellens, 2010).

(2) Integration of inquiry learning and game experiences

Many scholars find it difficult to integrate inquiry learning and games. Erhel and Jamet (2013) point out that there are two kinds of instructions in game-based learning: learning instruction and entertainment instruction; and the results showed that learning instruction can elicit deeper learning without negatively impacting motivation. Many scholars have made efforts to find this balance, and they reached a consensus that “educational games must be fun”. That motivates scholars to contemplate how to make students feel excited about the game, and then take the measures necessary to achieve the learning objectives. Two further remarks would be that the game process should be made fluent in order to make students feel immersed in games, and that gaming experiences also help to challenge players’ abilities (Gee, 2003).

The GIL learning model also takes measures to help students reflect and summarize to avoid the all too familiar phenomenon of students just playing the game rather than learning. But this
learning model does not prioritize fluency and fun, instead the game simply plays the role of providing a simulated virtual learning environment, where students can formulate hypotheses and test them. In a word, the game is a “virtual experiment”. Though it may make the game less fun, it can still guarantee the inquiry learning process. Based on the previous study findings, the integration of inquiry learning and game experiences is successful.

(3) Teachers’ assistance and supporting tools

Compared with traditional learning, the role of the teacher undertakes a new significance in GIL. This learning model requires more assistance and support. Students have higher expectations of their teachers, and they want their teachers to be able to provide more specific instructions for game playing and the inquiry process. This finding also highlights that in game-based inquiry learning, the game alone is not enough for successful learning and more learning support tools are needed to meet educational aims, such as online blogs and forums.

Summary

This chapter consists of a literature review, model creating, curriculum design, and an experimental study, and presents the game-based inquiry learning model. In general, this learning model is relatively successful and helps to apply educational games in normal teaching as well as enhancing students’ abilities in scientific inquiry and cooperation. But, considering the time schedule and other constraints, this study has many limitations. The study could be improved with regard to the curriculum design, examining the students’ learning behaviors and studying the teaching instruction strategy.

Acknowledgments

This paper was supported by a grant from the Beijing philosophy and social science planning project “Strategies to cultivate creative thinking based on game based learning” (No: 13JYB011)

References:


11. Supporting Personalized Learning via a Big Data & Learning Analytics Platform for Early Childhood Education

Daniel Chen, Ph.D. Candidate, Graduate School of Education, Peking University
Linping Zhao, Ph.D. Beijing Institute of Education
Yuxi Zhao, Master of Engineering, Peking University of Aeronautics and Astronautics
Huan Nie, Master of Education, Peking University
Lei Fu, Master of Education, University of Buffalo

Abstract

Early childhood education is one of the most important investments we can make. Research indicates that every $1 spent on well-designed early childhood interventions generates a return to society of $1.80-$17.07. A personalized, high quality, online Early Childhood Education course could benefit individual children, families and the community in various ways, such as improved cognitive development, high academic achievement, improved nutrition and health, and reduced social inequality. This paper discusses the challenges of big data collection and learning analytics in early childhood development areas and introduces integrated learning analytics and a personalized child development support framework. A joint project was undertaken by KBTC and Sesame Workshop to design and create an interactive multimedia learning course and use learning analytics platforms to provide digitalized personal assessment and tracking for a group of children aged 3-6 in China. The project uses the award-winning educational TV program Sesame Street together with cloud computing, mobile internet and big data analysis technologies to provide a personalized digital learning experience, progress tracking and follow-up adaptive learning recommendations. In order to present an overview of the large quantity of data in support of better learning analytics and personalized learning, a cross country, interdisciplinary collaboration framework is recommended.
Background

Early Childhood Education (ECE) focuses on teaching young children both formally and informally up until the age of 7 before they enter formal primary school education. On November 20, 1989, the UN General Assembly unanimously adopted the Convention on the Rights of the Children. All parties agreed that the education of the child shall be dedicated to a) developing the child’s personality, talents and mental and physical abilities to their fullest potential; b) developing respect for human rights and fundamental freedoms, and for the principles enshrined in the Charter of the United Nations; c) developing respect for the child’s parents, his or her own cultural identity, language and values, for the national values of the country in which the child is living, the country from which he or she may originate in, and for civilizations different to his or her own; d) preparing children for responsible life in a free society, in the spirit of understanding, peace, tolerance, equality of sexes, and friendship among all peoples, ethnic, national and religious groups and persons of indigenous origin; e) developing respect for the natural environment. In his UNESCO report “Learning: The treasure within” (1998), Mr Delors indicates that throughout one’s life education is based on four pillars: learning to know, learning to do, learning to live together and learning to be.

With the recent developments in neuroscience, educational technology and digital learning environments, understanding how children interact with their own learning environments, progress and development has become a particularly interesting research topic, as has the issue of personalized measures that can help children reach their full academic potential.

Early childhood education is one of the most important investments we can make. A 2005 RAND study indicated that every $1 spent on well-designed, early childhood interventions generates a return to society of $1.80-$17.07. A personalized, online, high quality Early Childhood Education course could benefit individual children, families and the community in various ways, such as improved cognitive development, high academic achievement, improved nutrition and health, and reduced social inequality. To provide better education for children in the 3-6 age bracket in China,

the Chinese Ministry of Education issued the “Guide for Learning and Development of Children Aged 3-6 Years”\(^5\) in 2012. It provides a general guideline on children’s knowledge and capabilities in the fields of health, language, society, science and art. The guide includes specific and feasible suggestions for parents and preschool teachers on how to provide learning and caring to Chinese children in the early childhood education stage. Despite turning their attention to early childhood education rather late, in the past 2 years the Chinese government, academic institutes, private educational technology and product firms have rapidly increased the resources and efforts in researching and developing educational technology and information platforms. For instance, a research group from the Graduate School of Education at Peking University focuses on the following areas: 1) Building integrated learning analytics and frameworks for personalized learning support platforms; 2) Developing skill/knowledge map-graphs databases for ECE; 3) Researching the Children Development Assessment framework for ECE; 4) Constructing big-data based descriptive, predictive analytics engines. In a similar manner, a joint development project undertaken by KBTC (Kowloon Blue Technology Corporation, Beijing, China) and Sesame Workshop (New York, USA) address the following questions: 1) How to provide an interactive learning curriculum for 3-6 year olds in China? 2) How to assess and measure children’s learning? and 3) What personalized learning experience could better support children’s learning and development progress and achieve their full academic potential?

Below, we will discuss the challenges of big data collection and learning analytics in early childhood development areas and introduce an integrated learning analytics and personalized childhood development framework. As a practical example, we discuss the aforementioned joint project undertaken by KBTC and Sesame Workshop. The project uses the award-winning educational TV program Sesame Street together with cloud computing, mobile internet and big data analysis technologies to provide a personalized digital learning experience and progress tracking, reporting and follow-up adaptive learning recommendations.

Related research, practices, technology and products

*Early Childhood Education learning standards*

Although it is controversial to establish standards in the field of early childhood education, the standards movement, which changed K-12 education, also extends to early education. Most states in the USA have standards which delineate the desired result, outcomes, or learning expectations for children below kindergarten age, and standards are playing an increasingly important role in early childhood education (NAEYC, 2002). Standards for pre-schools and kindergartens in science, behavior, mathematics and art have been widely discussed and adopted in the organization and assessment of children’s activities (Greenfield, Jirout, et al., 2009).

Researchers have also discussed the possible risk posed by ECE standards. The National Association for the Education of Young Children (NAEYC, 2002; Brenneman, K., Stevenson-Boyd, et al., 2009; Behar, 1974; Dixon, 1988) points out that the major risk is that the responsibility for meeting the standards will fall on children’s shoulders. Students who fail to meet these standards could potentially be labeled as educational failures, which would of course negatively impact their lives (Hatch, 2002). Further to this, experience in K-12 fields shows that standards play a limited role without sufficient investment in professional development, high-quality assessment tools, or school resources from a well-financed education system (Elmore, 2002).

*Data collection in Education*

The US federal government has supported efforts to gather educational data since the earliest version of the Office of Education (Public Law 39-73, enacted March 2, 1867). As the development of information technology has spread in recent years, data collection has received more and more attention. The Educational Technical Assistance Act (ETAA)\(^6\) authorizes the Secretary to support technical assistance to establish statewide, longitudinal data systems. The Secretary is authorized to award no fewer than 20 grants for comprehensive centers for technical assistance to local entities across 10 geographic regions. Each center must work with state educational agencies (SEAs), local

---

educational agencies (LEAs) and schools in the region where the center is located. In the state of Colorado, Data Pipeline\(^7\) has replaced the outdated Automated Data Exchange (ADE) system with a new method of capturing data. Data Pipeline has streamlined data collection, and the data collected has shifted from program-centric to a more student-centric collection model. It captures more real-time information, streamlines the data collection process and reduces manual burdens on school districts. Data from the process of learning and teaching can assist educators in improving their teaching activities, penetrate the fog of uncertainty surrounding the allocation of resources, develop competitive advantages, and improve the quality and value of the learning experience (Siemens & Long, 2011). However, the flipside of this is the threat data collection poses to students’ privacy.

Student Information Systems, with $100 million of support from the Gates Foundation and the Carnegie Corporation, encountered strong opposition from the parents of students because of the potential risk of information leakage.

**Learning analytics in Education**

“According to the definitions introduced during the 1st International Conference on Learning Analytics and Knowledge (LAK), learning analytics is ‘the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and environments in which it occurs’” (Baker & Inventado, 2014). Learning analytics has been well applied in fields such as medicine and business (Siemens & Long, 2011). It has been highlighted that learning analytics can help “identify at-risk learners and provide intervention to assist learners in achieving success”. It also helps “provide learners with insight into their own learning habits and can give recommendations for improvement” (Siemens & Long, 2011).

We found some examples of institutions successfully applying big data technology in ECE. For instance, Knewton, Inc. is one of the key players that embeds adaptive learning technology (based on big data technology) in online learning platforms that are provided by schools, publishers and other third parties. By collecting and analyzing data about learner’s interactions with the online learning materials, Knewton’s adaptive learning system can: 1) show a student’s understanding of a particular concept, or forecast his/her performance in the next test; 2) recommend the next proper

\(^7\) Colorado Department of Education. (n.d.). [Data pipeline]. Retrieved April 24, 2016, from https://www.cde.state.co.us/rise/gatheringinfo
Challenges of big data and learning analytics in Early Childhood Education

Big data is a term describing the storage and analysis of large and/or complex data sets using a series of techniques including, but not limited to: NoSQL, MapReduce and machine learning. Although big data and learning analytics technology have been developing at a rapid pace, there are many challenges in applying it in early childhood education. The major difficulties are: 1) the organizational culture and politics of ECE are neither sufficiently data-driven nor data savvy; 2) big data requires long-term investments, but funding is tough to raise from governments as funding is mostly devoted to K12 phases; 3) concerns regarding data security and privacy of information.
related to child safety; 4) the proportion of early childhood research efforts devoted to big data is relatively small compared to survey and observational data; 5) too few early childhood researchers with big data and learning analytics skills (Fischer, Anthony & Dorman, 2014); 6) the assessment of child development can hardly be completed using a traditional paper test, as the language comprehension skills of a child are insufficient; 7) the lack of meta data standards for the early childhood education field; and 8) most ECE learning activities happen offline with no sociometric badge device (commonly known as a “sociometer” used by MIT Media lab human dynamics groups) to automatically measure individual and collective patterns of social and learning behaviors.

**Integrated learning analytics and personalized learning support frameworks**

In October 2014, the Garnter Group published its analytics research paper and defined four levels of learning analytics: 1) descriptive analytics obtain retrospective information on what happened; 2) diagnostic analytics get insight on why it happened; 3) predictive analytics focus on predicting what will happen if the child completes certain learning activities; and 4) prescriptive analytics find foresight information to provide the child with a personalized learning environment in which they can achieve their full potential.

To apply the learning analytics model, we developed CHEN’s integrated learning analytics and personalized child development framework as shown below in Figure 1.

The integrated learning analytics and personalized child development framework form a conceptual model that integrates an IT support platform with early childhood educational subject matter expertise, the aligns with learning analytics steps to customize, track and report personal learning experience and progress.

The core elements of the framework consist of big-data storage, the user’s avatar profile, knowledge and skill development map-graph data, and development progress assessment components. All data associated with the child including in-school and extracurricular activities, LMS (learning
management system), PLE (personal learning envirnoment), and even biometric DNA (deoxyribonucleic acid) are used as sociometric badges, processed and fed into the big-data storage. The user’s avatar profile database is used to hide the child’s sensitive and private information. As mentioned, the learning analytic platform is based on big data and supports a personalized learning envirnoment generated from diagnostic and predictive analytics output. Progress, tracking and reports are generally available and associated with all components.

The integrated personalized child development (PCD) framework incorporates a wide variety of research and evidence-based practices and tools to enable schools, teachers and parents to carefully establish each student profile, build each student’s skills and knowledge development goals in the form of a personal ‘roadmap’. Teachers and parents can also assess students’ progress, analyze their learning style and behavior and customize the adaptive learning envirnoment to generate a truly personalized development program.

In order to take a systematic and reflective approach to implementing evidence-based analytics practices, the framework defines two analytical steps that should be taken before recommending a personalized adaptive learning envirnoment to the student: in Step 1 an ECE SME (early childhood education subject matter experts) performs diagnostic analytics to understand the student’s learning behavior and data-driven skill/development level assessents, and then offers deep insight on the whole map of the student’s skill/knowledge developmental stage, including any gaps in skill/knowledge development. Step 2 involves performing predictive analytics to examine student/classroom/school indicators and empirically predict student outcomes and set individual goals. As the indicators are based on students’ course grade, attendance, course level, suspensions and extracurricular involvement, teachers and parents can use the predictive analytics results to engage in an informed conversation on the child’s progress and assist in setting individual development goals.

Once these two analytical steps have been completed, the ECE SME recommends a personalized and adaptive learning envirnoment that addresses the student’s skill/knowledge development needs. Progress tracking and the reporting tool enables teachers and parents to monitor students’ progress
and further identify their needs and the appropriate resources; and it also enables them to develop and evaluate intervention programs to address any problems or deficiencies more effectively.
Case Study: KBTC application implementation of the framework

Since 2015, KBTC has adopted integrated learning analytics and personalized development framework to design the 3ikids Plato learning analytic and adaptive learning platform. The 3ikids Plato is designed to capture and analyze the data collected from children during the learning process. The data includes but is not limited to learning activities, online behavior, game playing, interacting with Sesame Elmo and the multimedia interactive curriculum, assessment, daily nutrition, school reports and social media data. This platform also provides personalized reports to parents that enable them to better identify and support their child’s learning needs.

The foundation: Big-data store with metadata

The foundation of the 3ikids Plato platform is the big-data store and metadata captured in the platform, which has been deployed in over 10,000 kindergarten schools in China. The big data associated with the child includes structured data which can be captured in relational databases and unstructured data such as audio, video, social media data stored in hadoop data store. In the 3ikids ECE information platform, parents, teachers and school principals use the platform for daily communication, information management, and online assessment and personalized at-home parent-child learning.

With the 3ikids teacher mobile app, teachers can not only capture students’ daily attendance, nutrition, classroom observations, course grade, extracurricular involvement but also perform weekly and monthly progress reports. Parents use the 3ikids parent mobile app to perform regular assessments of their children’s development in the areas of physical health, language, science, art and social skills. Additionally, parents can choose various online interactive learning courses for their children to complete. These learning activities and the students’ progress in them are captured and stored in the 3ikids Plato platform, which teachers and ECE SMEs can use to retrieve the data and perform learning analysis on it. The algorithm and model of the learning analysis of the data will be discussed in a separate paper. Parents can also use the 3ikids platform to discuss and communicate with ECE SMEs on diagnostic analytics and predicted results.
When dealing with data related to children, safety and private information protection always come first. In the 3ikids Plato platform, we use avatars to mosaic all the sensitive and private information with a virtual ID. We collect as much data as possible in order to have a better basis from which to assess and understand the child’s learning style and perspective as a whole. In the 3ikids ECE information system, in-school activities such as daily school lesson plans, incident management, attendance records, parent-teacher communication, growth portfolio and daily reports can be observed and recorded by teachers. Regarding at-home learning and development activities, the 3ikids ECE system provides an additional 5 modules such as a self-assessment module, online expert Q&A, parent-child activities, an interactive learning module and growth portfolio management. Information pertaining to the online activities is also captured, for example, students’ start and finish times, their progress, action, how much use they made of help and hints, the type of instruction, cursor movement over objects on screen, completion result and its comparison to the average and so on.

A particular aspect of the online interactive learning Elmo courses co-designed by KBTC and the Sesame Workshop is that it allows the child to interact with the online course in different multimedia forms while the Plato system captures detailed meta data for future learning analysis and recommendations. The design of Elmo Course also follows the “Head-Heart-Hand” model. Head, hand and heart is a holistic approach to developing ecoliteracy and was introduced by Orr (1992) and expanded by Sipos, Battisti and Grimm (2008). This model shows the holistic nature of transformative experience and relates the cognitive domain (head) to critical reflection, the affective domain (heart) to relational knowing and the psychomotor domain (hands) to engagement. The Elmo Course consists of online content and offline activities. The online content includes games, videos and activities. An online session lasts between 15 and 20 minutes. Learning activities include watching videos, listening & speaking, finding objects, drawing and matching the right pictures. In each course module, a learning report is provided to track the progress child has made. Offline activities include parent-guided manual activities using paper, stickers, storybooks, craft materials and so on. The offline course materials are designed to correspond to online teaching themes. Below, Table 1 presents the example of meta data captured and stored in the Plato system big data store.
<table>
<thead>
<tr>
<th>Key Meta data</th>
<th>Log-in Time</th>
<th>LevelID</th>
<th>Attempts count</th>
<th>Operation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log-in Duration</td>
<td>KDS map-grap ID</td>
<td>Clicks count</td>
<td>Operation Duration</td>
<td></td>
</tr>
<tr>
<td>Course ID</td>
<td>Course Name</td>
<td>Challenge-point</td>
<td>User ID</td>
<td></td>
</tr>
<tr>
<td>Lesson ID</td>
<td>Course Type</td>
<td>Competition-point</td>
<td>Behavior ID</td>
<td></td>
</tr>
<tr>
<td>Page ID</td>
<td>Lesson Name</td>
<td>Bonus point</td>
<td>User Role</td>
<td></td>
</tr>
<tr>
<td>Enrichment ID</td>
<td>Lesson Type</td>
<td>Smart points</td>
<td>App version</td>
<td></td>
</tr>
<tr>
<td>Page Name</td>
<td>Hoopover count</td>
<td>Client Environment Software Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Page Type</td>
<td>Client Environment HardwareType</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enrichment Name</td>
<td>Channel ID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enrichment Type</td>
<td>Resource ID</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 gives examples of what is captured in the 3ikids plato learning analysis platform.

*Measurement and Smart points*
The dynamic measurement system is a key part of the 3ikids Plato learning analysis platform. Progress measurement is based on historical data, content data, the child’s skill and knowledge map and learning behavior data. The Plato learning platform uses 3 types of learning enrichment in learning contents: activities, quizzes and games. In activities enrichment, success points are used to measure the end results of the assigned activities. Similarly, challenge points are used in quiz enrichment exercises to check comprehension results. Bonus points are used to measure the results of games enrichment. Smart points is the ultimate unit of measurement used in the Plato platform to measure the child’s progress.

\[ \text{Smart point} = \text{sum} (\text{success-points} \times \text{weight} + \text{challenge-points} \times \text{weigh} + \text{bonus-points} \times \text{weight}) \]

**Child development skills, knowledge graph-map and assessment framework**

Each country has its own national requirement of children’s development goals. In China, the Ministry of Education issued the “Guidelines for 3-6 year-old Preschool Children’s Development” which requires pre-school children to receive educational content coverage in five major areas: health, language, social skills, science, and art. Specifically, this guideline established precise development skills and knowledge areas for each category. The 3ikids Plato learning platform uses these as its base and develops a total of 319 child development skills and knowledge graph map elements.

Selecting an appropriate assessment method in the field of preschool children has proved to be a great challenge because children’s language skills are not yet fully developed due to their young age, and they therefore cannot be assessed with a traditional questionnaire evaluation. Parents or teachers could complete this as a third party observer; however, this gives rise to uncertainties regarding accuracy. To address these challenges, much data and element-based analysis is required, followed by a comprehensive analysis to integrate all inputs and form the final assessment.

Using assessment reports on the child’s learning progress and learning behavior, the Plato platform uses a predictive analytics engine to recommend further learning activities for the child and provide a tailored personalized learning experience.
Expected Findings

The 3iKids Plato learning analytics system is still in the pilot stage and will only be deployed in May, 2016. By end of 2016, there will be more than 100,000 children using personalized learning environments via the Plato learning analytics platform. In next phase of our research, we would like to address following areas: How can we further measure and quantify the impact the platform has on the child’s learning? To what extent can the predictive analytics engine and personalized learning platform affect the child’s learning and skills/knowledge development?

To create a useful assessment of the learning analytics system in the early childhood education domain, we need guidance from SMEs in child development. We would like to invite worldwide experts to join us and become collaborators in this field. To facilitate such collaboration, we have adopted the principle from the Finnish education system, which we learnt from a two week research visit to Helsinki University in October 2015. That principle bases collaboration on openness, sharing, freedom and responsibility. Only via collaboration, we can achieve the ultimate goal of the integration of technology and education. The assessment data in this area should be global, including the continents of Europe, Asia and America, Africa and Australia. Through an open architecture, data from third parties can be integrated into the platform and eventually create a true big-data platform on early childhood education, which all international research institutes, governments, organizations and caregivers could benefit from.

Conclusion

The big data and learning analytics platform is a key foundation to understand how children learn by breaking down the extent of their achievement in each of the various skills. It is vital to support children’s personalized learning in both online and offline environments. CHEN’s integrated learning analytics and personalized child development framework make it possible for parties across research disciplines and academic institutes, NGOs, governmental administrative bodies and private firms to cooperate in a meaningful manner to build a big-data store and learning analytics platform on a global level, to which all parties could contribute and from which they could benefit.
with the ultimate, shared goal of helping children to become healthier, smarter and kinder and, thus, reach their full potential.

Acknowledgements

We would like to express our appreciation to Professor Wang Qiong at Peking University for her advice and guidance on the topic of big data and learning analytics in early childhood education and to Professor Hannele Niemi at the University of Helsinki for her support and advice on this paper. Further thanks go to the KBTC 3ikids Plato learning analytics platform team for their great efforts in designing and developing the Plato platform for ECE. Our final thanks go to Mr Manabu Nagaoka, senior executive producer of the Sesame Workshop, and his team for co-designing and developing the interactive multimedia parent-child Elmo course and for their support of this research.

Reference


PART 3. Digitalization in teaching and learning

12. Teachers as researchers: current trends and hot topics

Shelly Zong, Jingjing Jiang and Yizhou Fan
X-learning Center, Graduate School of Education, Peking University

Abstract

Pedagogical scholarship is an important part of teacher’s professional development and a key way for teachers to improve their teaching abilities. The research questions that pique teachers’ interests usually relate to practical teaching experience and queries they have about their work. In Mainland China, teaching research is a compulsory course and something that teachers will typically do over the course of their degree. Hence, the question about what kinds of research topics teachers care about is a vital and basic one. By analyzing the data of three MOOC courses through text analysis, word frequency analysis and coding, we determined six research questions that Mainland Chinese teachers generally care about. The six research questions include students’ motivation, learning ability, the differences between students, pedagogy of teaching, technology of teaching and effective and efficient teaching (the remaining questions we counted as “others”). We believe these six research questions cover most of the topics teachers expressed an interest in, and they have popularizing and pervading significance to some extent. Furthermore, they encompass both theoretical and practical features of understanding Chinese scholarship on teaching, and simultaneously provide a different perspective on understanding teaching itself.

Key words: Scholarship of teaching; Teacher professional development; Research topics; MOOC
Background

American scholar Boyer mentioned scholarship on teaching in “Scholarship Reconsidered: Priorities of the Professoriate” (Boyer, 1990). Scholarship on teaching views teaching as a professional career rather than something that everyone naturally does. Teachers should translate their understanding into students’ learning based on their deep and extensive comprehension of the field they teach.

In the half century since the founding of the People’s Republic of China, only normal universities were responsible for teacher training in a closed system to train large numbers of teachers. Until the 1990s, under the demand of improving the quality of teachers, many comprehensive universities began to offer teacher training, which integrated and diversified the discipline. At the same time, the concept of research-oriented teachers attracted more and more experts’ attention. In 2004, China implemented the New Course Reform which required teachers to solve problems by conducting research. The New Course Reform also needs teachers to convert general thinking based on experience into scientific, systematic, specialized research. With the development of educational reforms, Chinese teacher cultivation pays more attention to teachers’ research abilities. Nowadays, the cultivation of research-oriented teachers is the most important aspect of teacher training. One example of this trend is how the X-learning research center of Peking University conducted first session of the MOOC Teacher research from August 4, 2015 to September 30, 2015. It was the first MOOC that educates teachers about research methods in China. A total of approximately 12,468 students enrolled, and 383 of them got course certificates.

There are various reasons why teachers conduct research. First, they can improve their professional judgment through research. Sometimes, when teachers are unsure about their teaching activities, they can conduct research to judge themselves from a professional perspective, which can enhance their professional judgment and professional development. In this respect, teachers who conduct research are concerned with their teaching efficiency and the quality of their teaching. Most of the research carried out by teachers focuses on teachers themselves and the classroom environment. Problems arise in their practical teaching work. Research allows teachers to solve realistic problems and improve the quality of their teaching. In addition, teachers can find blind spots in their classrooms by doing research and seeing their classroom’s nature through the prism of certain
phenomena. However, teacher-led research cannot replace practical ‘doing’ by teachers themselves: that is to say, the results obtained by researchers are not fit for the classroom. For example, there are many studies about theoretical basis of pedagogy, including educational psychology and learning theories. But they do not help teachers to solve a real problem in the classroom such as how to facilitate students to ask questions positively, for example in a flipped classroom method. Research is often conducted from an academic perspective rather than to solve a specific, concrete problem. Research by teachers themselves is more valuable to them, and in the future, great educational experts will be teachers with rich research experience. In the meantime, however, educational development needs teachers to conduct research.

Research questions are important to teacher-led research. An effective teacher knows how to ask insightful questions about teaching and students, gather evidence to answer these questions and solve problems in practical ways; they know how to analyze the data, and to make decisions accordingly about what, when, and how to teach next (Metzger, 2005). Teachers’ questions stem from teaching practices, so these questions are closely related to the problems that exist in the classroom and to teachers’ current understanding of topics, their students and their teaching context. Teachers’ research questions also stem from various sources, including professional and personal reflections on their practice, interactions with colleagues within or beyond their teaching settings, professional literature, and personal passions (DiLucchio, Leaman, Eglinton, & Watson, 2014). At the same time, asking research question can drive teachers to understand the teaching and learning experience more deeply (Perry, Henderson, & Meier, 2012). In fact, their research questions can begin simply enough: “How can I use storytelling to build literacy among bilingual preschoolers?” or “What is it about me or my care giving that helps me build securely attached relationships with toddlers?” (Perry, Henderson & Meier, 2012). In a word, all questions come from teachers’ interests and puzzles about teaching, and are the first step to research.

Teachers’ research is part of teachers’ professional development. Teachers need to continue studying and creating to enhance their professional competence. Considering this topic from the educational bodies’ perspective, their future development depends on having plenty of teachers who enjoy doing research, being bold in their exploration and are engaged in teaching research. Only by transforming their teaching from private to community property, teachers can get their teaching work academically approved (Shulman, 1993). Experienced teachers not only apply research results
in classroom but also generalize them for young teachers, cultivating an atmosphere of older teachers passing on their experience to help and guide younger members of staff in their professional journey. Young teachers could enrich their teaching experience by conducting their own research. From a practical point of view, teacher-led research could lead to a promotion and enhanced professional development (Leithwood, Harris, & Hopkins, 2008).

In recent years, there has been a grand development in Chinese educational innovation from the educational administrative departments at all levels; from the Ministry of Education to various teaching staff in different educational stages, to teachers in teaching. They have all done substantial work and achieved great results. In particular teachers’ professional knowledge in teaching will be an invaluable treasure for future educational innovation. If their know-how cannot be researched, disseminated and applied, educational innovation will stagnate.

Teacher research faces many challenges. Previous books and courses on research methods review various types and branches of research by integrating concepts, paradigms and methods, which are more systematic. These materials will require learners to comprehensively apply those theories to a specific situation and begin their own research topic after grasping the base knowledge. Such modules on educational and sociological research methods are commonplace in most undergraduate and graduate courses in the School of Education. Generally, researchers use quantitative research methods to reclaim and analyze questionnaires. They also use qualitative research methods to observe and interview students. In addition, they try to conduct some experimental research by teaching intervention.

In schools, teachers are very much like adult learners in that their learning skills and research methods need to be applied to real-life problem solving and daily teaching. Features of teacher-led research emphasize the fact that a systematic research method is difficult to implement in short teaching periods. They either do not have enough knowledge and confidence to carry out research, or/and the systematic research method training is too difficult to boost teachers’ confidence. They give up on their research easily. In the MOOC, provided by Peking University, there are strong cases to help teachers understand research methods more deeply.
Review of the current teacher research

By the 1950s, the “Teacher Action Research Campaign” emerged in the US. The campaign defined action research as research that intends to improve the practice of teachers, administrators and relevant personnel via scientific methods (Hammersley, 1993). In the late 1960s, British curriculum reform expert Lawrence Stenhouse made a point of stating that “teachers are researchers” and followed this in his humanities curriculum project. After this, more and more experts devoted themselves to related problems. At present, many researchers have made comprehensive analyses on the issue of teachers conducting their own research. In response to the topic of teachers as researchers, some scholars have focused on themes such as the related connotations, values, existing circumstances, problems and solutions.

Yang Liping thinks that “teachers as researchers” is a different concept to experts as researchers, which is the systematic and purposeful inquiry of school affairs (2007). Xu Yueting explored and analyzed the practice of teachers-led research and professional identity construction via questionnaires and interviews (2014). Fang Dongxin investigated primary school teachers in Shanghai and revealed the current situation, analyzed the causes and found solutions. He found that the research topics that teachers care about can be divided into the following categories: education practice, teaching practice and faculty development (2010). Dorothy Gabel conducted a study intended to determine the science education research interests of elementary teachers and to examine the data according to certain demographic variables. Her results indicated that hands-on experience, scientific content, cognitive development and learning styles, problem solving, and teaching strategies were among the top five research interests (Gabel, 1987).

Some scholars are dedicated to instructing teachers on how to do research. Lewis provided teachers with guidance on how to formulate research questions, including the definition of research problems, the source of research problems and so on (Lewis & Munn, 1987). Teachers’ research can be divided into various stages: reflection, raising questions, planning, taking action, and observation. These stages are spiraling (Zheng, 2005). Studies on “What kinds of questions did teachers care about when they engaged in research” are significantly fewer. There are few empirical
research questions that teachers care about. For example, in the study “Emerging Questions: K-3 Teachers’ Reflections on Action Research Questions” two K-3 teachers conduct research by asking questions. As a teacher, Yvonne cared primarily about issues relating to teaching effects and students learning abilities, and then she turned to learning differences. She said “I was keenly interested in differentiating instruction for all students - satisfying the needs of the enrichment students, intervening for the struggling students who require additional support for learning, and striving to meet the needs of the middle and above-average student not identified as gifted.” (DiLucchio C, Leaman H, Eglinton Y 2014). The other teacher, Lauren, cared more about pedagogy. She asked the research questions “What happens when children are engaged in two literature- discussion models?” And she said “[in] my work as a teacher researcher, I realize that the research question originated from a course in my master’s in education program that focused on student learning through literature.” (DiLucchio, Leaman & Eglinton, 2014)

Generally Speaking, many specialists and scholars have focused on the connotation, meaning, present situation and problems of teachers’ research and how to help teachers conduct their research. However, few people focused on the kind of research topics Chinese teachers care about.

**Method for investigating teachers’ research questions**

The core objective of this research is how to better answer the question “What research questions do teachers care about in China?” From many possible research questions and designs, we choose to use recycling and back-feeding structural questions to start our research.

In the MOOC course “Teacher Research”, we laid out the following discussion topics in the first forum of the first class. “What kind of teaching research questions do you care about?”; “Do you have any teaching research of your own? If not, please talk about some topics that you have heard about”, “Please tell us your subject, learning stages and research methods briefly.” We obtained the first batch of data by collecting the forum posts learners’ made in response to these questions.
However, after preliminarily analyzing and ordering these posts, we found their quality to be somewhat lacking. Some learners failed to answer the research questions clearly and often ignored some variables such as learning stages, subjects and research methods. Hence, we put those questions on the questionnaire and published them in the following round of MOOC courses. We also asked learners on three MOOC courses (Teacher Research, How to Make MOOC Courses, and the Flipped Classroom Teaching Method) to fill in the questionnaire.

We attempted to guide learners’ responses when designing the questionnaire. For example, the design of the question “Please write down the teaching research questions that you are interested in, and use sentences with question marks to express your research questions” seeks to encourage teachers to express their real teaching confusions and to present them in the form of research questions that they truly care about. In addition, we have designed specific questions to allow learners write down their learning stages, subjects and research methods.

We used “Text-Key Words-Code” to do the integral research design. Based on ordering the data, we extracted key words according to our central question “What kinds of research questions do teachers care about?” After ordering and analyzing the spread of the key words, we coded and proofread the research questions we collected. This bottom-up research design is the greatest feature of this research and also the basis behind determining the six research questions that teachers care about.

**Results**

**Overall description**

This research data is from post- and before-lessons questionnaire of three MOOCs which are offered by the Peking University x-learning center. As of March 20, 2016, the researchers had collected 526 samples, of which 495 are valid. Now, researchers continue to comb and analyze data from the four categories, including the source of the problems, the distribution of study section, the distribution of subjects and the categories of teaching problems that teachers are interested in.
Table 1. Data source

<table>
<thead>
<tr>
<th>Sources of the problems</th>
<th>Quantity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>How to build an MOOC</td>
<td>33</td>
<td>6.67%</td>
</tr>
<tr>
<td>Flipped classroom</td>
<td>93</td>
<td>18.79%</td>
</tr>
<tr>
<td>Teacher Research I</td>
<td>212</td>
<td>42.83%</td>
</tr>
<tr>
<td>Teacher Research II</td>
<td>157</td>
<td>31.72%</td>
</tr>
<tr>
<td>Kindergarten</td>
<td>7</td>
<td>1.41%</td>
</tr>
<tr>
<td>Primary school</td>
<td>77</td>
<td>15.56%</td>
</tr>
<tr>
<td>Junior middle school</td>
<td>79</td>
<td>15.96%</td>
</tr>
<tr>
<td>Senior middle school</td>
<td>95</td>
<td>19.19%</td>
</tr>
<tr>
<td>Vocational education</td>
<td>121</td>
<td>24.44%</td>
</tr>
<tr>
<td>University</td>
<td>111</td>
<td>22.42%</td>
</tr>
<tr>
<td>Others</td>
<td>5</td>
<td>1.01%</td>
</tr>
</tbody>
</table>

If we consider the source of these problems, study problems stem mainly from “Teacher Research I” and “Teacher Research II”, which account for 75% of the total samples. This mainly concerns the teaching content of the three MOOCs, since the goal of “Teacher Research” is to teach teachers how to conduct canonical research and encourage them to discover their own areas of research interest, but the other two MOOCs mainly focus on the flipped classroom teaching method and the MOOCs’ producer.

The distribution of study section is divided into seven categories: kindergarten, primary school, junior middle school, senior middle school, vocational education, university and others. The category of others mainly includes community education, training etc. Among them, the proportion of teachers in the vocational education stage reached a maximum of 24.44%, followed by university, senior middle school, junior middle school, primary school, kindergarten and others, respectively accounting for 22.42%, 19.19%, 15.96%, 15.56%, 1.41% and 1.01%. Overall, the number of primary school, junior middle school, senior middle school, vocational education and
university teachers accounted for was roughly balanced, which is also associated with the pedagogic origin of our MOOCs.

Table 2. Sample description

<table>
<thead>
<tr>
<th>Study Section</th>
<th>Subject Category</th>
<th>Quantity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-12 Stage</td>
<td>Chinese</td>
<td>48</td>
<td>9.70%</td>
</tr>
<tr>
<td></td>
<td>Mathematics</td>
<td>52</td>
<td>10.51%</td>
</tr>
<tr>
<td></td>
<td>English</td>
<td>34</td>
<td>6.87%</td>
</tr>
<tr>
<td></td>
<td>Physics, Chemistry, Biology (PSB)</td>
<td>42</td>
<td>8.48%</td>
</tr>
<tr>
<td></td>
<td>History, Geography, Politics (HGP)</td>
<td>24</td>
<td>4.85%</td>
</tr>
<tr>
<td></td>
<td>Information Computer Technology (ICT)</td>
<td>29</td>
<td>5.86%</td>
</tr>
<tr>
<td>Higher Education Stage</td>
<td>Humanities</td>
<td>69</td>
<td>13.94%</td>
</tr>
<tr>
<td></td>
<td>Sociology</td>
<td>29</td>
<td>5.86%</td>
</tr>
<tr>
<td></td>
<td>Science</td>
<td>47</td>
<td>9.49%</td>
</tr>
<tr>
<td></td>
<td>Engineering</td>
<td>38</td>
<td>7.68%</td>
</tr>
<tr>
<td></td>
<td>Medicine</td>
<td>13</td>
<td>2.63%</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>70</td>
<td>14.14%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>495</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Considering the differences between K-12 stage and higher education, researchers divided disciplines differently in the two stages. We divided the subjects into Chinese, Mathematics, English, PSB, HGP and ICT in the K-12 stage, and into humanities, sociology, science, engineering, medicine in the higher education stage. As community education and K-12-stage music, art and other subjects appear less frequently, and some vocational subjects are difficult to classify, we classified these subjects as “others”. In the K-12 stage, Chinese, Mathematics and English are seen as the most important, so these three disciplines are distributed in larger quantities. It is worth mentioning that the distribution of ICT is greater. This is because MOOC is a new way of learning, and ICT teachers can adapt to online learning more quickly compared to other teachers, who access the Internet every day. In the higher education stage, the humanities accounted for the most percentage, followed by science, engineering, sociology and medicine.

Six categories of Instructional Research Questions

According to the teachers’ description of research questions, researchers first extracted 1-2 keywords from each research question. It is worth bearing in mind that because we have counted
and analyzed the subjects and study section, the extracted keywords do not contain these two types of information. In addition to that, researchers examined word frequency statistics and found that the terms "flipped classroom", “interest in learning”, “teaching effectiveness”, ”students’ ability” were high frequency. Based on these high-frequency words, the researchers discussed, categorized, and eventually distributed the teaching problems teachers concerned into the following six categories:

*How can we inspire students’ motivation?*

This category includes “how can we improve students' motivation in the classroom?”, “How can we arouse students' interest in learning?”, and other related issues, for example, a university teacher raised a question about how to stimulate students' interest in learning in a sociology course. To answer this, he has conducted a preliminary investigation by way of questionnaires, classroom feedback, and discussion. The study found that it is difficult to arouse students’ interest in theoretical courses, and it often requires a combination of some practical teaching.

*How can we use specific pedagogy to teach?*

This category includes “the flipped classroom teaching method”, “micro-lesson teaching method” and other methods used in the practice of teaching and some related issues. This may be associated with the source of our data. Since there is an MOOC talking about the flipped classroom, many teachers pay attention to new pedagogies and devote themselves to applying these pedagogies in their classes.

*How can we achieve more effective and efficient teaching?*

Here, “effective” refers to the teachers’ ability to achieve the effects they expect, while “efficiency” refers to students learning more efficiently, they can learn more knowledge in same classroom-time compared in past. As one of the indicators to measure the effectiveness of teaching, teaching results always attract teachers’ attention. The study focused on how to improve their teaching effectiveness and how to achieve the same or even higher quality in a shorter period of teaching time.
How can we use new technology in teaching?

With the continuous development of information technology in education, new technology has been gradually integrated into front-line teaching. The “new technology” mainly includes mobile devices, interactive whiteboards, network platforms and multimedia technologies and tools. Far removed from the traditional single classroom blackboard and book teaching, teachers are drawn to the question as to how to combine these new technologies with the traditional class format and how to rationally use them to facilitate teaching and learning.

How can we improve students’ learning ability?

Teachers constantly refer to “student ability”, “practical ability”, “self-learning” in the collected posts, so we merged these issues into this category. For example, a junior middle school teacher posed the research question “Are there any ways of improving the learning ability of students?” The teacher conducted contrast experiments through documents and questionnaires and finally summarized an effective method of autonomous learning.

How can we deal with differences between students?

This category mainly includes the keywords “learning difficulties”, “student diversity”, and “individualized tutoring”, which refer to issues surrounding how to deal with differences in students’ learning abilities. Within the same class, there are cognitive differences between students, therefore the topic of appropriate teaching methods and how to implement them in order for students to obtain different levels of progress and receive individualized tutoring is also of interest for teachers.

Others

Within this category, there are a number of issues that are difficult to categorize, such as teaching reforms. These types of problems are not particularly close to our research focus and have less data, but cannot be treated as missing values. In this study, we have classified these questions as “others”.
According to the classification of the keywords, researchers classified, coded and proofread the research questions raised by teachers to ensure reliability and validity. The distribution of six types of research questions is as follows (including “others”):

![Research Questions Distribution](image)

*Figure 1. The distribution of the six types of research questions*

According to the graph “How can we use specific pedagogy to teach?” reached 29.09%, followed by “how can we achieve more effective and efficient teaching?” which accounts for 22.63%. Apparently almost half of the teachers’ research questions focused on “how can we use specific pedagogy to teach?” and “how can we achieve more effective and efficient teaching?” These two types of issues constitute 51.72% of the total data. In general, teachers are most interested in the concrete effects of teaching on learning and are committed to applying new pedagogy and technology into their teaching practice.

**Instructional Research Questions Teachers of K-12 Care About in Mainland China**

In this survey, we obtained 262 valid responses in the K-12 stage made up of 84 responses from kindergartens and primary schools (32.06%) and 178 from secondary schools (67.94%).
Data regarding the kinds of research questions kindergarten and primary school teachers cared about are shown below.

As we can see in Figure 2, nursery and primary school teachers care most about the question “How can we use specific pedagogy to teach?”, which accounts for 30.23% of the results. Kindergarten and primary school teachers also care about the question “How can we promote more effective and efficient teaching?” which constitutes 19%. In addition, nursery and primary school teachers are also interested in the topic “How can inspire students’ motivation?” which makes up 16% of the results. Kindergarten and elementary teachers do not seem to be concerned with research questions such as “how can improve students’ learning ability?” or “how can we use new technology in teaching?”
The research questions that kindergarten and primary school teachers care about are related to pedagogical issues, such as the flipped classroom, cooperative learning, and the application of micro-lessons. Some teachers raised research issues such as “the benefits and problems of cooperative learning in the flipped classroom”, “research on rural primary school English classes using the flipped classroom method based on Micro-video” and “flipped classroom teaching model applied research in primary school teaching mathematics”.

Statistical results of secondary schools

Figure 3. The distribution of six types of research questions in secondary school teaching

As the pie chart illustrates, middle school teachers care about similar questions to their kindergarten and primary school counterparts. Middle school teachers care most about the topic of “How can we use specific pedagogy to teach?” which holds 30.06% of the results. The second most significant topic for middle school teachers is “How can we achieve more effective and efficient teaching?” with 19%. In addition to that, “How can we inspire students’ motivation?” is evidently also a concern for middle school teachers, as it accounts for 16%. Middle school teachers care least about
the questions “How can we improve students’ learning ability?” and “How can we use new technology in teaching?”

We found that middle school teachers also care about pedagogy; more than half of them mentioned flipped classroom applications, for example. Some teachers raise research questions such as “the application of flipped classroom teaching methods in the instructional design of physics”, “the application of flipped classroom geography teaching in high school” and “feasibility analysis of the flipped classroom in rural middle school language classes”.

**Comparison of research questions cared about by teachers from a variety of subjects in K-12**

In secondary education, the teaching problems that teachers care about are as follows:

![Figure 4. The distribution of different subjects in K-12 teaching](image-url)
From the above bar chart, we can see that teachers from different subjects care about different research questions. Chinese teachers care more about the question “How can we achieve more effective and efficient teaching?” (26.09%), while math teachers care more about the question “How can we improve students’ learning ability?” (26.09%), and foreign language teachers respond more to the question “How can we use specific pedagogy to teach?” (42.86%).

Subjects increase in secondary school. In addition to the three major subjects of Chinese, mathematics, and English, arts and science courses also appear. Arts subjects include geography, history and politics, while science subjects include chemistry, biology, and physics. Since those subjects are drastically different, arts and science teachers also emphasize different research questions. Most arts teachers are concerned with the question “How can we achieve more effective and efficient teaching?”, while science teachers demonstrate more interest in the question “How can we use specific pedagogy to teach?”

**Instructional Research Questions Higher Education Teachers Care About in Mainland China**

In the stage of college and vocational education, the research questions that teachers care about reflect the prevalent problems in practical higher education teaching. In this survey, we have collected 234 valid responses from college and vocational education teachers, including 113 (48.29%) from college educators and 121 (51.71%) from vocational teachers.

**Statistical Results of Undergraduate Education teaching**

The research questions undergraduate teachers care about are as follows:
Figure 5. The distribution of six types of research questions in university teaching

We can see from the above pie chart that 31.86% of college teachers care about the question “How can we use specific pedagogy to teach?” and 24.78% of them care about the question “How can we achieve effective and efficient teaching?” Research questions about practical pedagogy, technology and efficient teaching account for more than half of the university teachers’ responses. Meanwhile, “How can we inspire students’ motivation?” is also a question that teachers care about, comprising 15.93% of the results. In contrast, questions such “How can we deal with differences between students?” and “How can we use new technology in teaching?” worry university teachers the least.

Regarding the instructional problems that higher education teachers in Mainland China face, especially in undergraduate education, mostly stem from the question “How can we use appropriate pedagogy to achieve better teaching effects?” Most research questions are about flipped classroom methods, mixed learning, cooperative learning, project learning and other specific pedagogies, such as “How to improve task performance in a big flipped classroom” and “How to launch mixed learning in normal teaching”. The questions that teachers find confusing in pedagogy are mainly concern the topics “Will the new pedagogy suit my course?”, “How can I use the new pedagogy
successfully in class?” and “Are these new pedagogies more effective and efficient compared with the old ones?”

In addition, learning interests and motivation also raise an important question for college teachers, many of whom have raised research questions about inspiring student’s motivation, such as “How can I inspire students’ learning motivation in sociology courses?”, “How can I make college students enjoy asking questions?” and “How can I use new pedagogy to solve ‘smartphone addiction’?” College students are losing their motivation to study, which becomes a common instructional research question and point of confusion for undergraduate teachers in mainland China.

Course teaching is very subject specific in undergraduate education. The most common classification of undergraduate education in the past has been science and engineering, and humanities and sociology. We can see the differences between teachers from different subjects.
Figure 6. The distribution of different areas in undergraduate teaching

As we can see from the bar chart above, teachers from science and engineering mostly care about the question “How can we use specific pedagogy to teach?”, which accounts for 27.08% of responses, but the number is much lower than that of teachers from humanities and sociology (39.53%). In addition to that, on the question “How can we inspire students’ motivation?”, teachers from science and technology showed more interest than they did for students’ learning motivation.

Statistical Results of Vocational Education

The research questions that vocational teachers care about are as follows:
Figure 7. The distribution of six types of research questions in vocational education

Compared with undergraduate education, vocational educators concern themselves more with the question “How can we inspire students’ motivation?” which comprises 26.45% of responses. Meanwhile, the questions “How can we use specific pedagogy to teach?” and “How can we achieve more effective and efficient teaching?” both hold approximately one quarter of the results. Vocational education teachers care less about learning abilities, using new technologies and differences between students than their counterparts from other educational levels.

Concerning the different types of subjects in vocational education, it can be said that teachers from science and technology and teachers from humanities and sociology care about different research questions.
Figure 8. The distribution of different areas in vocational education

In the figure above, we can see that teachers from science and technology subjects mostly care about the question “How can we inspire students’ motivation?” which represents 32.35%. And teachers from humanities and sociology are mainly interested in the question “How can we achieve more effective and efficient teaching?” which holds 30.91% of the results.

Research Methods Frequently Used by Teachers

In the questionnaire, teachers mentioned “experiment” and “questionnaire” most frequently when answering the question “What kind of research methods do you use?” They mentioned “interview” and “observation” in the second rank. Some respondents mentioned “action research”.

<table>
<thead>
<tr>
<th>Research Methods</th>
<th>Science &amp; Engineering</th>
<th>Humanities &amp; Sociology</th>
</tr>
</thead>
<tbody>
<tr>
<td>How to inspire students' motivation?</td>
<td>32.35%</td>
<td>18.18%</td>
</tr>
<tr>
<td>How to use specific pedagogy to teach?</td>
<td>23.53%</td>
<td>25.45%</td>
</tr>
<tr>
<td>How to achieve more effective and efficient teaching?</td>
<td>20.59%</td>
<td>30.91%</td>
</tr>
<tr>
<td>How to use new technology in teaching?</td>
<td>8.82%</td>
<td>3.64%</td>
</tr>
<tr>
<td>How to improve students' learning ability?</td>
<td>5.88%</td>
<td>5.45%</td>
</tr>
<tr>
<td>How to deal with differences between students?</td>
<td>2.94%</td>
<td>3.64%</td>
</tr>
<tr>
<td>Others</td>
<td>5.88%</td>
<td>12.73%</td>
</tr>
</tbody>
</table>
Quantitative research methods are mentioned most, such as experiment and questionnaire, which reflects teachers’ understanding of “research methods”. Perhaps these kinds of research methods are more familiar to them, as they can be objectively compared. For example, when teachers discuss "How to compare the teaching effects of the flipped classroom method in two classes", they often use an experiment.

**Research Questions that Teachers in Different Education Stages Care About**

We have divided teachers into four groups according to their education stages, which are primary schools, secondary schools, universities, and vocational education. The research questions that concerned teachers categorized by group are as follows:

![Figure 9. The distribution of different education levels](image)

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Kindergarten and Primary School</th>
<th>Secondary Schools</th>
<th>Undergraduate Education</th>
<th>Vocational Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>How to inspire students’ motivation?</td>
<td>10.47%</td>
<td>16%</td>
<td>15.03%</td>
<td>26.45%</td>
</tr>
<tr>
<td>How to use specific pedagogy to teach?</td>
<td>30.23%</td>
<td>30%</td>
<td>31.86%</td>
<td>25.62%</td>
</tr>
<tr>
<td>How to achieve more effective and efficient teaching?</td>
<td>22.09%</td>
<td>19%</td>
<td>24.78%</td>
<td>25.62%</td>
</tr>
<tr>
<td>How to use new technology in teaching?</td>
<td>11.63%</td>
<td>9%</td>
<td>7.08%</td>
<td>4.13%</td>
</tr>
<tr>
<td>How to improve students’ learning ability?</td>
<td>16.28%</td>
<td>12%</td>
<td>7.96%</td>
<td>4.13%</td>
</tr>
<tr>
<td>How to deal with differences between students?</td>
<td>3.49%</td>
<td>5%</td>
<td>2.65%</td>
<td>3.31%</td>
</tr>
</tbody>
</table>

From the above bar chart, we can see that middle school teachers care more about the question “How can we inspire students’ motivation?” than primary school teachers, the statistics of which are
16.08% and 10.47% respectively. Almost all teachers care about the question “How can we use specific pedagogy to teach?”, apart from teachers in vocational education (25.62%). Teachers also care very much about the issue “how can we achieve more effective and efficient teaching?”, and teachers from vocational education do so the most, with for 25.62%. They do not care about the question “How can we improve students’ learning ability?”, which shows that teachers from a higher education stage care less about this question.

Meanwhile, we can see that no matter if the teachers are from primary or secondary schools, or college, they are all primarily concerned with the question “How can we use specific pedagogy to teach?” The second most significant question is “How can we achieve more effective and efficient teaching?” followed by “How can we inspire students’ motivation?”. Teachers in vocational education mostly concern themselves with the question “How can we inspire students’ motivation?” (26.45 %). The second most important question for vocational educators is “How can we achieve more effective and efficient teaching?” (25.62%), followed by “How can we use specific pedagogy to teach?” (25.62%)

**Conclusion**

Having analyzed the data on “what research topics do teachers care about” collected via questionnaires, we will now discuss our conclusions below.

**Six kinds of research questions and teachers’ puzzle about teaching**

After organizing the text, extracting the key words and coding them, this research summarizes 6 research questions teachers care about. They are: “how can we inspire students’ motivation?”; ”How can we use specific pedagogy to teach?”; ”How can we achieve more effective and efficient teaching?”; ”How can we use new technology in teaching?”; ”How can we improve students’ learning ability?”; “How can we deal with differences between students?”(The remaining questions are counted among “Others”).
In the academic teaching field, teachers generally play a key role, and their reflection on the teaching process is directly related to their perplexity regarding certain points within this process. The research questions they cared about therefore stem from the difficult and normal phenomena they experience in their daily teaching (Amy, 2004). Questions develop gradually after careful observation and deliberation about why certain things happen in the classroom. Questions are not formed with the goal of quick-fix solutions but rather involve the desire to understand teaching or children’s learning in profound ways. (DiLucchio, C., Leaman, H., Eglinton, Y., & Watson, L. C, 2014). Combined with the analysis of the research questions teachers cared about, this research provides a special perspective from which to recognize and analyze common problems in current basic and higher education in China. Some examples include students’ lack of motivation and interest, and the fact that teachers have contact with new pedagogy but experience great difficulties in turning this theory into teaching practice. The teachers were concerned about the students’ learning outcome because of the senior and college entrance exams, but relatively speaking they were rarely concerned about students’ ability development. Meanwhile, with the rapid popularization of information technology in basic education, the teachers remain confused about how to take advantage of this new technology.

**How can we achieve more effective and efficient teaching?**

According to feedback given by teachers involved in this investigation, Chinese teachers are mainly concerned about the research questions “how can we use specific pedagogy to teach?” and “how can we achieve more effective and efficient teaching?” These two kinds of questions had higher than average percentages compared with the other types. Actually, they both reflected the idea that teachers care about teaching effects. This was also demonstrated in the question “how can we use specific pedagogy to teach?” Within this category, questions were expressed in ways such as “Could MOOC really promote educational equality?”; “Is the flipped classroom method valid in biology in high school?”; “How can I use the flipped classroom method in high school and what are the teaching effects?”; “How can I organize the learning activities in classroom?”; and “What is the influences of filled classroom in computer science vocational education stage?”
Caring about the teaching effects is a natural instinct for teachers. So, when they hear about a new pedagogical method, they are automatically concerned with its effects. The role of the teacher as a researcher moves teachers from a state of powerlessness to a position of power; they transform from being mere receivers of training and lecturing to initiators of change and more efficient and active teachers (Fareh, S., & Saeed, A.T, 2011). But for teachers, their students’ achievement is not the only thing they care about; students’ emotional development, ability improvement and metacognition development are also important. However, as it stands, teachers in China rarely think about these factors, perhaps due to the pressures of their work and their limited capacity for research.

*Students’ lack of motivation, especially in higher education*

In general, most teachers in higher education care more about students’ motivation, especially in vocational education, when compared with their basic education counterparts. “How can we inspire students’ motivation?” was the most popular research question. Students in the basic education stage faced academic pressures, which gave students a motivation to learn. However, when they finished the examinations at the end of high school, they will wave goodbye to learning under extreme pressure. In Chinese vocational schools, there are many problems such as the low numbers of students, the low quality of the teaching and the lack of job prospects upon graduating. In higher education, science teachers care more about students’ motivation, which differs from subject to subject depending on their characteristics; for example, science knowledge is strongly abstract and theoretical so it is often dull for students, which leads to a decrease in motivation.

Learning motivation is an inner mental activity that promotes and maintains learning activity, and makes it more close to the study goals formulated by the teacher. Given that differences in students’ motivation will affect learning directly, it is unsurprising that it is a top priority for teachers. Simultaneously, students in vocational schools lack career planning (Zhang Yang, 2012). For teachers, the problem of how to keep students motivated and willing to learn is the fundamental question; failing to solve this means that issues with teaching effects, ability improvement and learner differentiation will never be solved. This research has revealed some hidden dangers in Chinese education.
How do teachers view and recognize teaching research?

Teachers most commonly use questionnaires and experiments in their research. These two methods have high requests of the research design, and variable controlling and data collection are more difficult. They are also closely related to question of “teaching effects”. But for teachers, more convenient methods such as observation, journals and interviews are not popular.

We would argue that teachers’ understanding of teaching research is shallow. They believe that only research using rigorous methods is useful research. But it should be noted that course observation, teaching research discussion and teacher-student communication are also important research methods.

Discussion and Outlook

The study initially attempted to study the kinds of research topics that are important to Chinese teachers. Due to the limitations in time and resource constraints, researchers were unable to use the entire Chinese teachers sampling plan, so we chose random sampling. This means that the researchers chose to focus mainly on the problems that concerned these teachers, not on describing the country's overall situation.

The researchers collected the data by issuing questionnaires and collecting the posts on the class forum. This sampling method is relatively open and random, so the researchers were unable to control the sampling number and sources accurately. When focusing on a particular subject in a specific educational stage, the sample size is too small. Furthermore, because these MOOCs focus on particular topics, the teachers who participate in them may have some personal orientation. For example, the students of the flipped classroom teaching method are mainly concerned about pedagogy, and this influenced the sample and results of our research. In future, the researchers will
limit the range of study sections and subjects and cooperate with national educational administrative departments, in order to obtain a more accurate sample and in-depth study on the research interests of mainland Chinese teachers.

In addition, there were subjective factors that influenced the keyword extraction and integration, problems when encoding and so on. Although researchers took some actions to assure reliability and validity, such as conducting the pre-study about the forum posts, setting introductory questionnaire problems etc., in the coding section, three researchers coded the questions separately without conducting a systematic partner test, thus this part of the study contains greater subjectivity.

Finally, this study classifies teachers’ questions based on their research interests into six categories which are not completely independent from one another. There are relationships between them and qualitative research must be adopted to sufficiently explore them. The present study uses a research method based on keyword analysis, which lacks qualitative research on relevant academics and other front-line workers. Therefore, the researchers are unable to build a relationship between the six types of teaching problems that teachers are most concerned with, something that also warrants more in-depth study.

Reference


Maija Aksela\textsuperscript{1,2}, Jenni Vartiainen\textsuperscript{1,2}, Maiju Tuomisto\textsuperscript{2}, Jaakko Turkka\textsuperscript{2}, Johannes Pernaa\textsuperscript{2}, & Sakari Tolppanen\textsuperscript{2}

\textsuperscript{1}LUMA Centre Finland, University of Helsinki, Finland  
\textsuperscript{2}Unit of Chemistry Teacher Education, Department of Chemistry, University of Helsinki  
maija.aksela@helsinki.fi

Abstract

Information and communication technology (ICT) has been successfully used to promote children’s, youths’ and teachers’ competence in mathematics, science and technology in Finland through the LUMA Centre Finland. The LUMA ecosystem (LU stands for science and MA for mathematics) is a social innovation based on collaboration between 11 universities (including researchers and teacher trainers), educational administrations, the business sector, teachers, teacher associations, science museums and centers, families and the media. It is a Finnish model of how to promote LUMA learning, teaching and teacher training. One particular focus of the LUMA collaboration is to support the incorporation of information communication technology (ICT) into classroom practice, especially by supporting pre- and in-service teachers in building their technological pedagogical content knowledge (TPCK). This paper reviews some of the earlier research and development conducted by the LUMA Centre Finland on the incorporation of ICT into teacher training and non-formal science education. As an example, this paper summarizes the research done on molecular modeling, the microcomputer-based laboratory (MBL) in chemistry education and its’ implications for teacher education, and virtual learning environments in science education. This paper also discusses how design-based research has been used as a successful research method to connect theory and practice and to develop pedagogical ICT innovations in science education. Some going-on research topics (e.g. MOOCs) are also presented.

1. Introduction

The main aim of the LUMA Centre Finland is to promote a high level of knowledge in mathematics, science and technology for all and to ensure a sufficient number of professionals, specifically by aiding the incorporation of research-based practice into education. This is done by promoting formal,
non-formal and informal education for children and youths between the ages of 3 to 19 as well as offering training to pre- and in-service teachers and collaborating with families. The LUMA Centre serves as the umbrella organization for 13 LUMA Centres in 12 Finnish universities to strengthen and promote their collaboration at both the national and international level. It utilizes its 11 visiting labs in mathematics, science and technology at various universities around Finland to promote collaboration between schools and develop pedagogical innovations in science education through design-based research (e.g., Vihma & Aksela, 2014).

One unique aim of the LUMA collaboration is to support the incorporation of information communication technology (ICT) into classroom practice at all levels, from kindergarten to university, by promoting teachers’ professional development (CPD). The newest research on ICT use has been incorporated into teacher training in order to help teachers manage ICT in the 21st century. First, this means that teachers need to have and develop their technological knowledge (TK). Secondly, teachers need to understand how to use ICT to facilitate learning, or in other words, they need technological pedagogical knowledge (TPK). Thirdly, teachers need to know how to search for and present knowledge using ICT, meaning that they also need technological content knowledge (TCK). However, even these three factors alone are not enough for quality ICT-supported teaching. Therefore, LUMA teacher training emphasizes that teachers should have excellent technological pedagogical content knowledge (TPCK), thus integrating all the aforementioned types of knowledge. In practice, this means that teachers should possess a dynamic and transformative tacit knowledge of technology which is integrated into their pedagogical knowledge (PK) and content knowledge (CK) (Koehler, & Mishra, 2008; 2009; Chai, Koh, Tsai, & Tan, 2011; Rogers, & Twidle, 2013), as depicted in Figure 1.
The TPCK framework is based on the pedagogical approach known as “learning technology by design” which places emphasis on learner-centered learning-by-doing in authentic contexts. When this approach is applied to teacher training, teachers are engaged in authentic design activities related to educational ICT (Mishra & Koehler, 2006). The “learning technology by design” approach is based on the educational design research approach (e.g. Aksela, 2005; Pernaa & Aksela, 2013).

Science teachers have to stay up-to-date with the latest applications of educational technology and find the best ways to use them. The LUMA Centre Finland supports their lifelong learning through a continuum model (e.g. Aksela, 2010) that includes the following components: i) pre-service training, ii) an induction stage, and iii) in-service training. The base for lifelong learning is created during all levels of training for pre-service teachers. During their studies, pre-service teachers are provided with an excellent opportunity to practice interacting with children and youths by leading different LUMA activities. Authentic and regular experiences with students build skills to guide and manage the children and youths. In the induction stage that follows, newly graduated LUMA teachers collaborate actively and closely with their Alma Mater. The LUMA ecosystem’s online services offer many opportunities for these newly-qualified teachers in terms of self-development and chances to network with other recent graduates. Further on in their career path, experienced LUMA teachers at school level receive support from various LUMA activities (webzines, newsletters, in-service training courses, consultation, webinars, MOOC et al.). To respond to the challenges of an ever-evolving IT
society, the LUMA Centre Finland organizes high-quality LUMA in-service training, in which ICT plays a significant role in supporting teachers’ lifelong learning. These in-service training courses are also open to pre-service teachers, so that pre-service and in-service teachers can interact with and learn from one another. As there are frequently obstacles that prevent teachers attending these training courses in person, more and more in-service training is organized online via virtual learning environments (e.g. Vihma & Aksela, 2014).

Science teaching and learning through ICT

This chapter summarizes some of our earlier research on the incorporation of ICT into Finnish science education at school level and into teacher training, especially in the context of chemistry education.

The current state of using ICT in Finnish science education at school level

ICT can be seen as a novel way of pedagogical thinking that supports the use of various pedagogical and didactical methods in science education. Therefore, ICT has been used to support teaching and learning in mathematics, science and technology education in Finland since at least the 1980s. Furthermore, promoting the use of ICT in classroom practice is one of the central aims of the Finnish education policy designed by the National Board of Education (Opetushallitus, 2014; 2015).

Over the years, there have been many useful professional development projects to increase teachers TPCK and improve the use of ICT in science teaching in Finland (e.g. Aksela & Karjalainen, 2008; Lavonen, Juuti, Aksela, & Meisalo, 2006). As an example, an ongoing project, called LUMA SUOMI, supported by the Finnish Ministry of Culture and Education, aims to help integrate ICT into mathematics, science and technology education by teaching 6- to 16-year olds about programming and robotics. The LUMA Finland program intends to find novel and innovative tools and approaches to teaching practices, methods and learning environments. It is based on current research and it aims to provide practical action guidelines that can be employed in schools nationwide.

Since 1998, several studies have been conducted in Finland to examine how ICT is used in schools to promote science education (e.g. Aksela & Juvonen, 1999, Lavonen et al., 2006). The most recent survey (Helppolainen & Aksela, 2015) examined the opportunities and barriers that teachers encounter when implementing ICT use into science education. The study showed that TPCK training increases teachers’ positive beliefs in the use of ICT in teaching and learning. Furthermore, although
science teachers seem to have a decent skill level in using general software, their knowledge of science-specific software was often quite poor. Therefore, teachers seem to require more subject specific training on how to support students’ learning through ICT. To sum up, the survey concluded that the biggest barriers to ICT use were the lack of time, too large groups, the lack of TCPK and a lack of suitable software or materials (Aksela, & Lundell, 2007; Aksela, & Karjalainen, 2008; Helppolainen & Aksela, 2015). The research obtained from the Finnish teachers demonstrates that the benefits of using ICT in chemistry education lie in the diverse possibilities to enhance students’ motivation and cognitive processes for higher order thinking skills (Pernaa, 2011).

The use of ICT in pre-service chemistry teacher education

As discussed, the LUMA Centre Finland supports teachers’ lifelong learning in the context of ICT through a three-part continuum model (e.g. Aksela, 2010) centered on the following components: i) pre-service training, ii) an induction stage, and iii) in-service training. For over ten years, TCPK has had a strong presence in teaching and research made/conducted by the Chemistry Teacher Education Unit in the Department of Chemistry at the University of Helsinki (e.g. Aksela 2005; Aksela, & Lundell, 2008; Pernaa, & Aksela, 2009; Pernaa, 2011; Pernaa, Aksela, & Västinsalo, 2010).

On the base of earlier research and experiences, a TCPK strategy for chemistry teacher education was developed and piloted (see further on in the text for details). As the results demonstrate, providing TCPK in pre-service teacher education is the most effective way to enable teachers to use ICT skills. Other ways to enable the usage of these skills include offering in-service ICT training for teachers and teacher trainers, peer support and the introduction of quality tools (Ertmer, 1999; Ertmer, Ottenbreit-Leftwich, & York, 2006; Goktas, Yildirim, & Yildirim, 2009; Chai et al., 2011). ICT and real-situation teaching should also be combined in teacher education (Goktas et al., 2009). ICT training is most effective when it is integrated into pre-service teacher training courses. When trainee teachers are engaged in the planning and application of reasonable ICT-integrated lessons, both their basic skills (CK, PK and TK) and professional skills (TPK, TPCK) will develop (Angeli, & Valanides, 2009; Koehler, Mishra, & Yahya, 2007). The pre-service training stage must already concern itself with improving teachers’ competency in the target skills and assuaging any negative attitudes and beliefs they may have (Ertmer et al., 2006). As teacher educators are role models for the pre-service teachers, they should serve as role models by integrating and applying ICT technology in their own courses and teaching (Goktas et al., 2009; Myllyviita, & Lavonen, 2014).
In Finnish pre-service teacher training, there is a strong desire to use ICT diversely and the students are highly motivated to use ICT in their own classrooms (Meisalo, Lavonen, & Sormunen, 2011). In general, Finnish teacher education plays a key role in training future teachers to skillfully follow the Finnish National Curricula and integrate with ICT. Objectives for TK and TPK should be included in course and degree aims in a cumulative way (Myllyviita, & Lavonen, 2014). When using factor analysis to research the effects of the different factors contributing to TPCK (N=343), Chai et al. (2011) found the direct effect of subject specific content knowledge (CK) and technological pedagogical knowledge (TPK) on the development of TPCK to be of great significance. Technological content knowledge (TCK) for pre-service teachers can be supported and affirmed by providing students on pre-service education courses with opportunities to use the relevant ICT when teaching a specific topic (Goktas et al., 2009; Chai et al., 2011). In chemistry, for example, molecular modeling, electrolysis simulation and microcomputer based laboratory (MBL) make use of this kind of ICT (see Chapter later on).

Based on the previous research and 21st century ICT skills, an ICT strategy for chemistry teacher education was developed during the spring of 2014 and piloted in the fall of 2014. The multifaceted use of ICT has important significance for the education of chemistry teachers at the University of Helsinki. In the Chemistry Teacher Education Unit, students are educated to become skilled teachers who are ready to face the demands of school environments in the near future. Good ICT skills represent a key element of this goal, meaning that it is essential to supply students with various opportunities to continuously develop their ICT skills, to use digital teaching tools and applications competently (Tuomisto, Aksela, & Jääskeläinen, 2015).

All chemistry students learn basic ICT skills by completing the course ICT License (3 ECTS). The developed ICT strategy featured 20 subcategories (see Table 1) included in the courses offered by the Chemistry Teacher Education Unit (13 courses, course ICT License excluded). Nine of these courses are mandatory and the other five are voluntary for chemistry teacher students. In each of these 13 courses, one to three of the ICT strategy subcategories have been selected to be integrated into the course. Additionally, chemistry teacher students will train and apply their ICT skills to pedagogical courses under the guidance of experts in science pedagogy and in real school environments under the guidance of chemistry teachers from the practice school (Tuomisto, Aksela, & Jääskeläinen, 2015).

Table 1. Subcategories included in the ICT strategy of the Chemistry Teacher Education Unit. (Grey-colored sub-categories and courses were included in the applied ICT strategy research.)
After being in use for one semester, the suitability of the ICT strategy for chemistry teacher education was examined by a case study. The data was collected via pre- and post-semester e-questionnaires. The questionnaires were designed and piloted by the course teachers. The questionnaires included both Likert-scales and open-ended questions about the subcategories integrated into the courses of the 2015 spring semester. The pre-questionnaire was completed by participants before the semester (N=40, answering percentage 80%) and the post-questionnaire at the end of the semester (N=32, answering percentage 73%) (Tuomisto, Aksela, & Jääskeläinen, 2015).

The aim of the ICT strategy inquiry was to find answers to the following questions: 1) How will chemistry teacher students’ ICT skills change during ICT integrated teaching? 2) Which kind of ICT skills do students find to have a positive nature? 3) What kinds of challenges do students face when developing their ICT skills? (Tuomisto, Aksela, & Jääskeläinen, 2015).

At the beginning of the semester (pre-questionnaire), students had, on average, negligible knowledge or skills about simulation or modeling applications and the ways of virtually collaborating to share and modify materials. Students self-evaluated their skills as poor in blended or flipped

<table>
<thead>
<tr>
<th>Subcategories in ICT strategy</th>
<th>Integrated into course/courses</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Basic skills</td>
<td>ICT license (and applications on all courses)</td>
<td>3</td>
</tr>
<tr>
<td>2 Face your classroom</td>
<td>(on all courses: e.g. course platforms)</td>
<td></td>
</tr>
<tr>
<td>3 Visual learning</td>
<td>Introduction to chemistry education (blogs and wikis)</td>
<td>3 or 4</td>
</tr>
<tr>
<td>4 Cloud initiation</td>
<td>Models and visualization in chemistry education</td>
<td>5</td>
</tr>
<tr>
<td>5 Collaboration</td>
<td>on all courses (e.g. Google Drive, Dropbox)</td>
<td></td>
</tr>
<tr>
<td>6 Communication</td>
<td>The central areas of chemistry education I</td>
<td>6</td>
</tr>
<tr>
<td>7 Time management and productivity</td>
<td>Mathematics and science in society</td>
<td>3</td>
</tr>
<tr>
<td>8 Digital citizenship</td>
<td>Chemistry as a science and as a discipline</td>
<td>5</td>
</tr>
<tr>
<td>9 Search strategies</td>
<td>Introduction to chemistry education</td>
<td>3 or 4</td>
</tr>
<tr>
<td>10 Content strategies</td>
<td>Inquiry-based chemistry teaching II</td>
<td>5</td>
</tr>
<tr>
<td>11 Interactives</td>
<td>The central areas of chemistry education II</td>
<td>4</td>
</tr>
<tr>
<td>12 Powerful presentations</td>
<td>Media and multiliteracy in science and technology education</td>
<td>5</td>
</tr>
<tr>
<td>13 Professional learning networks</td>
<td>The central areas of chemistry education I</td>
<td>6</td>
</tr>
<tr>
<td>14 Evaluation and assessment</td>
<td>Inquiry-based chemistry teaching II</td>
<td>5</td>
</tr>
<tr>
<td>15 Differentiation</td>
<td>Media and multiliteracy in science and technology education</td>
<td>5</td>
</tr>
<tr>
<td>16 Dig the data</td>
<td>Science club education: Theory part</td>
<td>2</td>
</tr>
<tr>
<td>17 Blended or flipped classroom</td>
<td>Science Club Education: Practice part</td>
<td>3</td>
</tr>
<tr>
<td>18 Digital storytelling</td>
<td>Chemistry in the living environment</td>
<td>4</td>
</tr>
<tr>
<td>19 Emerging technologies</td>
<td>The central areas of chemistry education I</td>
<td>6</td>
</tr>
<tr>
<td>20 Models and visualization in chemistry education</td>
<td>Media and multiliteracy in science and technology education</td>
<td>5</td>
</tr>
</tbody>
</table>
classroom methods, in research strategies and in professional learning networks. But according to the pre-questionnaire results, students evaluated skills for critical evaluation of information (multi-literacy) and using digital learning platforms were good (Tuomisto, Aksela, & Jääskeläinen, 2015).

The most distinctive positive differences between the trainees’ ICT skills before and after the ICT integrated courses could be seen in the areas of managing simulation applications and applying flipped classroom methods (Table 2). After the courses, the students evaluated their ICT skills once again and most remarked a difference in their ability to use learning platforms to search for teaching materials, but it was only a negligible difference. Skills for searching for research literature about chemistry education and in using modeling applications were evaluated as having developed to some extent, even though the skills related to the latter were evaluated as poor (mean 2.0). Students also remarked little improvement in their skills of working with digital applications (mean 1.5) and in professional learning network (mean 1.9) (Table 2) (Tuomisto, Aksela, & Jääskeläinen, 2015).

Table 2. Self-evaluation concerning the development of ICT skills among chemistry teacher students in ICT-integrated chemistry teacher education in the 2015 spring semester (Tuomisto, Aksela, & Jääskeläinen, 2015)

<table>
<thead>
<tr>
<th>Self-evaluation concerning the development of ICT skills among chemistry teacher students in ICT-integrated chemistry teacher education in the 2015 spring semester</th>
<th>mean pre</th>
<th>mean post</th>
<th>skills development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation applications (e.g. PhET)</td>
<td>0.55</td>
<td>2.8</td>
<td>skills developed distinctively</td>
</tr>
<tr>
<td>Applications to support flipped classroom method</td>
<td>0.53</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Blogs (e.g. Wordpress, Blogger)</td>
<td>1.5</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Virtual sharing of ideas and materials (e.g. Lino)</td>
<td>0.48</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Searching research literature for chemistry education (e.g. ERIC, Google Scholar)</td>
<td>1.3</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Searching materials for teaching chemistry (e.g. LUMA.fi)</td>
<td>2.4</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Modeling applications (e.g. Jmol)</td>
<td>0.88</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Collaborative virtual working (e.g. Google Drive, Dropbox)</td>
<td>2.5</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Copyright and licenses (e.g. CC licenses)</td>
<td>1.9</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Viitautyökalut (esim. Citation Machine)</td>
<td>1.2</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Applications for managing your working (e.g. Evernote)</td>
<td>0.69</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Learning platforms (e.g. Moodle, Edmodo)</td>
<td>3.5</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>Professional learning networks (e.g. science blogs, LinkedIn)</td>
<td>1.4</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Critical evaluation of information published in internet</td>
<td>3.9</td>
<td>3.9</td>
<td>skills developed negligible</td>
</tr>
</tbody>
</table>
In a post-questionnaire (19/32 students), the students reported that the most pleasant ICT themes in the courses were as follows:

- learning to use different applications (e.g. Lino, Kahoot!, modeling applications, PhET simulations)
- blogs (possibility to reflect on one’s own learning; Wordpress, BlogSpot, Weebly)
- searching for research literature on chemistry education (about certain chemical phenomena; Google Scholar, NELLI, ERIC)
- making videos (e.g. iMovie)
- learning about copyright and applying it in course tasks (Tuomisto, Aksela, & Jääskeläinen, 2015).

The results reflect and support previous research findings that ICT-integrated chemistry teacher education seems to enhance participants’ multifaceted ICT skills (Goktas et al., 2009). Students evaluated their skills as very good in using classroom management systems and collaborating on resources as well as in searching for suitable e-material for teaching. Both simulation applications for teaching chemistry concepts and phenomena and relevant resources for sharing materials and ideas have been acquired on the courses. According to previous research, subject-specific ways of using ICT are important for developing students’ TCK (Goktas et al., 2009; Chai et al., 2011). In this study, students learned how to search relevant research literature about chemistry education, virtually share it with others and process their own learning in blog posts. This kind of new knowledge will possibly help to increase students’ PK and PCK. Ertmer et al. (2006) argue that students’ attitudes towards ICT should be made positive during these courses, a goal which, according to this research, can be achieved by ICT-integrated education.

Based on the case study and earlier research, this ICT strategy has been further developed, with an even more intense focus on promoting ICT skills and knowledge to better meet the ICT skills requirements of future teachers. In the new strategy, the previous 20 subcategories have been replaced by three major themes: pedagogical ICT skills, collaboration and digital citizenship. All three of these themes will be implemented into every course given by the Chemistry Teacher Education Unit. Furthermore, the concept of TPCK, and the barriers to and enablers of ICT-integrated teaching will be taught to all the students at the beginning of their studies. In addition, during every course the pre-service teachers will face real-school environments and opportunities to use ICT in a pedagogical way. In the future, the updated ICT strategy will also cover the in-service teacher training offered by the Chemistry Teacher Education Unit.
Molecular modelling through ICT in science education

An exemplary case of how multiple actors can and should cooperate in the LUMA ecosystem in order to enhance the use of ICT is the development of molecular modelling tools for chemistry teaching.

Models, modeling and visualizations are central in chemistry, as they make abstract entities visible, provide explanations and simplifications of complex phenomena (see image 1), and illustrate predictions on molecules and reactions (Gilbert, Justi & Aksela, 2003). For these reasons, models and visualizations have also been a persistent topic of interest in the Chemistry Teacher Education Unit. In 2002, this interest led to the creation of a course dedicated to modeling and visualization, meant for pre-service chemistry teachers. The first courses introduced pre-service teachers to niche computational tools, available mainly only to scientists. As the years went by, the modeling tools became technically much simpler to use.

Image 1. Students often find chemistry difficult to learn because of its three dimensional nature. Chemical phenomena can be represented at three different levels: macro (observable), symbolic (H₂O) and sub-microscopic (electron flow) (Gabel, 1999). ICT offers essential tools for visualizing complex and abstract phenomenon.
In line with the relevant technological developments, the course aimed to develop the pedagogical use of these tools. To meet the needs of future teachers, a design-based research method was utilized. Here, the experiences and perceptions of the teachers involved in the LUMA ecosystem were investigated to discern what is important for pre-service teachers. The results suggested that molecular modelling could i) help students and teachers alike to examine chemical phenomena and the chemical structural information involved, especially the 3D-structure (Aksela & Lundell, 2007); and ii) develop students’ visualization skills and illustrate models of difficult concepts (Aksela & Lundell, 2008). The Finnish chemistry teachers suggested the purposeful areas for modeling and visualization in chemistry to be orbitals, chemical bonding and spectroscopy (Aksela & Lundell, 2007).

The teachers’ experiences proved to be crucial to the design process. It was discovered that in addition to technological support, the teachers wanted more pedagogical support in their utilization of the technology (Aksela & Lundell, 2008). For example, teachers not only remarked that personal experiences help them to understand the value of ICT, but also that they want more adaptable materials in their native language (Aksela & Lundell, 2008) and that concept mapping activities are effective in web-based learning environments (Pernaa & Aksela, 2008). Furthermore, teachers wanted explicit examples of how certain curriculum aspects can be illustrated with molecular modeling (Aksela, Lundell & Pernaa, 2008). To address these needs, the teachers-in-training were included in the design-process of a new set of web-based activities that use a selection of ICT tools for both themselves and in-service teachers. Simultaneously, the feedback of the in-service teachers could help to further develop the actual activities and their practical implementation (Pernaa & Aksela, 2009).

The gathered results and a design-based research method were applied to the course design itself (Pernaa, Aksela & Väistinsalo, 2010) and to the in-service training programs provided for teachers. Two important aspects of these training programs include the informal communication during workshops, where teachers share their ICT-related experiences, and the fact that if ICT is used to mediate communication, as in newsgroups or social media, there must be a way to stimulate intrinsic motivation (Juuti, Lavonen, Aksela, & Meisalo, 2009).

The next step is to further improve the student-centeredness of modeling activities, starting with the modeling course for future teachers. As of September 2015, the design-goal has been to support the personalization of the research-based knowledge constructed in the previous years. Currently, new solutions are also studied through a pilot scheme which is based on a blog-learning diaries approach with a peer feedback system.
Another long-term process which seeks to enhance the use of ICT in chemistry learning within the LUMA ecosystem is the development of microcomputer-based laboratories, or MBLs. MBLs have been used for data acquisition, display and analysis to enhance experiments since the 1980s (Aksela, 2005). The displays visualize the progress of the phenomena in real-time, e.g. as a graph, which creates a direct link between the physical phenomena and its scientific representation which is suggested to i) motivate students (Nachmias, 1989); ii) off-load some of the cognition to the tools; iii) save time and promote discussion about the phenomena (Nakhleh, 1994; Rogers, 1996); and iv) increase understanding of the phenomena (Tinker, 1996; Aksela, 2005). Another feature that stimulates discussion is that the MBLs allow students to easily repeat the experiments using the same screen image and, thus, offers the possibility to easily compare and contrast their results (Newton 1997; Lavonen, Aksela, Juuti, & Meisalo, 2003). Other benefits include but are not limited to the ability to take the research of chemical phenomena outdoors (Lavonen et al., 2003).

However, reaping these supposed benefits is not easy: during the hands-on activities, many students talk about their graphs in a descriptive manner and much of their vocabulary is unscientific (Newton, 1997; Aksela, 2005). This emphasizes the role of teacher in the overall interaction and the importance of a learning environment that is carefully designed in order to maximize the potential benefits of MBLs (Aksela, 2005).

Long-term teacher training programs are needed to support the implementation of technology-based-inquiry (Gerard, Varma, Corliss, & Linn, 2011). The LUMA Centre Finland offers a visiting lab for student groups that adopts the aforementioned observations in their teaching and learning practices. In the visiting lab, pre-service chemistry teachers learn MBL implementation as a part of two courses focused on inquiry. The experiences obtained from the lab proved crucial in a COMBLAB project, in which research-based MBL activities were developed in a collaborative design process between six European universities. The aim of the activities was to enhance students’ abilities to design their own experiments, interpret results and communicate findings.

The activities were published on a project website (http://www.comblab.eu/en) as material for European in-service teachers. The project also boosted the short-term training programs provided in the LUMA ecosystem for in-service teachers. Additionally, one of the objectives of the COMBLAB project was to promote teachers’ learning by using curriculum material design heuristics (Davis, & Krajcik, 2005) together with additional heuristics for technological skills to design curriculum material that supports teachers in using MBL-based inquiry materials (Tolvanen et al., 2014).
The results of this project shed some light on how students perceived the MBL activities; they suggested that most of the students understood the point of these activities, that the activities helped them learn and, most importantly, that the activities couldn’t be done without the MBLs (Tortosa et al., 2014). It was also found that to promote learning, pre-service teachers still need support in the use of MBLs (Tolvanen, Aksela, Guitart, & Urban-Woldron, 2014). Further study related to the project focuses on the question of how MBLs can support understanding by identifying the characteristics which enable authoritative and dialogic discussion (Tortosa et al., 2014).

3. Virtual science learning environments for children and youths

This section summarizes the research-based virtual learning environments used in Finnish science education in the LUMA Centre Finland, and, as a unique example, the popular children’s virtual science club (Vartiainen, & Aksela, 2016).

Virtual learning environments within the LUMA ecosystem

Most LUMA activities for children and youths are extra-curricular. ICT is utilized as much as possible in the LUMA activities for children and youths as ICT is a natural part of 21st century life in developed countries. The use of ICT has the added benefit of interesting and motivating child and youth learners (e.g. Vihma & Aksela, 2014; Passey, Rogers, Machell, & McHugh, 2004). The use of ICT also promotes interaction and collaboration in multiple ways as well as encouraging personalized learning without the constraints of place and time. For these reasons, the LUMA Centre Finland uses more and more virtual learning environments to meet its goals of boosting interest and fostering learning.

The LUMA Centre Finland publishes freely available interactive web magazines, or webzines, with the aim of inspiring and supporting children and youths (e.g. Vihma & Aksela, 2014). The goal of these webzines is to encourage children and youth to interact with one another and with editorial teams made up of content experts at universities, companies, and so on. In this case, ICT provides a virtual environment for interaction and learning. Readers are encouraged to participate in discussions related to the articles, ask questions through ask-and-answer services, share their own ideas, experiences, and practices in the form of text, photos, or videos, and post the published content on social media sites.
An international MOOC course for youths as well as for teachers on the theme of sustainable energy was developed and is being run from 2015–2016. Studies on the participants’ reasons for attending the MOOC are already underway (cf. Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013).

**Children’s virtual science club**

As a more detailed example of the virtual learning environments within the LUMA ecosystem, we intend to discuss the virtual science club (see Image 2), meant for 3-6-year-old children as well as for their parents or educators. The virtual science club was developed through design based research (Vartiainen & Aksela, 2016).

Image 2: A child experiments with colors at home following the instructions of the Virtual Science Club on a tablet.

Children show their interest in scientific phenomena they encounter in their everyday lives by constantly observing and asking questions. Previous research has shown that children under the age of eight are especially interested in phenomena related to physical sciences (Baram-Tsabari, Sethi, Bry, & Yarden, 2006), such as weather, phase changes of water, light, density and surface tension.
Therefore, providing young children with a platform to explore and find answers to their questions is very relevant for this age group (Tolppanen, Vartiainen, Ikaivalko, & Aksela, 2015). However, parents’ attitudes towards science play an important role in the development of their children’s future attitudes (Jeynes 2005, Alexander, Johnson, & Kelley, 2012). The origins of children’s interest in science can be traced to early interactions in the context of science with their parents (Maltese & Tai, 2010). Though parents play a key role in a child's interest in science, there have only been a few attempts to bring science to homes. One reason for this may be parents’ lack of knowledge about science (Shymansky, Yore, & Hand et al., 2000). Even kindergarten teachers often ignore science education, or they concentrate mostly on biological contexts (Tu, 2006). Therefore, there is a growing need to provide non-formal learning materials for young children that can be used at home.

In order to offer such materials, the LUMA Centre Finland provides the virtual science club for children, which was developed through design-based research. The cornerstones of the development process were playful learning (Bulunuz, 2013), the importance of social and cultural interactions (Vygotsky, 1978) and guided inquiry (Samarapungavan Patrick, & Mantzicopoulos, 2011; Brown & Campione, 1994). Furthermore, it was acknowledged that the child’s developmental stage needs to be taken into consideration (Inhelder & Piaget, 1964). Therefore, the aim of the design-based research was to develop a learning environment that would:

- Be independent of time and place
- Support small children’s learning of science process skills
- Encourage the whole family to be curious and conduct experiments together
- Be interactive
- Not require reading and writing skills
- Be playful

The club was created using these principles, as explained below. In order to overcome the fact that families are often busy, and parents may find it challenging to take their children to a physical science club, the clubs are organized online.

In the online club, instructional videos on how to conduct a scientific experiment are uploaded once a week. These videos can be watched at convenient times for the family or the kindergarten teacher. In the videos, motivational characters use stories and pictures to explain phenomena to be studied by the children. The characters provide information on the tools and materials needed to study a certain phenomenon as well as instructions on how to report on the experiment. However, the results of the experiment are not given. In fact, the tasks are open-ended, meaning that children are free to
choose their own experimental design. This also means that the children will end up with different results, which can be equally correct. In other words, children are not meant to replicate the experiment demonstrated by the motivational characters but rather to rehearse their own science process skills.

After watching the instructional video, children conduct the experiment and report on it with the help of their parents or kindergarten teacher. As the children may not be able to read or write yet, the reporting is usually done through photos or videos. In order to increase interaction between the clubbers from different parts of the country, their photos and videos are published on the club website, so that clubbers can view each other’s work. The organizers of the club also give general video-feedback on the reports done by the children.

Our initial results indicate that the clubs can be highly successful learning environments for children and families if parents are given support in three different areas. Our study on using virtual science clubs at home was conducted as a case study. Seven parents who participated in the club with a child or children were interviewed via phone. Semi-structured narrative interviews were used with a stimulated recall method. The data was analyzed qualitatively as a grounded theory.

As a result, a model was formed that explains the kind of support parents need to do science activities with their children at homes. The three dimensions that emerged from the study are: 1) the affective factor, 2) the knowledge and skills factor, and 3) the organizational factor. Parents’ interest must be addressed to keep them engaged. For some parents, seeing how excited their children were to experiment was not enough of a motivation; they needed a more personal motivation. Parents also needed support to understand the scientific phenomena themselves, how to explain it to a small child and how to help their child find answers. Parents needed an external organizing body that would provide a schedule for experiments, send reminders and give feedback.

As a main conclusion, we need to consider that there are in fact two learners—a parent and a child—with different support needs. Parents usually start science programs with great enthusiasm but give up quickly (Shymansky, et al., 2000). A virtual learning environment can offer a zone of proximal development for parents that can provide more personalized support than, for example, science packages that are sent home from school or day-care. If the virtual learning environments offered parents support in all of the aforementioned three dimensions, the parents would be more likely to continue non-formal science learning with their children. In the future, special support for parents will be developed on the basis of these results.

4. Design-based research as a tool for developing innovative ICT learning environments
Using ICT in education in a meaningful way often requires a systematic and careful learning environment design. This can be achieved using design-based research (DBR) as a design tool. DBR is a research strategy in which experience-based design is supported through the combination of theoretical and experimental research phases (Edelson, 2002). It can be defined as a design methodology, which aims to develop teaching in real-world situations through a systematic, flexible and iterative research approach. The design process is carried out in iterative design cycles and the design decisions are justified through theory, formative and summative evaluation, collaboration between designers and the expertise of various stakeholders who form the design community (Design-Based Research Collective, 2003). The actual research methods used in DBR are determined on a case-by-case basis, as they depend on the design goals and design context (Barab, & Squire, 2004).

In every piece of DBR, the context and situation are unique, and careful planning and execution are necessary. As a result, it is difficult to present one comprehensive model for executing DBR projects, but this can be mitigated by Edelson’s (2002) practical DBR framework. Edelson proposes that DBR can be controlled by examining the design decisions made during the research. Edelson divides the possible outcomes of DBR into three design decision categories:

1. The **design process** decision category addresses the possibilities and challenges related to the entire design process. The design process category explains how the design community achieved the designed outcome.

2. The **problem analysis** decision category discusses the possibilities and challenges related to domain-specific knowledge. This category enables designers to determine the objectives of the design solution.

3. The **design solution** decision category addresses the possibilities and challenges of the design solution (a concrete artefact). This category produces, for example, new knowledge of the technical aspects and possible ways of using the designed learning environment (Edelson, 2002).

DBR is a relatively young research method in the educational field. It was developed in the 1990s to bridge the gap between educational research and the pragmatic needs of the actual educational field in schools and businesses. Teachers have long criticized the educational research community for not providing them with useful information (Brown, 1992). Over the past 20 years, the DBR community has been using DBR as a design strategy and developing DBR itself as a method. The use of the DBR has been steadily growing, and nowadays it is a widely used and published educational research tool (Anderson, & Shattuck, 2012).
DBR is well suited for developing ICT-based learning environments because it is a very practical approach. DBR typically produces concrete learning environment artefacts that have been developed in collaboration with end-users, such as teachers and students. In addition, Edelson’s model offers designers various possibilities to learn from the design work, and at the same time, the research-based approach produces new knowledge for science (Edelson, 2002; Pernaa & Aksela, 2013).

In the Finnish LUMA ecosystem, practically all research-based learning environment design work has been carried out via DBR since 2005. It has been used for developing inquiry-based MBL learning environments (Aksela, 2005), courses for teachers (Pernaa, Aksela & Västinsalo, 2010), software (Pernaa & Aksela, 2013) and virtual science clubs (Vartiainen, & Aksela, 2015), to name just a few examples.

5. Conclusions

For the past decade, the LUMA Centre Finland has implemented and developed ICT education for pre-service and in-service science teachers as well as for learners of different age groups (e.g. families). This has been done through research-based ICT activities, pedagogical models and virtual learning environments (e.g. virtual clubs, webzines, and webinars). Over the years, the implemented models have been continuously developed using design-research, increasing the reliability and the validity of the models used. As this paper shows, the implemented ICT activities have provided students with positive learning experiences and have helped to advance their learning by involving them in phenomena-based, contextual, and relevant learning environments.

Regarding pre-service and in-service teacher training, both subject specific and integrated ICT training have been found to be useful (e.g. Helppolainen & Aksela, 2015; Tuomisto, Aksela, & Jääskeläinen, 2015). Molecular modelling and microcomputer-based learning environments in particular have proven to be useful tools for meaningful chemistry teaching at schools and in teacher training. Furthermore, models, modelling and visualizations play a central role in chemistry as they make abstract entities visible. Having ICT instruction that is integrated into all pre-service teacher training courses (rather than separate ICT courses) positively impacts teachers’ use of ICT (Moursund, & Bielefeldt, 1999; Tuomisto, Aksela, & Jääskeläinen, 2015).

However, this paper also points out that there is still work to be done in implementing ICT in science education. As teachers play a key role in how ICT is implemented in classroom practice, further teacher training is needed. In such training, technological pedagogical content knowledge (TPCK) should be provided, meaning that training does not only focus on technical support but also on
pedagogical support in using technical tools. Furthermore, training should focus on subject specific ICT tools and the concrete needs of the teachers.

More research is needed to understand, in detail, what type of training best supports teachers’ ability to adopt ICT not only at a technical level but also at a pedagogical one. In addition, further research is needed to understand what type of pedagogical models best support the development of children’s and youths’ ICT skills in mathematics and best enrich science and technology education and teacher training (e.g. MOOCs).

References


Koehler, M. J., & Mishra, P. (2008). Introducing TCPK. Teoksessa AACTE Committee on Innovation and Technology (Eds.), Handbook of Technological Pedagogical Content Knowledge (TPCK) for Educators (pp. 3-29). Routledge: Oxon.


Vartiainen & Aksela (2015). Virtual Science Club for families. Published in the webpages of the LUMA Centre Finland. It will be published as an article later on.

14. Designing the First Finnish MOOCs

Otto Seppälä
Aalto University

Juha Sorva
Aalto University

Arto Vihavainen
University of Helsinki

Abstract

Two leading universities in Finland, Aalto University and the University of Helsinki, offer a programming course as a free online course, known as a MOOC. These courses have been taken by thousands of Finnish-speaking students and have received outstanding student feedback. We discuss the pedagogical choices of the two courses as well as the basis of these choices, which lies in theories of instructional design and computing education research. We identify the features of these courses that enable us to provide students with a better learning experience. Drawing on our experiences, we highlight future challenges in improving our own MOOCs as well as others.

1 Introduction

The past few years have seen the launch of many massive open online courses (MOOCs), often to great fanfare and with high expectations. In this chapter, we describe and discuss two particular MOOCs on the subject of introductory programming, which the authors and their colleagues designed and implemented. In both cases that we describe, the MOOC has emerged as a natural extension of a local large-class university course that makes use of online resources and tools to provide a blended learning experience. Our evidence regarding student retention and feedback suggests that the MOOCs have provided a useful and inspiring service to a number of students that is substantial by Finnish standards. Although the success we have had has been achieved within the rather homogeneous Finnish context, we hope that this discussion of our experiences will be useful to others who are transferring MOOCs out of existing university courses or intend to do so.

The chapter is structured as follows: Section 2 provides a general introduction to MOOCs, programming education and MOOCs on programming. The following two sections, 3 and 4, describe the two MOOCs created by the authors; their origins, learning objectives, pedagogical solutions, and supporting software. Section 5 presents course completion rates and student feedback ratings from the two courses. In Section 6, we reflect on our MOOCs in relation to the prevailing
MOOC “hype” and discuss the likely strengths and weaknesses of our designs. Furthermore, we make recommendations for MOOC design and raise research questions. Section 7 concludes the chapter.

2 Background: MOOCs and Programming Education

Massive Open Online Courses

In late 2011 the use of the term MOOC boomed after the “Introduction to Artificial Intelligence” MOOC given by Sebastian Thrun and Peter Norvig listed over 160,000 enrolled students and was followed by numerous MOOCs offered by various institutions. The New York Times dubbed 2012 “The Year of the MOOC” to describe the phenomenon of large numbers of individuals enrolling in online courses offered for free and the flurry of activity surrounding MOOCs generated by technology companies and funding agencies (Pappano, 2012). The largest MOOC to date has had over 1.1 million enrollments.

At the peak of the MOOC hype, MOOCs were touted as a means to revolutionize higher education and bring high-quality education to everyone in the world. Many continue to hold high expectations. However, although many MOOCs have boasted high enrollment rates, the completion rates have not been as high (Reich, 2014), and the promise of “education for all” has largely not been met (Rohs and Ganz, 2015). It remains an open question precisely how MOOCs serve the educational community and society at large as does the question of how to design a useful MOOC.

Types of MOOCs

The term MOOC was coined by Cormier (2008) to describe an open course conducted by George Siemens and Stephen Downes. Since then, the terms cMOOC and xMOOC have been used to distinguish between connectivist MOOCs, such as Siemens’ and Downes’ original, and MOOCs that extend existing educational practices. A connectivist cMOOC is free of institutional constraints and emphasizes collaborative learning among autonomous individuals who contribute to the learning resources. In contrast, an xMOOC is typically a free, online version of an existing university course. xMOOCs tend to be associated with well-funded, highly visible initiatives and corporations such as Udacity, Coursera, and OpenEdX, and their pedagogies are “dominated by [...] video presentations, short quizzes and testing” (Yuan and Powell, 2013). Although the MOOCs that we detail in this chapter have not received large amounts of funding and are not based on video
lectures, we still consider them under the broad umbrella of xMOOCs, as they are extensions of local university courses.

**MOOCs in Programming**

In Finland and around the world, the demand for computing-related degrees and programming courses has increased over the last few decades, augmenting the pressure to scale up instruction through digitalization. Given this, and the fact that the computing professionals who teach programming are often capable of adopting and developing technical solutions with relative ease, it is unsurprising that several of the early MOOCs have focused on computing content.

The teaching and learning of programming has been studied for several decades within *Computing Education Research* (CER), an emerging field of research (Simon, 2015), which is a form of discipline-based education research (National Research Council, 2012). However, it has been argued that the decades of research into teaching programming have transferred rather poorly into MOOCs. For instance, Ben-Ari (2013) argues that several programming MOOCs in which he participated were lacking in terms of program visualization tools as well as instruction on debugging and program design.

Much of the research on programming MOOCs has had one of three goals: *accessibility*, *interaction*, or *sharing*. Accessibility is concerned with providing participants with convenient access to learning materials and tools to make the first steps of learning to program as easy as possible. The goals of interaction are improved facilities for student participants to interact and collaborate fruitfully with their peers online. The third goal of sharing aims to help students display what they have constructed to other students and the world. Other themes beyond these three appear in the literature, such as learning analytics that draws on students’ programming behavior (Ihantola et al., 2015); for further information on educational data mining and learning analytics in MOOCs, see Chapter 15 by Multisilta and Korhonen in this volume.

The online programming environment developed by Tang et al. (2014) is an example of the goals of accessibility and sharing. The environment targets the easy creation and sharing of interactive programs such as games. It incorporates a program visualization tool, an indication of how researchers have started to address some of the concerns highlighted by Ben-Ari (2013).

In the next two sections, we turn from the literature to our own MOOCs. Sections 3 and 4 describe two MOOCs created by the chapter authors: how they came to be, what we expect participants to learn, and what types of support we offer to the participants. The reader will observe that although
the two MOOCs were developed separately, they have a lot in common despite their different particularities.

**Case 1: University of Helsinki**

Our first case study is the introductory programming MOOC offered by the University of Helsinki.

**History**

The goal of the Department of Computer Science at the University of Helsinki was not to create online courses. The work MOOC originates from dates back to spring 2010, when instructors at the University of Helsinki completely restructured the local introductory programming courses. The restructuring was based both on research on *cognitive apprenticeship* (Collins et al., 1989, 1991) as well as on instructor experiences from the software industry. The key ideas were that one learns programming best when supported by more advanced programmers, and when the tasks at hand are appropriately challenging and meaningful. One learns also programming best when the focus is on becoming a practitioner of the art from day one.

The programming instruction was transformed from a traditional lecture-based course to a hands-on approach, where students immediately start programming in computing labs; where they are guided by peers and instructors as well as carefully crafted online material. The learning approach emphasizes modeling, scaffolding, and fading: students first build a mental model of the task that they are working on, followed by suitable structures — scaffolding — that help them to work on the task. Once students become more familiar with the concepts and constructs, the scaffolding is dismantled — faded.

At the beginning, all programming assignments were manually assessed by peers and course instructors, but the automation of some of the assessment and instructional scaffolding was soon recognized as meaningful. During summer 2011, an automated assessment system called *Test My Code* which can be used to provide scaffolding and step-by-step feedback was developed and adopted (Vihavainen et al., 2013b). Once Test My Code was introduced, it transpired that there were no substantial reasons against opening the course materials to the masses. It was decided that the course would be provided as a MOOC. Furthermore, it was decided that the high-performing students in the MOOC would be invited to an interview and potentially offered admittance into the University of Helsinki. The very first MOOC in programming was launched in January 2012.
(Vihavainen et al., 2012; Kurhila and Vihavainen, 2015), and the courses have been offered continuously since. Since the beginning, MOOCs have been kept separate from the course offerings for the local students of the University of Helsinki, in which students work in physical labs with their peers and receive support from more advanced students as well as teachers. The organizers of the MOOC are part of a CER research group at the university, which has grown in conjunction with the development of the local programming course and the MOOC.

**Present Situation**

The MOOC in programming has been offered as an entrance exam to the University of Helsinki since spring 2012, and as of January 2016 almost 250 students have been admitted through the MOOC. When compared to students admitted through the traditional path, the MOOC students fare better in their first year studies and complete more courses (Vihavainen et al., 2013a).

For students who wish to receive a diploma from the course, the University of Helsinki organizes written exams at schools across Finland. The students who attend the course as students of the University of Helsinki (organized separately from the MOOC) participate in two courses: “Introduction to Programming” and “Advanced Programming”, both worth 5 ECTS credits, which officially corresponds to about 200 to 300 hours of work, although the data we have collected suggests that the average student who completes the course spends distinctly less time than that on the the courses.

Currently, the entrance exams are organized during the spring semesters. However, the MOOCs are offered throughout the year as a self-paced course where subsequent course parts are unlocked once a student has completed enough assignments from the previous part.

The Test My Code system remains the core of the technical MOOC platform, whose other main components are listed in Table 1. Schools and other universities can request a free organization account in Test My Code where teachers can clone existing courses for their own use and specify their own schedules for the course. So far, over 20,000 MOOC-student accounts have been created in the Test My Code system.

---

8 European Credit Transfer system, http://ec.europa.eu/education/ects/ects_en.htm
Learning Objectives

The course is primarily intended for students with no previous programming background and focuses on helping students take their first steps towards becoming a software professional. Students become familiar with writing algorithms, and they learn how to approach programming by dividing programming problems into smaller solvable and testable sub-problems. Furthermore, students learn how to design and create large software using object-oriented programming. Students complete the MOOC by working through the assignments individually. The assignments are paced with 12 deadlines (typically one deadline per week, 14 deadlines as of spring 2015). The first three weeks of the course introduces students to imperative programming using Java: Students practice by writing programs that use variables, iteration, methods, lists and console input and output. From the fourth week of the course, classes and objects are introduced, and the course continues with students writing further, larger programs, which require the students to incrementally use the concepts that they have encountered in the material. Object-oriented concepts such as interfaces, inheritance and polymorphism are covered when needed, as are essential features of the Java API, such as lists, maps, sets, file I/O, exceptions and GUIs. Good programming practices are emphasized throughout the course; the use of meaningful variable and method names, the readability of source code by code indentation, refactoring existing code into smaller methods, using the single responsibility principle, and using automated tests. Basic algorithmics, such as sorting and searching, are also discussed and practiced.

Pedagogy

The course pedagogy follows the principles of extreme apprenticeship (Vihavainen et al., 2011), which is a contemporary interpretation of cognitive apprenticeship (Collins et al., 1989, 1991), intended for programming instruction in large universities. Guided individual work on programming assignments is the core of the course. In the most recent course iterations, there have been over 400 programming tasks — some of which are individual, and some of which serve as scaffolding for the student while they are working on a larger program. Learning objectives are embedded into the assignments, and the material has been carefully built around them.

Many of the assignments are composed of incremental tasks that lead to the construction of larger software. Incremental tasks imitate a typical problem solving process. Students practice programming but are constantly influenced by the written-out thought process behind the subtask
division that the course designers have pre-performed. Assignments are intentionally written out to be as informative as possible, and often contain sample input/output descriptions or code snippets with expected outputs that provide further support for the programming process: these help the student confirm that he or she is proceeding in the correct direction.

The learning material is constructed so that new topics are immediately applicable to the subsequent assignments. The material emphasizes the working process using worked examples (Caspersen and Bennedsen, 2007) and process recordings (Bennedsen and Caspersen, 2008). Both are used to emphasize how a program is crafted using stepwise subtask division: when encountering a challenging problem, one must seek to divide the problem into smaller subproblems that can be solved.

In addition to the structural support from the material, the Test My Code system provides on-demand scaffolding. Each assignment has manually crafted tests that provide direct support to the incremental nature of constructing computer programs. These tests are structured so that the students can focus on progressing in small steps even within a single task. Although the majority of the assignments can guide students through a specific path, each week also contains some relatively open assignments where students are given more responsibility concerning the program design. The importance of such assignments must be acknowledged, as every student should be capable of independently performing elementary program design and problem solving. Scaffolding is faded: open-ended assignments are given only after students have practiced with strictly defined assignments.

Students may participate in an online discussion channel where they can ask questions related to the course and assignments as well as help other course participants. Here, we have observed an emergence of MOOC alumni, who guide others even though they no longer participate in the course (Nelimarkka and Vihavainen, 2015).

4 Case 2: Aalto University

This subsection introduces the introductory programming MOOC offered by Aalto University. We refer to this course as Aalto-MOOC. It has its genesis in, and is in many ways identical to, a local large-class CS1 course, which we will refer to as Aalto-Local.
Like the University of Helsinki MOOC described above, the Aalto-MOOC exists in the context of a research group in the field of CER. It arose as an extension of a local blended-learning course and features a pedagogy driven by concrete practice and supported by various technological aids.

**History: From Aalto-Local to Aalto-MOOC**

In the 1990s, teachers at Aalto’s Department of Computer Science adopted and developed tools for automatically assessing homework on computing courses and providing instant feedback online. This line of work was motivated by a combination of large numbers of CS1 students, finite teaching budgets, and the recognition that each of those students should gain a substantial amount of practice. A research group emerged that focused on automatic assessment, CER, and educational technology.

Within this context, Aalto-Local and its supporting software platform have been gradually developed by a small group of computing education researchers over more than ten years. One of the larger developments was carried out in preparation of the fall term of 2013, as the goals, materials, and practical arrangements were comprehensively revamped. The new incarnation of Aalto-Local used a highly blended approach: It was driven by online materials but supported by activities both online and — voluntarily — on campus. As it happened, this change also laid the groundwork for the Aalto-MOOC.

A fair number of the local students took Aalto-Local effectively as an online course. This, in combination with the extremely positive student response, the software solutions already in place for handling large numbers of students, and the generally enthusiastic atmosphere around the MOOC concept at the time, motivated the launch of the Aalto-MOOC the following year. The aim of the Aalto-MOOC is to provide a learning opportunity similar to Aalto-Local to a wider audience made up of students from other Finnish universities and polytechnics, high schoolers, and lifelong learners.

**Present: A Two-Year-Old MOOC**

At the time of writing, the Aalto-MOOC has been offered twice, in fall 2014 and in fall 2015. It is not run separately from Aalto-Local; rather, the MOOC students are effectively taking Aalto-Local without participating in the optional on-campus activities. The local students and the MOOC
students are not segregated from each other: They have the same deadlines and materials, and they interact in the same discussion forums.

For the purposes of the following discussion, we identify two groups of students:

1. **Aalto SCI students:** The students of the Aalto School of Science, who were previously the exclusive target audience of Aalto-Local and for whom the course was designed. Roughly a third of these students major in computing; other common majors include engineering, physics and industrial management. These students are generally high achievers; they tend to be highly motivated to learn to program, highly motivated to receive a high grade, or both. Aalto-Local is part of their degree requirements. Roughly half of these students have no or very little prior experience with programming; the other half have differing levels of experience.

**MOOC students:** In this group, we include all participants from outside Aalto University. In addition, we include students from Aalto’s other schools (e.g., arts, business), who are not part of Aalto-Local’s original audience. These other Aalto students resemble external students in many respects; for instance, they volunteer to take the course and they generally do not participate in the on-campus activities. The MOOC students are a more varied group than the Aalto SCI students in all respects, including, but not limited to, motivation, expectations, occupation, hours available for studying, and prior exposure to computing.

Table 1: Course platforms and supporting tools. Platforms and tools that have been developed in-house are shown in italics.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Systems at Aalto</th>
<th>Systems at the University of Helsinki</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platform for course management and delivery</td>
<td>Goblin (Häisälä, 2005)</td>
<td>Test My Code, GitHub, Custom web services</td>
</tr>
<tr>
<td></td>
<td>A+ (Karavirta et al., 2013)</td>
<td></td>
</tr>
<tr>
<td>Feedback collection</td>
<td>Goblin extension</td>
<td>Test My Code, Embedded questions in material</td>
</tr>
<tr>
<td>Assessment</td>
<td>Goblin, ebook components, Rubric (Auvinen, 2009)</td>
<td>Test My Code</td>
</tr>
<tr>
<td>Programming language</td>
<td>Scala (EPFL, 2015)</td>
<td>Java</td>
</tr>
<tr>
<td>Programming environments</td>
<td>Eclipse + Scala IDE ebook components</td>
<td>NetBeans + Test My Code</td>
</tr>
<tr>
<td>Discussion forum</td>
<td>Piazza.com</td>
<td>IRC, Google Groups</td>
</tr>
<tr>
<td>Interactive visualization</td>
<td>Jwee (Sirkiä, 2013)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kolbeu (Sirkiä and Sorva, 2015)</td>
<td>Articulate Storyline</td>
</tr>
<tr>
<td>Ebook authoring tools</td>
<td>Sphinx + reStructuredText Custom Sphinx extensions</td>
<td>HTML, JavaScript, Wrigley’s</td>
</tr>
<tr>
<td>Plagiarism detection</td>
<td>Radar</td>
<td>Custom software</td>
</tr>
</tbody>
</table>

The size of the two populations is quite different. There are consistently ca. three hundred students in Aalto SCI who attend the course each year. The MOOC attendance figures are somewhat less consistent; the first year’s offering received significant media coverage, which raised the number of
active MOOC accounts to 1260. In contrast, we had 594 active MOOC students in the second year. These figures only include students who submitted the first, trivial programming assignment. That is, students who only registered in the course platform have been excluded. The number of such inactive accounts is roughly equal to the number of active accounts.

**Learning Objectives**

The Aalto-MOOC is designed for beginners. Its twinned goals are to 1) help students appreciate and enjoy computer programming, and 2) to teach them to read, modify, and write programs. The course starts with imperative object-oriented programming paradigms but transitions towards functional programming. It covers topics typical of an object-oriented CS1, such as classes, iteration, and inheritance, as well as some less common ones such as higher-order functions. Longitudinal themes include abstraction, software quality, and mutability, among others. In this course, we only expect students to learn to program detailed specifications rather than designing programs based on loose problem statements; tackling ill-structured problems is left to be covered by subsequent studies.

Aalto-Local is designed to be a 5 ECTS credit course for the students of Aalto’s School of Science. This implies that we expect them to invest approximately 100 to 150 hours of work over the fall term. Students who take the Aalto-MOOC are expected to invest a similar or greater amount of time, on average.

**Course Structure**

Students complete the Aalto-MOOC by working through the materials either individually or in pairs. There are 12 deadlines over a period of 13 weeks, but that aside, the students are given free rein in choosing how, where, and when they study. Whatever the students choose, nearly all their official course activities revolve around an interactive online ebook which has been created by the teacher. The ebook takes the form of a website, which contains tasks of various kinds, expository texts, interactive visualizations, and the occasional video. Students are expected to work through a section of the ebook for each deadline.

---

9 This ebook is openly accessible online at https://greengoblin.cs.hut.fi/o1_current/. It is in Finnish. An English translation may happen in the future, given suitable funding.
To receive even the lowest passing mark, a student is effectively required to work through nearly all the tasks in the first half of the ebook. The other tasks are required for higher marks. To gain an official certificate of completion, Aalto-MOOC students are also required to take a final examination that is marked “pass” or “fail”.

The software platform for the Aalto-MOOC, which has been developed largely in-house, is summarized in Table 1.

**Instructional Design**

The Aalto-MOOC aims to provide substantial *deliberate practice* (Ericsson et al., 1993) of programming skills. By using interesting, concrete projects, we hope to motivate the students to work as hard as the scope of 5 ECTS credits allows. Through careful sequencing of varied learning activities, including simple “drills” where useful, we hope to make the students’ hard work as effective as possible.

Program authoring practice forms the core of the course. It is complemented by other forms of practice that have a low *cognitive load* (Plass et al., 2010) such as worked examples, completion problems, and ebook-embedded questions (Sorva and Sirkiä, 2015). Students *read* a lot of code in addition to writing it. Larger programs always come with skeleton code that students flesh out. Sorva and Seppälä (2014) provide a more detailed description of this pedagogical approach in which concepts are introduced through an overarching project but then practiced separately before being brought back to bear on the original project.

The design of the learning activities and the ebook text are based on research findings concerning the particular difficulties that students have when learning introductory programming and the non-viable conceptions that students may have when programming concepts. Given that many of these misconceptions and difficulties are related to the “hidden” execution-time behavior of programs and the so-called *notional machine* (Sorva, 2013), we make concerted efforts to help students form a viable conception of program execution using a combination of interactive program visualization and practice tasks (Sorva and Seppälä, 2014).

**Feedback, Guidance, and Discussions**

Given that the students write their programs to detailed functional specifications, their solutions can be automatically assessed by programs that have been integrated into the course ebook. Automatic assessment has its limitations (Ihantola et al., 2010), but it saves money and has the benefit of being
near-instantaneous. The assessment system tests the functionality of student-submitted programs and immediately produces a test report and a grade; the student can then resubmit if they are unsatisfied. Most of the embedded questions (multiple-choice and such) produce written automatic feedback for both correct and incorrect answers, as configured by the ebook author.

One of the Aalto-MOOCs larger programming assignments in which students design and implement a game is not amenable to fully automatic assessment. It is assessed manually by teaching assistants with the help of a rubric-based tool that partially automates the process and helps the assistants to produce better written feedback in a reasonable amount of time (Auvinen, 2009). The students have access to an online forum where they can ask questions and discuss course topics with their peers and the course staff. The forum is very active, and questions typically receive a response within a quarter of an hour. Moreover, students are prompted for questions, reflections, and feedback at the end of each chapter of the ebook, that is, several times per week; participation is required to register the student’s assignment marks in the course platform. Summaries of the students’ questions and comments are published weekly, with answers and additional commentary from the teachers. Requiring the students to give frequent feedback throughout the course provides the teachers with insights into genuine learning situations and challenges.

As noted above, Aalto-Local and the Aalto-MOOC share most practical arrangements. The only difference is the additional guidance available to local students: Members of the course staff are available on campus to help with the assignments, and the students are free to make use of this assistance as much or as little as they like. Teaching assistants monitor the Aalto SCI students’ progress weekly and send brief encouraging feedback via e-mail. Although Aalto-Local is not a lecture course, there are two introductory lectures for orientation as well as a course wrap-up session at the end.

5 Outcomes

A typical concern regarding MOOCs is that only a small proportion of students complete the course that they sign up for, and for many, the only activity in the course is signing up to it. In this section, we consider how the participants in the MOOCs fared and compare that to the course outcomes at our local institutions.
Table 2 shows the attendance statistics for the MOOC in programming offered by the University of Helsinki between 2012 and 2015. As the system that is used to assess the students’ programming assignments is the same system via which students enroll on the course, the data only has information on students who have completed at least one course assignment, viz., written a very simple program that outputs their name. When considering the courses, there is no major difference between the number of students that complete one programming task and the number that complete ten. At the same time, going from ten tasks (which can be done easily during a single week) to 100 tasks (least four weeks of course participation), reveals a noticeable drop. Only roughly half of the participants (46–55%) who start the MOOC complete at least 100 tasks.

Whilst the drop-out rate is rather large at the beginning of the course, the proportion of students who choose to stop the course decreases as the course progresses. Figure 5.2 shows this trend over the MOOC courses from 2013–2015 and provides a comparison point with a seven-week introductory course offered locally at the University of Helsinki. When comparing the local courses with the MOOCs, we can see that the local course also has a noticeable drop-out rate — some 20% of the students who complete at least a single assignment stop working on the course assignments by the last week of the course.

When considering the number of participants who complete the course, there is no specific “completion criteria” in the MOOC. In our local courses offered before 2015, students had to complete at least roughly 50% of the assignments to be able to attend the exam. Thus, one comparison point could be the percentage of students completing at least half of the assignments, which would range between 30 and 40% across the years. At the same time, only 5-12% of the MOOC participants complete all the course assignments — this is similar to our local courses, as there are “challenge” assignments which many do not need or wish to participate in.

---

10 Although the numbers in Tables 2 and 3 may seem small compared to the largest MOOCs around the world, they are fairly high considering that there are fewer than 10 million people in the world who speak Finnish as their first or second language, while the same number for, say, English is over one billion.
The students who have completed the course have praised its content and tools. Many have been admitted to the BSc Computer Science and MSc programs in the University of Helsinki, where they typically performed above average in their studies.

<table>
<thead>
<tr>
<th>Year</th>
<th>1 task</th>
<th>10 tasks</th>
<th>100 tasks</th>
<th>&gt; 50% tasks</th>
<th>&gt; 90% tasks</th>
<th>all tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 (373 prog. tasks)</td>
<td>405</td>
<td>?</td>
<td>187</td>
<td>?</td>
<td>70</td>
<td>?</td>
</tr>
<tr>
<td>2013 (353 prog. tasks)</td>
<td>677</td>
<td>605</td>
<td>374</td>
<td>270</td>
<td>166</td>
<td>81</td>
</tr>
<tr>
<td>2014 (362 prog. tasks)</td>
<td>1287</td>
<td>1119</td>
<td>668</td>
<td>499</td>
<td>271</td>
<td>131</td>
</tr>
<tr>
<td>2015 (430 prog. tasks)</td>
<td>984</td>
<td>863</td>
<td>449</td>
<td>301</td>
<td>179</td>
<td>53</td>
</tr>
</tbody>
</table>

Table 3 shows the enrollment and completion statistics of the Aalto-MOOC for 2014 and 2015. In this course, unlike in the University of Helsinki MOOC, the students have to create an account to try out the exercises, which largely explains the high number of accounts that are completely inactive, or they have only tried an exercise that introduces the discussion forums. Moreover, some of the students with an account never attempt an exercise, instead merely clicking around the material — a behavior discussed by DeBoer et al. (2014).

Figure 5.2 shows the percentage of initially active students throughout the course timeline. The course is structured so that the core material required for passing the course is covered in Weeks 1–7; optional topics follow in later weeks. In effect, this means that practically all of the students who reach Week 7 pass the course. As the figure shows, most of the passing students continue on to the optional topics, which are required for higher grades. There is a drop after Round 9, a challenging, open-ended, two-week assignment.

As at the University of Helsinki, the pass rate for the Aalto MOOC is relatively high in MOOC terms, despite the fairly heavy workload of the course. This can be attributed to a number of factors. The fact that the course was given in Finnish makes the student body more homogeneous than most MOOCs given in English. If we take a more detailed look at the passing students, the largest group form university students and graduates, roughly equivalent in size to the number of high school students and students in polytechnics combined; this is in line with findings from other MOOCs. The university students are likely to have relatively good self-regulation skills.
On average, the MOOC students reported spending roughly 10 hours per week on the course. Even though the course is time-consuming, the non-local students who filled in the final survey rated the course 4.67 out of 5 and commonly wrote highly enthusiastic free-text feedback.

Table 3: Aalto MOOC: enrollment and completion. “Points” refers to assignment points received for completing tasks

<table>
<thead>
<tr>
<th></th>
<th>year</th>
<th>accounts created</th>
<th>10 points</th>
<th>100 points</th>
<th>1800 points (pass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aalto SCI</td>
<td>2014</td>
<td>280</td>
<td>259</td>
<td>249</td>
<td>231</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>311</td>
<td>281</td>
<td>277</td>
<td>264</td>
</tr>
<tr>
<td>MOOC</td>
<td>2014</td>
<td>2799</td>
<td>1260</td>
<td>855</td>
<td>336</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>1177</td>
<td>594</td>
<td>432</td>
<td>219</td>
</tr>
</tbody>
</table>

Figure 1: Weekly % of active University of Helsinki MOOC students. The graph shows data both from the MOOCs offered between 2013 and 2015 and shorter local courses offered in 2014–15.
6 Discussion

Have Our MOOCs Been a Success?

Neither of our MOOCs started out as a MOOC. Our goal was to create effective large-class university courses whose exercises, materials, and automatic feedback were available at all times, from anywhere; opening the courses to the general public happened as a natural extension of this process. We wished to improve local students’ learning: the time that they might have spent listening to lectures was re-purposed to allow students to study materials and work on practice programs. The technology that we use in the MOOCs was created and adopted in order to make more effective use of university teachers’ and teaching assistants’ time and to improve the feedback that students receive. Both the materials and the technologies were created as complements to face-to-face tutoring, not as replacements for it.

Running any good MOOC is a strenuous and time-consuming business. Nevertheless, given this history of course development, the step from running a local course to running an open course was relatively small in our cases. Launching a MOOC the way we did was certainly cheaper for us in comparison to creating a comparable MOOC from scratch, and indeed the latter option would not have even been financially viable. That being said, budget options tend to have disadvantages. Attempting to teach thousands of students within the scope of a single course has its disadvantages. MOOCs have their disadvantages. And so it is with our MOOCs as well.

Our MOOCs correspond to existing university courses that have been designed with a particular audience in mind. Even though the course materials feature meaningful examples and problems, the MOOC students receive little assistance in relating the course contents to their myriad of interests and life situations. We have not been able to design contextualized courses for different learner groups; despite being open to everyone, our MOOCs are not going to be successful in teaching “computing for everyone” (cf. Guzdial, 2015).

We must also acknowledge that since our courses are in Finnish, we are only reaching a rather homogeneous and — globally speaking — relatively privileged audience. The observation from the
literature that many MOOC participants already have some prior knowledge of the course topics also applies to our courses.

Then, what are our MOOCs good for? As attested by the pass rates and feedback ratings quoted in the previous section, there are numerous students who have found our MOOCs to be a valuable and inspiring learning experience. Clearly, many people simply benefit from the opportunity to access a carefully designed university course — or even a fully online simulacrum of one. These people include lifelong learners who wish to brush up or expand on their knowledge, teenagers who want to explore future opportunities and students from other educational institutions who do not offer a comparable course. Additionally, MOOCs may benefit from the student recruitment efforts of the host institutions, either implicitly by showcasing good courses or explicitly as a vehicle for recruitment, as is the case at the University of Helsinki.

**Collateral Benefits from Running a MOOC**

In regular university courses, classroom discussions can compensate for unclear lecture materials. TAs are on hand to help with problematic exercises, and students meet face-to-face with friends who are taking the same course and to advise each other. Since xMOOCs are less forgiving, the quality of the course materials and the scaffolding worked into them become even more crucial. Publishing and advertising local materials to the world also creates its own pressures to provide a quality service. “Moocifying” our courses has led to tangible benefits for local students, as we have made countless improvements, both small and large, to our courses.

One way in which MOOC takers improve the local students’ education is the feedback they provide to teachers. Another is their contribution to online conversations with other students. MOOC students have provided a rich variety of perspectives on our programming courses; some come from the industry, for instance, while others use computing for various different purposes. At Aalto, we have found MOOC students’ input — questions, feedback, anecdotes — to be highly valuable for the teacher-curated weekly summaries that are shared with local students as well. The MOOC students also enrich the discussions on public forums, both in terms of perspectives and also in terms of sheer numbers of active students who are willing to help others. Finally, in our experience, running MOOCs has given an exhilarating motivation boost to already-motivated teachers.

**Open Questions: Social Interaction in MOOCs**
Despite the positive aspects mentioned above, we see the social side of learning as something to improve upon in our MOOCs, which are largely based on exercise-driven self-study from interactive ebooks. Currently, discussions on the MOOC forums typically center on specific technical issues in particular programming problems and involve a limited sub-population of the course participants. We would like to see more discussion of concepts and ideas as well as more collaborative learning and social knowledge construction. It is an open question as to how to enhance an exercise-driven drill-and-practice format to encourage students to also collaborate with others.

Improvements to existing technical solutions are also needed to make the most of online discussions. For instance, Zhu et al. (2015) have pointed out that the typical kinds of discussion threads in online forums are not ideal for holding conversations about programs and their execution; they suggest a different approach in which conversations are anchored in program code or visualizations. Conversations about topics other than programming might benefit from analogous solutions.

**Open Questions: Dissemination and Collaboration**

Both of our MOOCs were launched by people involved in computing education research groups. This raises some interesting questions. As noted in Section 2, some earlier programed MOOCs have been criticized for ignoring results from CER. In this chapter, we have mentioned some of the ways in which our courses do draw on CER and other educational research. The extent to which this contributes to the success of our courses is an open question, but we surmise that it does play a role. More generally, we have preliminary evidence that building on discipline-based education research may help address at least some of the issues associated with the excessively traditionalist “talking head” pedagogies that feature in many MOOCs. A difficult open question is how best to disseminate results from CER and other educational research to MOOC providers who do not engage themselves in education research; such dissemination is notoriously difficult.

Dissemination even within a discipline such as CER is difficult (Ben-Bassat Levy and Ben-Ari, 2007). A prime example of this can be observed in the tradition of tool-building that exists within CER: programming educators and computing education researchers tend to have the ability, and often have the tendency, to create software tools to support their courses. This is evidenced by the number of locally developed tools in Table 1. One drawback of this tradition is that isolated groups
tend to build their own tools rather than working together (Brusilovsky et al., 2014). Indeed, despite their close geographical and disciplinary proximity, the authors of this chapter have developed their MOOCs largely in isolation from one another. There is clearly potential for greater collaboration both nationally and internationally in designing online tools and pedagogies.

7 Conclusion

The two programming MOOCs that we have discussed as well as the university courses upon which they were founded, are examples of a broader, ongoing movement towards blended online education. These courses are characterized by an emphasis on semi-authentic practice, the use of automatic assessment, instructional design founded on research, and the extensive, continuous collection and use of input from students. We have tentative evidence that these are some of the features that have helped us provide a meaningful learning experience to a substantial proportion of students.

Even so, this is just a small step. Our solutions have been tailored for the particular subject matter of introductory computer programming and to particular settings. Although our MOOCs provide a much more hands-on experience than the archetypal lecture-plus-exam university course does, the experience is nevertheless similar to a large-class university course with limited teacher guidance. It seems necessary to complement xMOOCs such as ours with other, novel solutions if large-scale online education is to address the great variation that exists between subject matters, between the backgrounds of potential participants, and between those participants’ different learning goals.

From the general literature on education and psychology as well as from discipline-based education research, we can draw suggestions on what works. Now it is at the time to investigate those suggestions in a massive, open context.

References


15. Learning analytics

Ari Korhonen
_Aalto University_

Jari Multisilta
_Tampere University of Technology_

Abstract

In online learning, many Learning Management Systems (LMS) and Massive Online Open Courses (MOOC) collect data from their users. The field studying the use of the educational data is known as Educational Data Mining (EDM) or Learning Analytics (LA).

One of the main reasons for creating and giving open online courses is the rich data which is possible to collect from the learning process and students. This data can include background information about the students, forum discussions, log data collected from the system usage, the solutions to the problems submitted by the students, and much more. Especially in scalable courses that are targeted to large number of students, automatic assessment and feedback provides an interesting source of data. The learning platform can collect not only the submitted solutions and the corresponding grading information (such as points or other marks awarded to the student), but it also traces the paths a student took while solving the problems.

General analytics tools, such as Google Analytics, can be used to evaluate the use of a learning service, but it provides only very superficial information on the learning process. Generic data includes web navigation data such as page hits, the number of visitors to a page and time spent on the page. We claim that there is a great need to utilize learning related user data to support the understanding of the learning process in much deeper way. To be able to do so, learning data should be collected and analyzed in relation to the content; and the content needs to be structured in a pedagogically meaningful way.

The many data sources allow us to ask research questions from multiple perspectives. Real time data analysis can provide instant feedback loops for the learners and instructors, e.g., in the form of progress reports. The same data can be utilized to develop the system further in the long run. Likewise, institutions are nowadays interested in monitoring courses and sharing best practices. The
main goal is to develop courses based on data analysis. This is achieved by organizing experimental studies (A/B testing), applying (educational) data mining techniques, and employing machine learning methods to make predictions on data. In this paper, we discuss the future of learning analytics and evidence-based development of online courses.

**Introduction**

In online learning, many learning management systems (LMS) and Massive Online Open Courses (MOOC) collect log data from the users. The field studying the use of the educational data is sometimes referred to as Educational Data Mining (EDM) or Learning Analytics (LA). Long and Siemens (2011) claim that big data and analytics will be the most important factor that shapes the future of higher education. According to Siemens (2013) “education systems – primary, secondary, and postsecondary – have made limited use of the available data to improve teaching, learning, and learner success.”

In this paper, we review the latest research on the emerging field of EDM and LA and discuss the usefulness of these in evaluating the learning process. It seems that if LA is based on very basic click data, it can be used to evaluate the learning outcomes but provides only very superficial information about the learning process. We claim that there is a great need to utilize learning-related user data so that it promotes our understanding of the learning process in much deeper way. To be able to do so, learning data should be collected and analyzed in relation to the learning content, and this content needs to be structured in pedagogically meaningful way.

**EDM and Learning Analytics**

Baker and Yacef (2009) define educational data mining as “an emerging discipline, concerned with developing methods for exploring the unique types of data that come from educational settings, and using those methods to better understand students, and the settings which they learn in”. Educational data mining has emerged from the analysis of logs of student-computer interaction (Ferguson, 2012).
Ferguson (2012), Long and Siemens (2011), and Siemens (2013) define learning analytics as “the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments which it occurs”.

These concepts look to the educational data from different perspectives. Educational data mining is focused on the technical challenge: How can we extract value from the big sets of learning-related data? Learning analytics is focused on the educational challenge: How can we optimize opportunities for online learning? (Ferguson, 2012).

Although the educational data mining and learning analytics communities have different backgrounds, they are currently exploring future collaboration (Siemens & Baker, 2012) which will bring out an overlap of the analytic tools and techniques from both communities (Siemens, 2013, p. 1382).

**Big Data and Cloud Computing**

According to Manyika, et al. (2011, p. 1) big data means “datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyze”. It is not only the size of the datasets that makes data big. Zikopoulos, Eaton, deRoos, Deutch and Lapis (2012) say that big data is characterized by three variables: volume, variety and velocity. Big data may contain data that hails from many sources and occurs in different formats.

Traditionally, data is managed in a structured database, such as in an SQL database. In contrast to well-structured data, big data can be unstructured or multi-structured. For example, large amounts of Twitter messages contain both structured information (sender, time, location, URL) and unstructured information (free text). The data collected from an online learning environment contains multi-structured data. For example, by submitting a response to an exercise, the student generates structured information, such as the sender and submission time, and unstructured information, such as an essay.

Cloud computing can be seen as the global platform for educational software and services (Manyika, et al. 2011, p. 32). The cloud-based educational software and services collect transaction and log data from user activities. The data is not necessarily structured, and the database grows at a
varied speed. It is also stored in the cloud. To understand the data, a certain level of business intelligence is required. In the case of educational services, business intelligence could be based on the underlying pedagogical thinking.

The Uses of Educational Data

Romero and Ventura (2007) categorize educational data mining into the following categories:

- statistics and visualization,
- web mining,
- clustering, classification, and outlier detection,
- association rule mining and sequential pattern mining,
- text mining.

The data collected from educational software and services can be used in many ways, for example for administrative purposes or evaluating the learning outcomes. An important application area for educational data mining has been student modelling. According to Baker and Yacef (2009), student models “represent information about a student’s characteristics or state, such as the student’s current knowledge, motivation, metacognition, and attitudes”. Educational data mining has also been used to improve the domain knowledge structure. For instance, if several users struggle with the same online exercise, it could suggest that the corresponding theory module should be improved. The knowledge model could also be structured by analyzing the content and building links between the content modules based on some kind of taxonomy. This kind of knowledge modelling was done already in the early days of hypermedia (Multisilta, Pohjolainen, 1995). The current data logs in automatically assessed exercise systems can reveal misconceptions that are inherent to the content to be learned. For example, threshold concepts (Mayer and Land, 2003) typically cause multiple learners to struggle with the same exercise. This kind of troublesome barrier to student understanding leads to a misconceived way of following procedures. Data analysis can reveal much of such new misconceptions that help us to give better feedback to learners and overcome these issues (Seppälä, Malmi, Korhonen, 2006).
An important use of educational data is to gain more in-depth knowledge of how students learn and collaborate in online environments. The question is: do the current methods in LA really support the understanding of pedagogical processes?

**Learning Analytics in evaluating the Learning Process**

Learning analytics collect and analyze the traces the students leave on a learning environment such as a Massive Online Open Course (MOOC). In general, the aim is to find causality between student activities and learning outcomes. However, the data collected from MOOCs is not standardized, nor is it strongly linked to educational activities and the content, and it cannot be compared to data from other MOOCs. Veeramachaneni et al. (2013) proposed a harmonized “raw” data format for MOOCs by establishing an open-ended standard data description to be adopted by the entire science education MOOC-oriented community.

The data collection can be divided into two categories: 1) generic interaction data collection, and 2) educational data collection from specific learning activities. The difference between these two categories is that the first is not related to education, whilst the second is related to the learning content, which can be utilized in analyzing the collected data. In both cases, the quality of the data dictates the usefulness of the data.

Generic data collection includes web navigation data which are collected by web analytics tools, such as Google Analytics or the open source web analytics tool Piwik. Examples of generic interaction data are page hits, the number of visitors to a page and the time spent on the page.

Specific data collection is based on the content and the activities users are exposed to in the learning environment. Specific data collection has to be designed as a part of the content. It is difficult to transfer to other contexts, and the data from different systems are not easy to compare. Examples of specific data collection include *events* (for example answers to a multiple choice question or the selection of a specific menu choice) that have a specific meaning in terms of the content and the context. For example, if the learner selects a menu option that represents a wrong answer in a certain exercise, the generic data collection could only provide us with information about the frequencies of responses of the menu options. However, the specific data collection could offer us a much deeper understanding of the responses if, for instance, we know that the first menu option is a distraction because the answer represents a misunderstanding of the concept the exercise is about.
Moreover, data collection depends not only on the level of abstraction but also typically on
- the different stakeholders that have different demands related to the data, and
- the real time data visualization that brings more constraints to the data collection
  method.

Table 1 illustrates this from five different perspectives: students, teachers, institutions, developers,
and researchers. Different stakeholders need different analysis tools and methods and are interested
in different kinds of data collection. Depending on the stakeholder, the data can be generic data or
specific to the content. In addition, the feedback loop can be real-time or post-mortem, that is,
analyzed during or after the course.

If the aim is to provide real-time data visualization (RTDV) about the progress of a single student, the situation is different than in the case of a developer conducting an experimental study, for example, about the usability of the user interface. In RTDV, the student typically requests the visualization after each submission, while the teacher may be interested in the same data but collected from multiple students (i.e., statistics). Thus, student interaction provides rich real-time data that can be analyzed and visualized in real-time for the student and on an on-demand basis for the teacher. However, the requests performed by a teacher are more real-time than the data analysis done by institutions, developers, and researchers. They look into this data “post mortem” to improve the course and learning environment, i.e., after the whole course has (or from an institutional point of view, a number of courses have) ended. Researchers, on the other hand, might want to conduct an experimental study that typically not only needs plenty of time for data analysis but also more design consideration before the experiment (i.e., what kind of data to collect in the first place).

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Analysis Tool</th>
<th>Analysis Method</th>
<th>Data Collection</th>
<th>Feedback loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>visualization</td>
<td>progress report</td>
<td>specific</td>
<td>real-time (immediate)</td>
</tr>
<tr>
<td>Teacher</td>
<td>composition</td>
<td>Statistics</td>
<td>specific/generic</td>
<td>real-time (on-demand)</td>
</tr>
<tr>
<td>Institution</td>
<td>compilation</td>
<td>Statistics</td>
<td>specific/generic</td>
<td>post-mortem</td>
</tr>
</tbody>
</table>

Table 1: The table illustrates the different stakeholders and levels of Learning Analytics Data.
The analysis’ tools and methods in the table are examples of possible tools and methods available for the stakeholders. In addition, it should be noted that the same person can play many different roles at the same time, i.e., the teacher can be both developer and researcher in this simplified overview. Moreover, the distinction between researcher (that is, one who conducts more statistical data analysis) and developer (one concerned with constructive research) is not strict. The value of learning analytics is that a teacher can see the world through the eyes of a student. Institutions have a compilation of statistical data from many courses, researchers have even more data including background information collected only for their research purposes, and finally the developer has access to all data including the click-and-point data.

Next, we will present examples of learning analytics in use in different learning environments. Ketamo (2014a) presented a method of collecting learning data from the gaming environment, where learners teach a game character. From the data, the gaming environment can produce detailed information of the learning process. Ketamo has collected anonymized data from players of his game around the world and has presented how the data can suggest differences in competences in certain mathematical topics between different countries. For the individual learner, the game provides a visual clue of how their learning is progressing.

Kiili, Devlin, Perttula, Tuomi and Lindsted (2015) state that many educational systems do not establish a close link between learning and summative assessment. Based on the data they collected from two separate games, they conclude that game-based assessment can create a better understanding of mathematical competence compared to summative testing. In this sense, games and the data analytics behind a game can be described as formative assessment. In formative assessment, the learning process is evaluated often, and the assessment helps the learner to improve his or her own learning (Sadler, 1989). The focus is on the quality of the learning process and not so much on the outcome of a specific (summative) test.

An example of an assessment tool for MOOCs is the Learning Fingerprint (Ketamo, 2014b). The Learning Fingerprint is a system where the learner evaluates his or her learning after each learning task, such as after watching a video clip. The system displays a map of the learners’ progress in the course, in which the modules and topics the student has already mastered are displayed along with

<table>
<thead>
<tr>
<th>Researcher</th>
<th>A/B testing</th>
<th>A/B testing</th>
<th>specific/generic</th>
<th>post-mortem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developer</td>
<td>log data</td>
<td>Traces</td>
<td>specific/generic</td>
<td>post-mortem</td>
</tr>
</tbody>
</table>


the areas that require more work. The system resembles the Experience Sampling Method (Larson & Csikszentmihalyi, 2014) in which test subjects are asked at random points about the activity that is being researched. Thus, Learning Fingerprint collects data for personal use and is based on the semantic structure of the content modules and their relations.

One of the current trends in data analysis is to reveal new misconceptions that help to give better feedback for the learner (Seppälä, Malmi, Korhonen, 2006). Educational data mining techniques as well as special algorithms to cluster misconceived solutions can be developed to catch errors from students’ submissions (Korhonen, Seppälä, Sorva, 2015). Some of the erroneous submissions are slips, but if the same systematic errors are committed by many students, new misconceptions can be revealed and used to devise better feedback.

See also the online book Learning Analytics: From Research to Practice edited by Johann Ari Larusson, Brandon White.

Conclusions

In online learning, learning environments such as games and MOOC courses collect data from their users. The data opens up many possibilities to utilize it, but there are also unsolved questions, such as privacy issues.

There are several levels of learning analytics data. As mentioned above, different stakeholders have different analysis needs, and whether the data is generic or specific depends on the stakeholder. In addition, the feedback loop can be real-time or post-mortem that is analyzed during or after the course.

There are already examples of how the data can be used to unveil otherwise hidden problems within the learning process. At its best, learning analytics should aim to support individual learners by providing formative assessment tools.

The Finnish school system is based on a national core curriculum that was reformed in 2014 and will be effective as of 2016 (Vahtivuori-Hänninen, Halinen, Niemi, Lavonen & Lipponen, 2014).
Much of the assessment in the Finnish school system is based on formative assessment. The new core curricula emphasize the use of digital tools in learning, and, thus, provide more possibilities to implement learning analytics as a part of a formative assessment in digital learning environments.

Kelly and Seppälä (2016) note that parents, students and policymakers are increasingly aware of the risk of violating certain privacy rights by collecting data in MOOC environments. Globally available courses exasperate the situation, and the rules of using the data are not only based on directives and regulations, but also on social guidelines and trust. Kelly and Seppälä (2016, p. 655) conclude that “the ethics of researching online learning is still a matter of debate”.

References


In Search of the future of Educational Challenges in the Chinese and Finnish Context

Jiyou Jia
Peking University

Hannele Niemi
University of Helsinki

Education throughout Chinese history and today

After browsing this book, readers may have received some controversial and seemingly contradictory information about Chinese education and the application of ICT within it: the usage of smartphones in the university classroom has a positive influence on students’ learning performance, but the school teachers have changed their attitude toward tablet computer usage in the classroom from positive to negative. The government and educational authorities have bought large amounts of educational resources from high-tech companies, but only a small percentage of students actively participate in the learning activities on offer.

Though the complexity and dynamics of the educational system, as shown in Figure 1 of the Prologue, could explain this controversy somewhat, one feature of Chinese education formulated through thousands of years could help readers better understand the contemporary disagreement, and look for future work.

Throughout China’s long history up to present day, education has played a very important role in technical, economic and social development as well as individual growth. Without education, it would have been impossible for China to be the world’s largest economy for most of the past two thousand years and to produce some of the most significant inventions ever, such as paper, printing, gun powder, the compass, calculus and so on. The rulers treated the national examination system as a key way to discover elite young students from among the nationwide ranks to fill governmental vacancies. Conversely, poor parents from rural areas and the urban lower classes regarded education and examination as the sole way to alter their children’s fortune and future as well as their own. Schools and colleges came into existence two thousand years ago, and a number of pedagogues, philosophers, politicians and scientists contributed creative ideas and wisdom to Chinese educational development; Confucius being perhaps the most famous and successful worldwide. In his private schools, he taught
more than three thousand students, and 72 of them were celebrated sages. His pioneering pedagogical thoughts, including education for everyone and teaching based on individual aptitudes and ability, have not only enlightened people during his own time and over the past two thousand years but will also inspire educators and educational researchers forever.

Since the 1800s, the Chinese have been struggling against colonization and for economic, social and political modernization and resurgence. Researchers and policy-makers introduced the school and university system from Europe in the first half of the twentieth century, from the former USSR in the 1950s and from the United States after the 1980s one after another in order to have Chinese students master the modern scientific and technological knowledge originating from the western world. Contemporary Chinese education is, therefore, heavily influenced by western theories, despite of its long-term tradition rooted in Confucianism.

Since the implementation of the reform and opening policy in 1978, the Chinese economy has been steadily expanding, and the education system has also experienced continuous reform and evolvement in order to promote scientific, technological and social advancement. However, due to its giant territory, vast population and chronic backwardness, social, economic and educational development is not balanced nationwide. A vast gulf exists between eastern, western and middle provinces, between metropolises and small cities, between urban and rural areas, and even between two nearby schools or universities.

The current Chinese education system is illustrated in Figure 1. Prior to the age of six, children either attend kindergarten to receive pre-school education or stay at home. From age six to fifteen, children are legally required to attend primary and junior middle school to receive compulsory education from grades one to grade nine. However, due to large variation in primary schools, some parents want their children to go to better schools. For instance, some universities have their own primary schools for the children of their faculty and staff members. These attached schools are regarded as better schools because on average the students’ parents are better educated and have higher incomes. Normally the “nearby policy” is adopted by local education authorities to select from the enormous pool of applicants for the better schools, i.e., only residents of the officially designated buildings near the schools are allowed to send their kids to the school. However, school administrators and teachers often want better educated children as students, so specially designed examinations to overcome the “nearby policy” are a common occurrence. In Figure 1, the arrow from kindergarten or family to primary school is labeled with “near plus exam”, which explains this entrance requirement. It should be observed that in the process of urbanization in recent years, the proximity-based entrance policy
to schools provides a vital contribution to the real estate development in big cities as well as in smaller
towns. The so-called school district apartments or houses are more expensive than others.

Chinese Education System

<table>
<thead>
<tr>
<th>Grade</th>
<th>Age</th>
<th>Education institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-</td>
<td></td>
<td>University and college</td>
</tr>
<tr>
<td>12-17</td>
<td></td>
<td>Senior middle school</td>
</tr>
<tr>
<td>(some are model schools like schools attached to a university or college, most are ordinary schools)</td>
<td>Exam</td>
<td></td>
</tr>
<tr>
<td>11-16</td>
<td></td>
<td>Vocational middle school</td>
</tr>
<tr>
<td>10-15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-14</td>
<td></td>
<td>Junior middle school</td>
</tr>
<tr>
<td>8-13</td>
<td></td>
<td>(some are model schools like schools attached to a university or college, most are ordinary schools)</td>
</tr>
<tr>
<td>7-12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-11</td>
<td></td>
<td>Primary school</td>
</tr>
<tr>
<td>5-10</td>
<td></td>
<td>(some are model schools like schools attached to a university or college, most are ordinary schools)</td>
</tr>
<tr>
<td>4-9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-6</td>
<td></td>
<td>Kindergarten or family</td>
</tr>
</tbody>
</table>

Figure 1 The education system in China

After six years in primary schools, pupils move to a junior middle school. Better middle schools, such as ones attached to a college or university, often have proximity-based entrance requirements along with an exam. After three years of studying in a junior middle school, pupils have finished their obligatory education at the age of 15 and can either enter a senior middle school oriented at universities or colleges, or a vocational middle school oriented towards blue-collar jobs and less-skilled work. Higher education graduates are often more competitive than vocational middle school graduates in terms of high-paid careers. As a result, the competition for entrance to a senior middle school, especially to a better senior middle school, is extremely fierce. The only entrance approach to senior middle schools is a city-wide, county-wide or province-wide examination.

Having completed three years in a senior middle school, the now 18-year-old students must pass the nation-wide higher education entrance examination to attend university or college. The difference among universities and colleges is also vast, as shown in Figure 2. Among 2553 ordinary universities and colleges, 112 key universities are recognized by the Ministry of Education and called “211” universities, which is the abbreviation of the one hundred good universities in the twenty-first (21) century. Among the 112 universities, 38 are recognized and called “985” universities, which the central government set the task of becoming world-class universities in May, 1998. The two elite universities, Peking University and Tsinghua University are at the top of the 38 excellent ones. In
order to be enrolled into an elite, excellent or good university, students must achieve an acceptable mark in the national examination. If the exam score is too low, the student can not be admitted to a university or college and is faced with the bleak prospect of searching for a job in the highly competitive job market.

The above introduction to the current Chinese education system shows that examination plays a vital role in students’ transition from a lower educational stage to a higher one. The students’ examination results determine their future and fortune generally. They are regarded as an essential factor to evaluate not only the students’ learning performance but also the school’s teaching accomplishment and its teachers because the examination is deemed to be the only fair form of assessment in a developing country with an extremely complicated society. This is the starting point to understand almost of all educational phenomena in China, including the ICT (Information and Communication Technology) application in education.

**Chinese Higher Education System**

The purpose of ICT integration into ordinary teaching and learning, as stated many times by educational officials in the media and national plans, is to cultivate students’ basic knowledge, skills and literacy in the information era, to foster their creativity, and to prepare them for the future work place. After nearly forty years of continuous growth since the 1970s, the Chinese economy is undergoing a radical transformation from a labor-intensive, resource-consuming industry to a knowledge-intensive industry. New industrial branches such as e-commerce, e-health, and e-learning and so on are needed for social and economic transformation and to meet the great demand for new
job opportunities for young graduates from middle schools and higher education. In response to this, the concept of Internet + (Internet plus traditional sections) was proposed by the central government, including projects such as Internet + Logistics, Internet + Commerce, Internet + Health, and also Internet + Education.

Students’ exam scores only reflect their learning outcomes regarding the target content in the textbooks learned in a term or in the past few school years, but it fails to reflect their innovative thinking, information literacy and working capability in the future. Therefore, educational researchers and practitioners should not only consider ICT’s short-term impact on students’ examination scores but also rethink how we use ICT to facilitate students’ explorative and innovative learning. This point has been emphasized repeatedly by Chinese Premier Dr. Li Keqiang, who recently visited Peking University and Tsinghua University on April 15, 2016 (Xinhua News Agency 2016). The Chinese demand for economic and social advancement requires more and more creative recruitment, and the use of emerging technologies ranging from artificial intelligence to virtual reality to inspire students’ creativity. This is the future of ICT for Chinese education.

**Education throughout Finnish history and today**

The Finnish educational system has received plenty of international attention because of the high learning outcomes of its 15-year-old pupils. Program for International Student Assessment (PISA) measurements have placed Finland among the top rankings since 2000. The differences in achievement between its schools have also been smallest in the world. Even though it had a small decline in the rankings in 2012, Finland still has one of the highest performing educational systems in the world.

The reasons for Finnish success have been discussed in hundreds of international forums, and the most common question has been how it can be possible that – with only average monetary investment by the Finnish government, a very small amount of homework and number of school lesson hours, and an extremely light educational evaluation system that does not use inspections – the Finnish education system can achieve such consistently high quality and equality results in international comparisons (Reinikainen, 2012).

Finland was initially related to a part the Swedish Kingdom (1249–1809) and was later a Grand Duchy within the Russian Empire, 1809–1917. Finland became an independent nation in 1917. Educational
history roots in Western cultures. The crucial turning point was when Sweden became a Protestant country following the Lutheran religion in the 16th century. Personal responsibility, persistency, and high morals were values taught by the Lutheran church long before the secular educational system was established. The Lutheran church launched reading schools in all villages and even sent travelling reading teachers to remote areas. The church set literacy as a basic requirement for all men and women wanting to get married, something that was authorized by the church in those days. Literacy was important for getting all people able to read religious texts. When the Finnish independence movement grew in the 19th century, it also emphasized the importance of culture and civilization. A combination of religious values, national identity formation, and respect for education and teachers created the value basis on which the Finnish educational system was established in the 1900s. This educational system consisted of a parallel model dividing students into two groups at the age of 10: a more academic route and a vocational route. The latter did not have access to higher education. This divided the nation into two different groups who by no means had equal opportunities. In the late 1960s the whole system was overhauled. Since then, all students have 9 years of common basic education and thereafter 3-4 years of secondary education, and both routes offer access to higher education. Universities and other higher education institutes have their own entrance examination procedure. Open universities and universities of applied sciences also provide higher education courses. The proportion of the population with a higher education degree among people age 25–34 was 18 % in 1970, 29 % in 1990 and 37 % in 2010. There are also many education paths for adults to learn at any stage of life.

The Finnish system is not based on testing and examinations. It is based on an ecosystem in which the main aim is to create routes for continuous learning and to support all people in their learning process. The entire system revolves around the still valid principles expressed in the school law (628/1998):

- The purpose of education referred to in this Act is to support pupils’ growth into humanity and into ethically responsible membership of society and to provide them with the knowledge and skills needed in life. Furthermore, the aim of pre-primary education, as part of early childhood education, is to improve children’s capacity for learning.

- Education shall promote civilization and equality in society and pupils’ prerequisites for participating in education and otherwise developing themselves during their lives.

- Our aim shall further be to secure adequate equity in education throughout the country.
Given our reflections on the integration of ICT into the Chinese educational context, we may also ask ourselves what role technology plays in the Finnish educational setting and what are the major challenges related to its use in schools.

The current Finnish basic and secondary educational system is decentralized. The local provider/authority is responsible for the quality of education. This means that at the local level, local authorities must create well-functioning educational services and allocate resources accordingly. In recent years, Finland has endured a very difficult economic recession. There have been serious budget cuts at both national and local levels. These cuts threaten equality and educational services to which educational technology belongs. In addition, Finnish local providers are responsible for students’ learning outcomes and for teachers’ pedagogical capacity to use new learning environments. When technology provides new tools, teachers should be supported in finding their teaching and learning value. Teachers need to learn how to mediate new digital resources and environments to their students and, thus, provide versatile paths for personalized learning.

Creating schools as learning communities is the core aim of the new national core curriculum (2016) for basic education. It demands that teachers and students learn by dialog and sharing. ICT, social media and open, digitalized learning environments are revolutionizing school culture. Encouraging and supporting learning environments are needed to help students to become active learners and knowledge creators. Learning communities require joint efforts of all partners including students, teachers, principals, parents and other stakeholders. Even though there are good examples set by many schools, cooperative culture is just one of a variety of issues that need to be improved in Finnish schools.

The successful educational use of ICT calls for a community-oriented approach. Leadership plays the most important role in achieving this end. For instance, Yuen et al. (2003) have argued that using ICT is strongly dependent on the school leaders’ vision and their understanding of the role and impact of ICT in the curriculum. We also have research-based knowledge (Niemi et al., 2013) that suggests that if principals have a clear vision, they support collaboration that allows teachers to set joint objectives and even to teach together in new learning environments. A common feature of schools with such leadership was the continuous development of a dynamic local curriculum, which allowed for reforms when responding to students’ needs. Teachers also sought new ways to collaborate across subjects and student groups. The following were also typical:
Curriculums developed together and modified according to teachers’ new ideas for better student learning

Room for new methods and content

ICT seen as a tool, not as a purpose in itself

A strong emphasis on students’ future needs and life skills

Finnish is spoken in a very small area, yet schools need learning materials and tools in their native language. Tools should also fit a pedagogic purpose in such a way that they provide meaningful learning spaces to both low and high achievers and also to students from immigrant backgrounds and from different cultures. The development of relevant digital learning materials and tools demands educators, researchers and technology companies working together for new learning solutions.

A short epilogue

China and Finland are vastly different countries in terms of their respective populations, languages, history, cultural roots and educational systems.

When discussing new ways to teach and learn, both countries face similar opportunities and challenges. Both countries see ICT and new learning environments as tools for teaching and learning; in China particularly for better learning performances, and in Finland as a resource for supporting different learners and providing tools to overcome learning difficulties. Both countries see technology as a tool, not as an aim itself; they both emphasize that new digital tools and materials should be pedagogically relevant and that teachers need support and training to learn how to use them.

We can also understand that both countries have a historically and culturally rooted respect for teaching and learning. Technology is a powerful tool, but it should be developed to meet teachers’ and students’ needs.

Teaching and learning are firmly rooted in both nations’ histories. Today this respect presents itself as a growing awareness of the fact that 21st century students need new skills and competencies to cope with our ever-changing modern world, and technology is a significant part of these changes.

References


**Authors**

**Maija Aksela**

Professor Maija Aksela has 25 years of experience in science education and teacher training in Finland. She is the head of the national LUMA Centre Finland and the Chemistry Teacher Education Unit in the Department of Chemistry at the University of Helsinki. She has published approximately 300 papers. Many of her research projects are related to both formal and non-formal science education and also have a strong connection to ICT. Professor Aksela has been leading the LUMA Finland program for Science and Math education since 2014 and will continue to do so until 2019, sponsored by Ministry of Finland. She has many international collaboration activities, for example she has been Finland’s representative in the ALLEA (ALL European Academies) working group on Science Education since 2010. Professor Aksela has received an impressive total of 14 different honours and awards for her innovative work in science education.

E-mail: maija.aksela@helsinki.fi

**Pirjo Aunio**

Since 2000, Aunio has conducted research on the development of mathematical skills, learning difficulties in mathematics, the assessment of mathematical development, and mathematical and cognitive skills interventions. She has done unique work in developing evidence-based assessment and intervention tools to be used by teachers. She has published over 60 peer-review articles and books. Aunio works as a professor (Special Education) at the University of Helsinki. She is also a visiting professor at the University of Oslo (Norway), the University of Johannesburg (South Africa) and she is a visiting scholar at the National Institute of Education (Singapore). She regularly reviews international scientific journals and research grant foundations.
Daniel CHEN

Daniel Chen is a Ph.D. Candidate at the Graduate School of Education at Peking University. He is also the co-founder and Vice Chairman of KBTC Co., a leading global educational technology and service company focusing on Early Childhood Education. His research interests include big-data-based child development assessment, gaming learning, and MooC technology. He holds 5 USA patents and 3 Chinese patents. He authored a book entitled “Service-oriented Industry Solutions design principles and best practices” in 2011.

E-mail: daniel.chen.gse@pku.edu.cn

Feng Kuang CHIANG

Feng Kuang Chiang is currently an associate professor at the School of Educational Technology at Beijing Normal University, China. He obtained his Ph.D. in educational technology from National Kaohsiung Normal University, Taiwan in 2009. Chiang was a post-doctoral fellow at the Institute of Applied Mechanics at National Taiwan University. His research interests include learning science, the integration of ICT in education, e-Schoolbag for instruction, learning space, and STEM in education.

E-mail: fkchiang@bnu.edu.cn

Yizhou FAN

Studying at the Graduate School of Education at Peking University and working in the Peking University X-Learning Center, Fan’s main research directions are learning analytics, MOOC data analysis and instructional design. In the past three years, he has participated in the first batch of MOOC course research and construction and in the exploitation of MOOCs for teachers’ professional development. Moreover, he has carried out much research about learning behavior patterns. In future, he will also focus on foreign language acquisition and quantitative research.

E-mail: yizhou0034@126.com

Lei FU

Lei Fu graduated from Beijing Normal University in 2007 with a bachelor’s degree in physics, and received his master’s degree in education informatics at the University of Buffalo. He is one of the first online course product managers in China, specializing in online course designation and science education for children. He is interested in STEM education, learning analysis, adaptive learning and educational measurement.
Vilhelmiina Harju

Vilhelmiina Harju is a doctoral student at the Institute of Behavioural Sciences at the University of Helsinki. Her research interests include lifelong learning, non-formal learning environments, and learning and teaching with digital technologies.

E-mail: vilhelmiina.harju@helsinki.fi

Heikki Hervonen

Heikki Hervonen (MD, PhD) has had a teaching career spanning five decades as a senior lecturer and professor in anatomy at the Faculty of Medicine at the University of Helsinki. He has been a key person in curricula reforms and a pioneer in developing and implementing active learning methods, such as problem-based learning in medicine. Based on his outstanding educational merits, he was selected as a founding member of the Teachers’ Academy at the University of Helsinki in 2013. In recent years, he has become an expert on learning methods and biomedical sciences in the iPad project. Hervonen has actively promoted the research-based development of digital and mobile learning not only in the Faculty of Medicine but also in national and international contexts.

E-mail: heikki.hervonen@helsinki.fi

Tarja-Riitta Hurme

Tarja-Riitta Hurme (PhD, Education) is a senior researcher at the Department of Teacher Education and at the Centre for Learning Research at the University of Turku, Finland. Her main research interest focuses on collaborative learning processes in technology-supported as well as face-to-face learning situations. Hurme’s research has been focused on self-regulated and shared learning in different learning context and domains, such as mathematics, and currently, in music. Her publications include both international peer-reviewed scientific journal articles and book chapters. Together with colleagues, she made the first national report on using online learning as a part of hospitalized children’s schooling.

E-mail: tarja-riitta.hurme@utu.fi

Jiyou JIA
Dr. Jiyou Jia is a professor at the Department of Educational Technology at the Graduate School of Education, Peking. He is also a director at the International Research Center for Education and Information at Peking University, China. He was invited to work as a guest professor in 2015 by the Technical University of Munich, Germany. He received his bachelor’s and master’s in education from Peking University and was awarded his Ph.D. by the University of Augsburg, Germany. His research interests include educational technology and artificial intelligence in education. He has published more than 80 articles in international and national journals and peer reviewed conferences, and he has authored and edited five books in Chinese, English, and German. He has been responsible for a dozen national projects and international cooperation projects. He serves as a reviewer for six journals indexed in SCI/SSCI, co-chair and/or a member of the program committee of more than 20 international conferences. Furthermore, he is an advisory expert for several scientific, government and social organizations. His research has won a number of national and international prizes.

E-mail: jjy@pku.edu.cn

Jingjing JIANG

Jiang graduated from the School of Education Science at Nanjing Normal University in 2015 and is currently studying at the Graduate School of Education, Peking University. Jiang’s main research direction is instructional design and education technology in addition to the area of STEM and innovative education. Jiang is also engaged in areas such as the effect of digital and network technologies in research integrity and atmosphere construction.

E-mail: pkujjj@pku.edu.cn

Shuhan JIANG

Shuhan Jiang is currently an undergraduate at the School of Educational Technology, Beijing Normal University, China. Her research interests include Lego Robotics education as well as the study and instructional design of novel engineering courses.

E-mail: 872196318@qq.com

Ya Na JIANG

Ya Na Jiang received her master’s degree from the School of Educational Technology, at Beijing Normal University, China. Her research interests include mobile and ubiquitous learning and teacher training.

E-mail: 188024808@qq.com

Yu JIANG
Yu received his master’s degree from the Department of Educational Technology, Peking University. At present, he works for the National Center for Educational Technology in China. Yu has published many journal papers in some important Chinese journals in the field of educational technology, such as the Journal of Distance Education and e-Education Research, and his book The Power of Games has had an impressive influence upon people’s understanding of the educational values of games since its publication. Currently, Yu’s research focuses upon gamification and educational informatization.

E-mail: jiangyu@pku.edu.cn

Morris Siu Yung JONG

Dr Jong is an assistant professor of the Department of Curriculum and Instruction at the Chinese University of Hong Kong, where he also serves as the director of the Centre for the Advancement of IT in Education and the co-director of the Master of Arts Program in Information Technology in Education. His research interests include digital game-based learning, GPS-supported mobile learning, computer-supported collaborative learning, and teachers’ professional development in IT in education.

E-mail: mjong@cuhk.edu.hk

Veera Kallunki

Veera Kallunki works as a post-doctoral researcher at the Institute of Behavioural Sciences at the University of Helsinki. Her doctoral dissertation concerned the learning of DC-circuit phenomena during small group discussions. Her recent publications deal with digital storytelling, multidisciplinary teaching, and learning processes.

E-mail: veera.kallunki@helsinki.fi

Ari Korhonen

D.Sc. (Tech) Ari Korhonen is a senior university lecturer at Aalto University, Finland. He is also an adjunct professor at the University of Turku, Finland. Korhonen has been working in the field of educational technology since 1997. He has developed several systems capable of automatic assessment and feedback as well as engaging students to digital learning environments. Korhonen has been a co-author in more than 60 internationally peer-reviewed journal and conference papers. He currently sits on the editorial board of ACM Transactions on Computing Education and is a guest editor for a special issue on learning analytics.

E-mail: ari.korhonen@aalto.fi
Kristiina Kumpulainen

Kristiina Kumpulainen, PhD, is a professor of education in the Department of Teacher Education in the Faculty of Behavioural Sciences, University of Helsinki. She is the founding member of the Playful Learning Center (www.plchelsinki.fi) where she leads research projects on digital and creative learning, with a specific interest in STEAM. In the past, she has served as the Director of Information and Evaluation Services on the Finnish National Board of Education and as the Director of CICERO Learning at the University of Helsinki, Finland. Her research addresses dialogic learning in science and mathematics classrooms, classroom interaction, teachers’ professional learning, learning across contexts, digital technologies and media, learner agency and identity development. She has published widely on these topics in international peer-reviewed scientific journals and books, and presented her research at international conferences and seminars. She is an editorial board member of the European Journal of Educational Psychology and the International Journal of Educational Research. At present, she co-leads a working group of the EU-COST network ISCH COST Action IS1410 on the digital literacy and multimodal practices of young children (DigiLitEY).

E-mail: kristiina.kumpulainen@helsinki.fi

Baoping Li

Baoping Li is currently a lecturer at the School of Educational Technology at Beijing Normal University, China. She obtained her Ph.D. in educational technology from Beijing Normal University, China in 2009. Her research interests include the integration of information and communication technologies into education, teachers’ and students’ perceptions of technology-rich learning environments, and designing innovative learning activities for a one-to-one student to tablet PC ratio in primary and secondary schools.

E-mail: libp@bnu.edu.cn

Xiaoqing Li

Xiaoqing Li is a teacher at the Advanced Innovation Center for Future Education at Beijing Normal University, China. She obtained her Master’s in Educational Technology from Liaoning Normal University, China in 2012. Her research focuses on teacher training.

E-mail: lixiaqing8507@163.com

Teemu Masalin
Teemu Masalin is an IT specialist with 15 years of experience at the University of Helsinki. His background is in media education and ICT journalism. Teemu serves as an IT expert for the iPad project in the Faculty of Medicine and has coordinated the project from the start. He has provided support to both students and teachers throughout the project and been consulted on mobile learning projects in other faculties at the University of Helsinki, and more recently at the Qatar University School of Medicine. His research focuses on mobile learning.

E-mail: teemu.masalin@helsinki.fi

Jari Multisilta

Jari Multisilta is a professor of multimedia at the Tampere University of Technology, the director of the University Consortium of Pori, and an associate professor at the University of Helsinki, Finland. Multisilta received his MSc in Mathematics from the University of Tampere in 1992 and his Dr.Tech. from Tampere University of Technology in 1996. Currently, his research interests include networked and mobile learning, mobile social media, mobile video storytelling, and learning analytics. He was a visiting fellow at the Nokia Research Center from 2008-2009, a Nokia visiting professor in 2012 and a visiting scholar at the H-STAR Institute, Stanford University in total 18 months during 2007-2014.

E-mail: jari.multisilta@tut.fi

Huan NIE

Huan Nie is a professional product manager of Internet websites, Apps, software, etc. He designed a tool for analyzing and visualizing website users’ interaction behaviors when working in the Department of Big Data in JD (an online shopping mall in China). He dedicates himself to the research and practice of applying multi-media technology, games, and big data technology in supporting learning and teaching.

E-mail: niehuanforever@163.com

Hannele Niemi

Hannele Niemi, PhD, has been a professor of education at the University of Helsinki since 1998. She was the vice rector responsible for academic affairs at the University of Helsinki in 2003–2009. She has published over 300 peer review articles and tens of books on education and teacher training. Her work is translated into over ten languages. She has contributed to many European Union and OECD projects as an expert or researcher and served as a keynote lecturer in teacher education in more than 30 international forums. Niemi has been awarded the honor of doctor, or Professor Honoris Causa, from the University of Bucharest in Romania (2010), the J.C. Koh Professorship at Nayang Technological University in Singapore (2010) and two Finnish Universities (2013, 2014). Her main research interest areas are quality of teaching and learning, technology-based learning environments and values in education.
Johanna Penttilä

Johanna Penttilä is a doctoral student at the Institute of Behavioral Sciences at the University of Helsinki and a researcher in the Research Foundation for Studies and Education Otus. Her research interests center around knowledge building and the utilization of technology in learning. Currently, she is studying digital storytelling and its effects on students’ conceptual understanding in the context of science learning.

E-mail: Johanna.penttila@helsinki.fi

Johannes Pernaa

Johannes Pernaa is a media engineer and also holds a PhD in chemistry learning environment design (Uni. Helsinki 2011). His research interests are design-based research, lifelong learning and chemistry visualizations. He is currently working as a chief publishing officer in the Finnish educational publishing house e-Oppi Ltd.

E-mail: Johannes.pernaa@helsinki.fi

Eeva Pyörälä

Eeva Pyörälä (PhD, MME) is a senior lecturer in university pedagogy. She has worked for 25 years in educational development in the Faculty of Medicine at the University of Helsinki and made a major contribution to curricula reforms and communication skills studies in medicine and in establishing the Teachers’ Academy at the University of Helsinki. She is responsible for higher education courses in medicine and dentistry. Eeva is active in medical education development and research at national and international levels and is an expert in the higher education iPad project. Her research focuses on mobile learning, communication skills, assessment, active learning methods, collaborative learning and qualitative research.

E-mail: eeva.pyorala@helsinki.fi

Heikki Ruismäki

Heikki Ruismäki is a professor of skills and arts in the Department of Teacher Education (from 2003 to present day) and vice dean (societal impact) in the Faculty of Behavioral Sciences at the University of Helsinki (since 2014). Earlier, he was the first professor of Music Education at the University of Oulu (1993-2003). At University of Oulu, he worked as a developer and organizer. His research interests (www.mv.helsinki.fi/home/hruismak/) are related to the class teacher and music teacher education, its development as well as music technology, working conditions and well-being of music teachers and music. He has also examined informal, open learning
environments, pedagogic possession of arts as a school subject and communication technology (ICT), network learning, and developing teacher training. In his most recent studies, Ruismäki has concentrated on a broader field of arts education.

E-mail: heikki.ruismaki@helsinki.fi

Inkeri Ruokonen

Inkeri Ruokonen (PhD, MuL) has been a senior lecturer in music didactics, arts pedagogy, and education in the Department of Teacher Education at the University of Helsinki since 1995 to present day. She is a member of the Teachers' Academy and has developed and researched new learning environments, especially in interdisciplinary arts education and music. She has organized several conferences on intercultural and interdisciplinary arts education and published scientific research articles and other books on arts education. Her research focuses on music and arts education, new learning environments and communication technology, early giftedness and intercultural arts education.

E-mail: inkeri.ruokonen@helsinki.fi

Otto Seppälä

Otto Seppälä, DSc (Tech.), is a University Lecturer and computing education researcher in the Department of Computer Science at Aalto University, Finland. His research includes topics such as automated assessment and feedback, and introductory programming education. As a member of the Aalto MOOC team, Seppälä received the Aalto High 5 Award for his work on organizing Aalto University's first MOOC offering. Seppälä has worked on a number of educational software projects.

E-mail: otto.seppala@aalto.fi

JunJie SHANG

Dr Jun Jie Shang received his BSc and MSc from Peking University in 1996 and 1999 and was awarded his PhD in Education from the Chinese University of Hong Kong in 2007. He is currently an associate professor and vice dean at the Graduate School of Education at Peking University where he also serves as the director of the Department of Education Technology. His research interests include game-based learning, learning science and technology, student and school development through technological innovations.

E-mail: jjshang@pku.edu.cn

Juha Sorva

Juha Sorva, DSc (Tech.), is a computing education researcher and university lecturer in the Department of Computer Science at Aalto University, Finland. His research interests include
introductory programming education and program visualization, and he is the lead pedagogical
designer of the university's first massive open online course (MOOC). In 2015, jointly with the rest
of the MOOC team, Dr. Sorva received the Aalto High 5 Award for advancing the university's
educational mission. His doctoral dissertation was selected for the 2013 Thesis Award by the
CICERO Learning network.

E-mail: juha.sorva@aalto.fi

Lulu Sun

Lulu Sun is currently a master’s candidate at the faculty of Education at Beijing Normal University,
China. Her research interests include technology-enhanced language learning and classroom
observation in the technology-rich classroom.

E-mail: 15600917236@163.com

Mingze Sun

Mingze Sun is currently an undergraduate at the School of Educational Technology, Beijing Normal
University, China. Her research interests include learning space, and STEM in education.

E-mail: 664186721@qq.com

Sakari Tolppanen

Sakari Tolppanen holds a PhD in science education. His doctoral thesis dealt with the topic of
supporting sustainable education through non-formal education. In addition to doing research, he
has been actively involved in training pre-service chemistry teachers at the University of Helsinki.

E-mail: sakari.tolppanen@helsinki.fi

Maiju Tuomisto

Maiju Tuomisto has been working as a chemistry and home economics teacher for 12 years and as
a chemistry textbook writer for 10. She received her Lic.Phil. in 2015. In her current position at the
University of Helsinki in the Chemistry Teacher Education Unit, Tuomisto is working as a doctoral
student and a teaching coordinator. She specializes in educational games and molecular
gastronomy in chemistry education.

E-mail: maiju.tuomisto@helsinki.fi

Jaakko Turkka
Jaakko Turkka graduated as an MPhil qualified as a chemistry and mathematics teacher. He now works as a PhD student doing research and teaching courses within the Chemistry Teacher Education Unit at the University of Helsinki.

E-mail: jaakko.turkka@helsinki.fi

**Jenni Vartiainen**

Jenni Vartiainen, MSc, is a doctoral candidate in the Department of Chemistry at the University of Helsinki and a project manager at the LUMA centre Finland. Ms. Vartiainen’s main research interest is pre-school level science education and small children’s playful learning environments for learning science process skills. She is also interested in promoting children’s and young people’s interest and enthusiasm in natural sciences, ICT, mathematics and technology as well as supporting teachers’ important work at all levels of education.

E-mail: jenni.vartiainen@helsinki.fi

**Arto Vihavainen**

Arto Vihavainen, MSc, is a university instructor and researcher in the Department of Computer Science at the University of Helsinki, where he is one of the key persons responsible for the development of programming education and research. Vihavainen was instrumental in the design and implementation of the first Finnish MOOC. His research interests include a broad range of topics ranging from agile programming methodologies to education research and learning analytics.

E-mail: aviHAVAI@CS.Helsinki.FI

**Xiaomeng WU**

Xiaomeng WU, PhD, is an associate professor of educational technology and teacher education at Peking University. She has also been a visiting scholar at Berlin Freie University. Her research interest include teaching and learning in schools with ICT, online learning, information literacy education for youth, PBL, teacher training and professional development. She has published many research papers and a monograph entitled *Understanding the Teachers in Educational Change*. In addition to her academic research, she has collaborated with Intel, the Chinese Association of Science and Technology (CAST) and various ICT companies as a consultant, trainer and project collaborator.

E-mail: XMwu@GSE.Pku.EDU.CN

**Lu ZHANG**
Lu is a master’s candidate from the Department of Educational Technology, Peking University. She received her bachelor’s degree from the Department of English Literature, Peking University. In 2015, Lu studied in the Faculty of Behavioral Sciences at the University of Helsinki as an exchange student. Her study focuses on math games and game-based learning.

E-mail: zhanglu1176@163.com

Linping ZHAO

Dr. Zhao Linping is the director of preschool teaching and research department in the Beijing Institute of Education. She is the chief trainer of the Chinese National Training Program in early childhood education. Dr Zhao’s research interests include arts curriculum design for early childhood education, child development assessment and evaluation, and policy study.

E-mail: 1045095590@qq.com

Yuxi ZHAO

Yuxi Zhao graduated from Shenyang University of Technology in 2008 with a bachelor’s degree in computing and received his master’s degree in software engineering from the Peking University of Aeronautics and Astronautics. His research focus is the application of big-data technology on early childhood education.

E-mail: zhaoyuxi@3ikids.com

Xiaoning ZONG

Xiaoning ZONG graduated from the Art College of Peking University in 2014, and currently studies at the Graduate School of Education (GSE), Peking University. Zong’s main research direction is instructional design in the online education environment, including MOOCs. Zong has engaged in two MOOC projects, namely “How to make a MOOC” and How teachers can conduct teaching research”. Zong’s current research interest relates to the design ideas and strategy of MOOC promos.

E-mail: 779155171@qq.com