Finnish Innovations and Technologies in Schools

A Guide towards New Ecosystems of Learning

Hannele Niemi, Jari Multisilta, Lasse Lipponen and Marianna Vivitsou (Eds.)

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In most projects, teachers, students, parents, researchers, policy makers, and companies work together for joint aims. The authors would like to express their deepest thanks to all the partners. Cooperation has opened many new ideas and ways to promote high-quality learning.

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PROLOGUE

Towards a Global Ecosystem

This book combines several perspectives on how the Finnish educational system has made steps to provide students with the skills and competences needed for their lives in today's society and in the future. The book uses ecosystem as a metaphor for an educational system. The ecosystem in biology means biodiversity and high interconnectedness between species; ecosystems work in systemic wholeness. Faced with environmental changes, they can adapt, adjusting and transforming in an environment, but they are also vulnerable to losing important elements in systems' functionality.

Part I describes how the Finnish educational system has aimed at sustainable education by ensuring that different parts of the system are interconnected while at the same time keeping it open to transformations. Chapter 1 gives an overview on how a strong commitment to the value of equal opportunity and a vision of lifelong learning throughout the system have been consistent objectives for 40 years. High-quality teachers with strong academic, research-based teacher education, local responsibility for educational quality, and a strong support system for different learners have produced consistently high student learning outcomes in all Programme for International Student Assessment (PISA) measurements. Adult competences are in the top. The Finnish educational system has been adaptive, taking into account the changes that have happened in society but has also been a transformative agent, intentionally promoting improvements and changes.

Chapter 2 describes how a national curriculum system in Finland has been an important tool when preparing new generations to live in changing contexts. Approximately every 10 years, an extensive curriculum revision process is undertaken. The process of the new national core curriculum for the basic education started in 2012 and will be completed by the end of 2014. The preparation is very open and collaborative, inviting all possible stakeholders to share contributions. After the core curriculum is completed, schools and teachers, students, and parents prepare local curricula based on the national core curriculum and these local curricula will be in use in 2016. The new national core curriculum crystallizes the vision of education for the future and the expertise needed in Finnish society. The ongoing curriculum process is a key factor in developing educational sector in Finland for 21st-century skills and competences. The importance of the core curriculum does not only describe what should happen in the Finnish classrooms, schools, and municipalities in the coming years, but will voice the ideals, values, and endeavors for the nation's next decade. The Finnish

educational ecosystem is also vulnerable and needs ongoing evaluation to ensure that it is a well-functioning system. All parts in the ecosystem should work in mutual interaction and support, which requires cooperation between political decision-makers, school administrations, teachers, and other partners in the educational system. This approach will maintain trust in education without heavy-handed control or regulations. This kind of system has developed in Finland over the last 40 years and it will never be fully completed. When there are changes in society such as immigration, an aging population, or new kinds of jobs, the system must have the capacity to change and accommodate comprehensive reforms in the ecosystem.

The expansive use of digital technologies in education has generated the need for fresh perspectives and approaches in the development of pedagogical methods and models. In the Finnish educational context, there is a strong emphasis on how to integrate technology in innovative ways that enable crossing boundaries in formal and informal learning settings. Part II of the book illustrates some implementations of technological innovation using mobile technology and digital storytelling at schools. Chapter 3 introduces the model of Global Sharing Pedagogy, which can be used when designing how to teach and learn 21st-century skills. The model has four elements: (1) active, student-driven knowledge creation; (2) collaboration; (3) networking; and (4) digital media competencies and literacies. The chapter describes how the model has been applied to a digital storytelling project with the aim of strengthening learners' agency of engagement through new pedagogical applications of technology. Chapter 4 gives examples of how digital storytelling has been used with different topics in Finnish schools and in international collaboration. Chapter 5 focuses on Science, Technology Engineering and Mathematics (STEM) learning. It gives empirical data on how recording videos and generating digital stories promote science learning from the perspective of students. The results indicate that recording and generating digital stories provide a high added value to the learning process.

Part III is devoted to fun and games. Ensuring that all learners involved in school are actual learning is a universally immense challenge, and motivational factors are crucial. Chapter 6 introduces innovative learning solutions and practices for physical activities in schools. Exergames are games with physical activities that engage students in moving. The authors propose an approach to learning by creating educational exergames that rely on user-generated content and oblige children to move during school hours. They report encouraging results of a pilot study in which students created educational exergames for their peers. Chapter 7 describes how students can learn mathematics by teaching the subject to their virtual pets in a game environment. The pedagogical idea of SmartKid Maths is to put a learner (or player) into the role of a teacher. The player gets her own virtual pet that she teaches and the pets compete against other pets by solving mathematical problems. The pet has formed an "intelligence" based on what her owner taught it. The pet can succeed only if the teaching has been effective. Empirical results supply evidence that students learn mathematics when gaming. In addition, user-generated behaviors can provide teachers and parents very detailed

information about an individual child's learning process. This learning analytics data can be very useful for providing support to the individual learner in her learning path. It is also valuable at the educational system level; regional or even national level data about bottlenecks in the learning process are an excellent tool in curriculum construction.

Part IV describes how teaching and learning can be developed cooperatively with teachers, students, parents, researchers, and companies. Networking and joint aims form an ecosystem that can support the creation of new ideas and practices. The contexts and experiences discussed in the book are based on systematic investigations within a framework that allows for an organic relation between research and pedagogy in schools. Chapter 8 provides an example of how teachers can themselves become researchers and work with scholars at universities and with a large range of different partners. The chapter describes three Design-Based Research (DBR) projects in which teachers and researchers have engaged in the design of educational innovations that can be easily adopted by other teachers. The outcomes of these three projects are innovations that focus on the use of Information and Communications Technology (ICT) in teaching, learning, and collaboration. The project has developed the Innovative School (ISC) model that emphasizes students' learning, learning environments, teachers' professionalism, leadership, and partnerships.

Networking is the main focus of Chapter 9, which describes how to provide inspiration, joy, and support in STEM learning for children, youth, and teachers through the Innovative LUMA Collaboration. LUMA is an umbrella organization involving the collaboration of schools, universities, and businesses with the aim of promoting and supporting lifelong learning, studying, and teaching of STEM subjects at all levels of education. Chapter 10 is linked with LUMA activities but describes one of its special projects, the International Millennium Youth Camp, which has been held in Finland since 2010. The aim of this unique camp is to increase youth interest in the natural sciences, mathematics, and technology. It is an active learning ecosystem for future scientists.

The educational ecosystem needs renewable sources of energy. Teaching and learning demand new practices, especially in using technology in education. The Finnish solution has been large multidisciplinary research and development networks in which researchers, practitioners, and both the private and public sectors have worked together. Chapter 11 summarizes processes and results in one large national research program that contributed to research-based and practical guidelines for ICT use at schools in Finland. Finally, Chapter 12 introduces how schools and companies are working together in a co-configurative project on Agile Product Development. The cooperation requires that partners understand their own roles and learn a joint language for promoting new tools and practices for learning.

The Finnish educational ecosystem is a living system and only as a living system can it promote high-quality learning. The Finnish system is very much based on mutual trust; all partners need to understand the value of education and the fundamental values of the system, equity and lifelong learning. Sustainable education requires joint and often very long-term aims and networking among the

different partners. It also demands political decisions that ensure high-quality education to all learners. Sustainable education is always shifting between adaptation and transformation, and it needs innovations and new prospects. This volume aims to bring together the knowledge gained through multi-layered experiences and present cases of collaborative and technology-enabled learning environments for the 21st century.

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PART I

FRAMES FOR THE FUTURE AND 21ST-CENTURY SKILLS

HANNELE NIEMI

1. THE FINNISH EDUCATIONAL ECOSYSTEM

Working for Equity and High Learning Outcomes

ABSTRACT

This chapter provides an overview of how the Finnish educational ecosystem has strived for equity and high quality. Several fundamental elements in the Finnish system combine for the purpose of making education available for all. These features are flexibility of the educational structure, lifelong learning throughout the system, enhancement-led and encouraging evaluation practices, superior education and professional roles for teachers, and local responsibilities in developing curricula. Finland has been among the top countries in PISA achievement measurements for the last decade. Society and learning environments are changing and the Finnish educational system is seeking new modes of organizing teaching and learning. One area in which the idea of an ecosystem is growing more important is the use of educational technology, typically called information and communication technologies (ICT), in teaching and learning. After describing the general educational ecosystem, the chapter will also introduce how to strengthen students' learning with technology. It provides an example of how technology changes an entire school culture and makes it more like an ecosystem.

Keywords: *ecosystem, education, technology, learning, ICT*

INTRODUCTION

According to the Collins English Dictionary, an ecosystem is "a system involving the interactions between a community of living organisms in a particular area and its nonliving environment". The concept has its roots in biology, where typical ecosystems are a forest, a pond, and grassland. The most important feature of the ecosystem is interconnectedness. Species work in close interaction to provide the necessary ingredients for their survival. Warmth, water, and energy sources all make their own contributions to the ecosystem. The concept of ecosystem has recently expanded to more general meanings, especially social structures. The systems of human actors or companies and organizations can also be described as ecosystems. In the Collins English Dictionary, an ecosystem can also be "any system of interconnecting and interacting parts".

Education is a series of intentional processes that promote and enhance learning at different age levels and throughout life. The concept of lifelong learning used to

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connote adult learning, but today it refers increasingly to the concept of learning at different ages, as a life-course process and used covering 'life-wide learning' (e.g., Barnett, 2013; Jackson, 2011). Niemi (2003, 2009) has reported that life-wide learning has two complementary components, both vertical and horizontal dimensions of learning that help us to see the holistic nature of learning. The vertical learning dimension means life-course learning, at all ages**.** The horizontal dimension refers to learning in different situations and life areas that are cross-boundary**,** such as working life and labor organizations, leisure time, and virtual learning environments. Learning is a part of our lives everywhere, and crosses the boundaries of traditional learning institutions. New communication and information technologies (ICT) have radically changed our learning: the where, when, and how of today's learning is seamless and in many ways boundless, providing people nearly endless opportunities for learning. Learning spaces are everywhere, if we know how to use them.

In this book, the ecosystem in teaching and learning including learning environments, is treated as a system comprised of several subsystems. We can speak about a macro-level ecosystem when different levels or sectors of the educational system are working together. These subsystems could be educational sectors like general and vocational education and stages like basic, secondary, or higher education The macro-level system includes several subsystems, some of which operate as midlevel parts in the system. They consist of social practices and the structures of how institutions and organizations work together. In an ideal situation, from a life-wide perspective they should have the common aim of . supporting learners in the different phases in their lives.

Learning can be also described at the micro-level of the ecosystem, where individual persons are learning and their knowledge production is influenced by individual characteristics such as earlier knowledge, skills, motivation and attitudes, and the learner's cultural background (Säljö, 2010, 2012; Vygotsky, 1978). The competences of self-regulative learning and collaborative learning are clearly among the most important skills for the 21st century (European Union, 2006; OECD, 2013a, 2013b). How well students can access and progress in the educational system depends not only on their individual qualities, but also on how learning environments support learning and how well other subsystems like health and social services mesh with educational services (OECD, 2010a). Learning is linked with processes and contexts that belong to many subsystems both within and outside the educational ecosystem.

The system functions well when its different parts are working productively and effectively together, but as in a natural environment, ecosystems do not always work well. There can be serious dysfunctions and imbalances, as we have learned from the many reports of climate change. The same is true for educational eco systems, as different sectors, partners, and actors are not interconnected and there can be many tensions and cultural practices that separate different parts of the system from one another. An ideal educational system would provide learning paths that create access for different learners throughout their lives and a system that promoted life-long and life-wide learning. In that perfect setting, teachers

would work in collaboration, multi-professional groups would solve problems cooperatively, and teachers and students would learn from each other. In a well-functioning educational ecosystem technology provides tools and spaces for knowledge creation, and different partners share their ideas and contributions to joint tasks. Many sociologists, notably Habermas (1987), describe how systems in a modern society can be separated from each other and can become colonialized through hierarchy and lack of communication. As in society, so in education; the subsystems can become separated into segmented territories with their own aims, social practices, and power structures; eventually, collaboration between the parts vanishes. Critics of postmodern times (Beck, 1992; Giddens, 1991) describe recent times in terms of dispersion, where earlier structures are broken and many hierarchies have collapsed, leaving scattered and fragmented environments that place an enormous responsibility on individuals to create their own plans and profiles in an ever-changing atmosphere. Education and learning environments face this same concern; even though there appear to be many opportunities for learning, we have to see that without system-level supportive structures, many learners are powerless.

In this chapter we reflect on the entire Finnish educational system from the viewpoint of an ecosystem. The major questions are: How do different parts relate to each other and how does the complete system function in providing genuine learning opportunities to different learners? What are the functions and dysfunctions and how have previous dysfunctions been solved?

THE FINNISH EDUCATIONAL ECOSYSTEM

High Learning Outcomes

The Finnish educational system came to international awareness when the first PISA results were published in 2000. Learning outcomes of 15-year-old students in reading literacy, mathematical literacy, and science literacy were at the top level (Table 1), and the differences between schools were the smallest in the world.

In every PISA measurement, the Finnish results have remained on the highest tier (e.g., OECD, 2003, 2006b, 2009, 2010b). Even in 2012, Finland was among the best countries, although its scores were slightly lower (OECD, 2013a). The number of participating countries or economies has increased vastly over the years. We can see from OECD statistics (2014, pp. 4-5) that Asian countries have taken a leading role in educational achievements; Shanghai-China, Singapore, Hong Kong-China, Chinese Taipei, Korea, Macao-China, and Japan, had the highest scores in mathematic literacy in 2012. Among, European countries Finland in still among the best performers.

Table 1. Finland's results in different PISA measurements.

Finland's Results	*2000 28/32*[1]	*2003 30/41*	*2006 30/56*	*2009 33/65*	*2012 32/65*
Reading Literacy	1st [2] (1st)	1st (1st)	2nd (2nd)	2nd (3rd)	3rd (6th)
Mathematical Literacy	4th (4th)	1st (2nd)	1st (2nd)	2nd (6th)	6th (12th)
Science Literacy	3rd (3rd)	1st (1st)	1st (1st)	1st (2nd)	2nd (5th)

[1] OECD countries/All participant countries
[2] A ranking order among OECD countries (among all countries participated in PISA measurements)

In the 2012 PISA measurements, 44 countries or economies also participated in the measurement of problem-solving skills. In this more general achievement area, Asian countries were again the highest and Finland was the only European country that break into the top ten (Table 2).

Table 2. Problem-solving in PISA measurement in 2012 (OECD, 2014).

OECD average	**500**
Singapore	562
Korea	561
Japan	552
Macao-China	540
Hong Kong-China	540
Shanghai-China	536
Chinese Taipei	534
Canada	526
Australia	523
Finland	523

The Finnish educational system has also succeeded among older ager groups. The mean Finnish proficiency scores of people aged 16 to 65 in both literacy and numeracy are significantly above the average of OECD countries participating in the Survey of Adult Skills (PIAAC). Finnish adults are in second place in the Survey of Adult Skills with Japan.

The OECD report summarizes (2013b, p. 8):

> Roughly every fifth Finn and Japanese reads at high levels (Level 4 or 5 on the Survey of Adult Skills). This means, for example, that they can perform multiple-step operations to integrate, interpret, or synthesize information from complex or lengthy texts that involve conditional and/or competing

> information; and they can make complex inferences and appropriately apply background knowledge as well as interpret or evaluate subtle truth claims or arguments.
>
> They are also good at numbers: they can analyze and engage in complex reasoning about quantities and data, statistics and chance, spatial relationships, change, proportions and formulae; perform tasks involving multiple steps and select appropriate problem-solving strategies and processes; and understand arguments and communicate well-reasoned explanations for answers or choices.

The reasons for this 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 investments by the Finnish government, a very small amount of homework and number of lesson hours in schools, and an extremely light educational evaluation system that does not use inspections, the Finnish education system can achieve such consistently high results in quality and equality in international comparisons (Reinikainen, 2012).

In the Finnish educational system, the many subsystems are designed to be connected, and the most important factors are outlined below.

Equity as a Basic Value

Equity has been a leading principle of Finnish education policy, covering the entire educational system from early education to higher education and beyond into adult education (Kumpulainen & Lankinen, 2012; OECD, 2013b). This objective can be seen in every governmental program over the past twenty years even though there have been different political parties in the government (e.g., Finland, Government, 2011; MEC, 2012). Equity is the value basis of the national curricula at all levels of the educational system (FNBE). The principle entails that everyone needs sufficient learning skills and opportunities to educate and develop themselves in different learning environments throughout their lifespan (MEC, 2014). The Finnish official policy has been summarized as follows:

> The main objective of the Finnish education policy is to offer all citizens equal opportunities to receive education, regardless of age, domicile, financial situation, sex or mother tongue. Education is considered to be one of the fundamental rights of all citizens. (FNBE, 2014)

Since the late 1960s, Finland has been developing its education system towards a comprehensive model that ensures equal opportunities for all learners. Education is defined as a citizen's basic service in the Finnish Constitution. In Finland, basic education is equitably available to all children irrespective of their social status, sex, domicile, economic status, mother tongue, and cultural or ethnic background. Comprehensive school encompasses year-classes 1 to 9 and is intended for the entire age group of 7- to 16-year-olds. Compulsory schooling starts in the year when the child turns seven years and ends either when basic education has been

completed or when 10 years have passed from the start of compulsory schooling. The system does not employ streaming or tracking and students are in mixed ability groups and provided with versatile supports for achieving the aims of the basic education.

It requires political will to make equal opportunities a reality for different learners; equity can be achieved only if there are support systems for those learners that are in danger of dropping out. According to education researchers (Kumpulainen & Lankinen, 2012; Laukkanen, 2008; Niemi, 2012; Schleicher, 2007; Simola, 2005), Finnish educational policy has deliberately aimed at equity in education, which is the main reason for its good learning outcomes. In Finland, the educational system is based on a strong inclusion principle, as The Finnish National Board of Education expresses:

> The fundamental principle of Finnish education is to provide equal opportunities for learning and growth to every pupil or student. Support for learners plays a key role. This entails removing barriers to learning, physical, attitudinal or pedagogical, early intervention and support and welfare. (FNBE, 2014)

Flexible Education System for Lifelong Learning (LLL)

According to an analysis of governmental education policy documents, LLL is considered holistically in Finland (Niemi & Isopahkala-Bouret, 2012). The lifelong learning viewpoint is systematically integrated into education policy and other policy sectors relating to education and training. According to this holistic approach, LLL is a program that starts from a person's early years and continues throughout the full life course. Life-wide learning is integrated at all levels of the educational system, in both the academic and vocational educational tracks. A holistic approach considers both formal and informal learning (Figure 1).

One of the central aims of the Finnish education system is to have an educational infrastructure that is devoid of so-called 'dead-ends'. Compulsory education comprises the nine years of comprehensive school, but the national aim is to keep all children in connection with the educational system for at least 12 years and to provide several routes for lifelong learning after that. The aim of the system is to enable an individual's education to continue. Nearly 100% (a dropout rate of less than 1%) of each age cohort completes the nine years of comprehensive schooling (Statistic Finland, 2013).

The system provides several routes for learning after the secondary level. People can continue their education immediately through higher education institutions. Alternatively, flexible choices exist for adult learners to return to formal education after they have gained some work experience. A central aim is strengthening the flexibility of the educational system in such a way that all citizens can find individual learning paths throughout their lives.

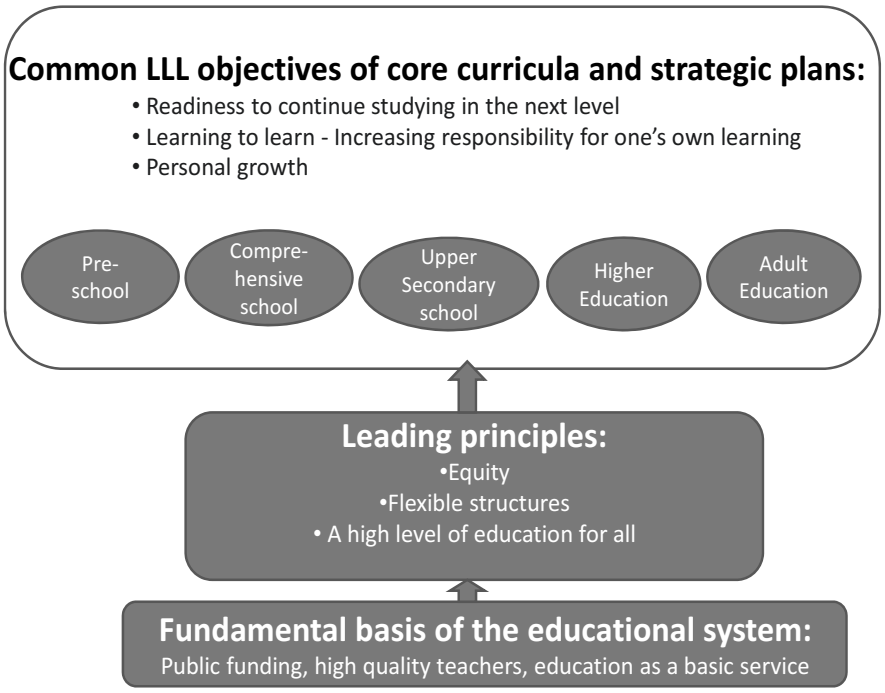

Figure 1. The leading principles and major LLL objectives in the Finnish educational policy. Reproduced from Niemi and Isopahkala-Bouret (2012).

People can continue or supplement their education at any level of the system. In principle, it is possible for those who have chosen a vocational path earlier to move to an academic path or vice versa. The flexibility of the system provides conditions for adults who have left education earlier in life to continue their educational path (Niemi & Isopahkala-Bouret, 2012):

> Lifelong learning policy entails that transitions from one level to another and from education to the labor market are as flexible as possible. (MEC, 2014)

The educational structure is designed for lifelong learning. The entire age cohort completes basic education at 15 years of age and approximately 95% of students continue directly to the upper secondary level. The group that does not continue is in danger of being excluded from the educational system and the labor market. The system offers a so-called '10th grade' to try to solve this problem by offering the opportunity to learn the necessary skills for the secondary level and to provide tutoring and study guidance. Many kinds of workshops and activities have also been organized at the local level. Extending the compulsory education to 10 years has also been under discussion at the national level and a tentative decision on the extension was made in April 2014 (Finland, Government, 2014). The focus is on

how different students can be guided and supported in time and then helped them to find the motivation to learn.

There is also a need to strengthen immigrants' access to educational services. The Finnish Educational Evaluation Council has an evaluation project (2013-2014) on how educational services are arranged and how well they function. The tentative results of the evaluation show that there are gaps remaining in fully supporting different minority groups in their educational paths (Finnish Educational Evaluation Council, 2014).

These examples illustrate that even though there are now and long have been serious efforts to make the ecosystem well-functioning, there are also weak or even broken links between different elements of the educational ecosystem. Many Finnish evaluations of the education system have raised the issue of how to encourage the different levels of education to work so that all students can be kept on a lifelong learning path. The ecosystem in education is a complex, living organism that needs to be evaluated and developed systematically.

Local Freedom and Responsibility

The Finnish educational system is decentralized; local education authorities are responsible for the provision and quality of educational service. Governance is very light; instead of a detailed, imposed national curriculum, there is a national curriculum system that provides a value basis for the entire educational system and defines objectives for each educational level. In these core curricula objectives are expressed at a general level, with the purpose of providing the basis for local educational providers to do the detailed work. Halinen and Järvinen (2008) and Halinen and Holoppa (2013) point out that local education authorities and schools are granted wide autonomy in organizing education and implementing the core curriculum. This strategy provides the freedom to make individual choices based on the local needs of different schools, with the core curriculum serving as a common national foundation. Local decision-making is also seen as a means of increasing local officials' and teachers' commitment to the implementation of the curriculum.

Teachers have extensive freedom regarding how they teach and what kinds of assessment methods they use. They can also select textbooks and other learning materials, and can even choose whether to use textbooks at all.

Support Systems

An inclusion policy in special needs education is absolutely critical for promoting all students' equal rights to learn. The basic principle is that all students with learning difficulties must be given help and support to overcome those issues. They can have extra tuition hours or special needs instruction integrated into their own classes, and temporary or longer-term help in special classes or groups. In each school there is a multi-professional student care group which consists of a principal, teachers and special needs teachers, social workers, and a nurse.

According to a new decree passed in 2011 every teacher is responsible for identifying students' learning difficulties at the earliest stage possible (FNBE, 2014). Special needs support is divided into three levels based on students' needs:

> Support for growth, learning and school attendance is shaped into three categories: general support, intensified support and special support. Everyone is entitled to general support. It is a natural part of everyday teaching and the learning process. Intensified and special supports are based on careful assessment and long-span planning in multi-professional teams and on individual learning plans for pupils. (FNBE, 2014)

Career guidance and counseling is provided to all pupils at comprehensive schools, as well as at the upper secondary and higher education levels. The chief goal of student counseling is to support students' growth and development in such a way that they make progress in their study skills and social maturation, and to have essential knowledge and skills for planning their lives (FNBE, 2011). Furthermore, the new national objective is to organize counseling support for those who are outside the educational system.

Enhancement-led and Formative Evaluation Policy for Promoting Quality

The quest for good learning outcomes is on the educational agenda of many countries. Globally, much controversy exists over the best way to use assessment as a tool to achieve high learning outcomes. Some countries have chosen standardized testing, which stresses competition between schools and focuses on measurable performances. The Finnish alternative has been enhancement-led evaluation at all levels of education.

The purpose of assessments and evaluations is to improve education, not to put different subsystems or units in competition against one another. This principle is applied at both the macro and micro levels of the educational system. There is no inspection system to control the educational arrangements at particular schools or institutions (FNBE, 2014; Sahlberg, 2011); instead, there is a national evaluation system. Evaluations are implemented to find evidence to support the continuous development of education and learning (Kumpulainen & Lankinen, 2012).

Since the mid-1990s, the Finnish National Board of Education has conducted national assessments of learning outcomes, mostly in the 9th grade of basic education (FNBE, 2014). Regular assessments have been carried out in mathematics, the students' mother tongue (either Finnish or Swedish), literature, and occasionally in other subjects as well. National assessments produce information about the quality and results of education and training in relation to the objectives stated in the national core curricula. These assessments are sample-based and thus do not cover an entire cohort. The results are used to develop and improve education. All schools that are being sampled in a given assessment receive individual feedback reports, which are delivered to schools as soon as possible after assessment data collection, as recent results are more valuable to schools than results that are months old. Feedback has typically been received as

soon as two months after the data was collected (Laukkanen, 2007). At the local level, authorities are encouraged to produce their own internal and external evaluations to develop education. Policymakers are informed about the status of education by assessments and special up-to-date reports organized by the Ministry of Education and Culture.

The aim of the national evaluation system is to support the local education administration and the development of schools as goal-oriented and open units, and to produce and provide up-to-date and reliable information on the context, functioning, results, and effects of the education system as a whole (Niemi & Lavonen, 2012). The Ministry of Education is responsible for general education policy and financing educational evaluations. Until May 2014, national evaluations were organized by The Finnish Educational Evaluation Council, The Finnish Higher Education Evaluation Council, and the Evaluation Unit of the Finnish National Board of Education. These three agencies are now being merged into one unit that will be a national evaluation center with responsibility for evaluations that remain committed to the principle of enhancement-led evaluation.

At a student level, enhancement evaluation aims at supporting students' learning by diagnostic and formative assessments. The Finnish National Board of Education stipulates that (http://www.oph.fi/english/education):

- Student assessment and evaluation of education and learning outcomes are encouraging and supportive by nature;
- The aim is to produce information that supports both schools and students to develop;
- National testing, school ranking lists, and inspection systems do not exist.

High-Quality Teachers and Teacher Education

High-quality teachers are unquestionably one of the major reasons for students' high learning outcomes (e.g., Niemi, 2012; Schleicher, 2007; Toom & Husu, 2012). Teachers in Finland are members of a respected academic and ethical profession (Niemi, 2014). Finnish teacher education (TE) for both primary and secondary school teachers is a 5-year MA program in a university setting. The MA programmers are very attractive to young people; class teacher programs for grade levels 1 to 6 are very popular among talented applicants and less than 10% of applicants are accepted (FNBE, 2014). Secondary school teachers also face very strict entrance requirements: academic ability, especially thinking skills; motivation for the career choice; and social skills are all tested in the entrance examinations. Successful applicants are thus well-trained for and deeply committed to the teaching profession.

Finnish teacher education has committed itself to a strong research-based approach. The critical scientific literacy of teachers and their ability to use research methods are absolute necessities for success. Research studies provide education students with an opportunity to complete an authentic project in which they must formulate a problem in an educational field, be able to search independently for information and data related to that problem, elaborate on what they have found in

the context of recent research in the area, and synthesize the results in the form of a written thesis. They learn to study actively and internalize the researcher's mindset as they carry out the work as reflective practitioners.

Studies have analyzed teachers' and student teachers' concepts of and feedback on the researcher studies that form a part of teacher education. Jyrhämä & Maaranen (2012, p. 110) conclude:

> Based on our results, it seems that teachers' inquiry-orientation is first and foremost an attitude towards one's work. The focus is on the development of one's self, as well as the development of the school community, alternative ways of working, reflection, dialogic, feedback etc.

Niemi (2011) has found very the much same kind of experiences among student teachers. The most important abilities they had learned through research studies were (Niemi, 2011) critical thinking, independent thinking, inquiring and scientific literacy, and questioning phenomena and received knowledge. In the Finnish educational system, teachers must take an active role in raising serious questions about what they teach, how they teach it, and the larger goals towards which they are striving. Teachers need to view themselves as public intellectuals who combine theory and implementation, thinking and practice, all in the struggle for a culture of democratic values and justice. Teachers have both a right and an obligation to articulate educational needs and challenges in the society that they serve. They also have to be active in public debates and decisions affecting the development of schools and education. As professionals, teachers cannot only be implementers of decisions, but also partners in their development. Teachers are expected to be able to take active roles in evaluating and improving schools and their learning environments. They are also expected to refresh their professional skills, to cooperate with parents and other stakeholders, and to be active citizens (Niemi, 2011; Toom & Husu, 2012).

NEW LEARNING SPACES CREATE NEW DEMANDS FOR ECOSYSTEMS

When speaking about success in education we can see that in the Finnish case the major factors are the strong value basis, system-level structures, and human-related issues like teachers' training and capacity. We may ask if technology plays any role in learning outcomes. This question must be seen in a larger perspective than only short-term learning outcomes. Achieving the skills demanded by the 21st century requires that ICT be integrated as a tool for teaching and learning, In the 1990s, Finland was one of the world's leading information societies, and the government supported the educational use of ICT. With the new millennium, the first wave of ICT projects came to an end, and a Society for Information Technology and Teacher Education (SITE) 2006 study found that financial investments for the educational use of ICT had not been in line with high expectations. It also revealed that mere investments in technical resources or infrastructure do not create new school cultures and learning experiences that actually promote 21st-century skills and learning (see also Kozma & Voogt, 2003;

Law, Kankaanranta, & Chow, 2005; Law, Pelgrum, & Plomp, 2008). SITE 2006 and the OECD (2009) reported that students used new communication technology, particularly social media, outside of schools but that it was not used in their everyday school lives. This gap was certainly true in Finland, where new ICT tools were not used as effectively and pedagogically as they could have been in Finnish schools.

International and national reviews gave a strategic impulse to launch new ICT programs in Finland. The national strategy of ICT in School's Every Day Life was published in 2010 (FNBE, 2011; MTC, 2011), and several research and development projects began in order to find more effective ways to implement ICT in teaching and learning. They revealed that in Finland there were certainly schools with excellent technological infrastructure and enthusiastic teachers who could use new pedagogical models and practices but there were also schools that lagged far behind in their ICT use (see also Vahtivuori-Hänninen & Kynäslahti, 2012). The main message from these studies was that ICT cannot be simply an additional element in teaching and learning; rather it must be fully integrated with the everyday rhythm of schools.

In a Finnish study (Niemi, Kynäslahti, & Vahtivuori-Hänninen, 2013), results showed that when promoting new technology and practices in schools, many components overlap and support each other. The following six main characteristics of successful integration were identified: 1) ICT is included in strategic planning, as part of school culture; 2) teaching and learning methods facilitate participation and leading to empowerment; 3) flexible curricula; 4) high investments in communication; 5) optimal leadership and management; and 6) teaching staff's strong capacity and commitment. The research indicates that an open school culture allows staff to take risks when applying new technology, creates learning environments, and empowers learners (Niemi et al., 2013).

Typical features of teaching and learning in the schools referred to above were students' active role in knowledge creation, active and participatory learning, collaboration, and an emphasis on formative and self-evaluations rather than testing or external assessments. In these schools principals and teachers had together created a joint vision of how to use ICT as a future learning tool, and the schools had allocated resources to develop a culture of sharing (Niemi et al., 2013).

Curricula in the successful schools were flexible and renewal-oriented, and changes were based on the students' needs. The technology was not an aim in itself but rather formed a natural part of life and learning in the classrooms. The needs and suitable teaching practices of each grade had been taken into account, and the nature of the curriculum was dynamic.

According to the results, integration of ICT in everyday life requires both pedagogical and organizational qualities. Educational technology cannot be a separate subsystem on its own. Many of the results support the ideas that are central in discussions about the role of schools in developing 21st-century skills, particularly in promoting collaboration and a shared learning culture (Kozma & Voogt, 2003; Law, Kankaanranta, & Chow, 2005, Law, Pelgrum, & Plomp, 2008;

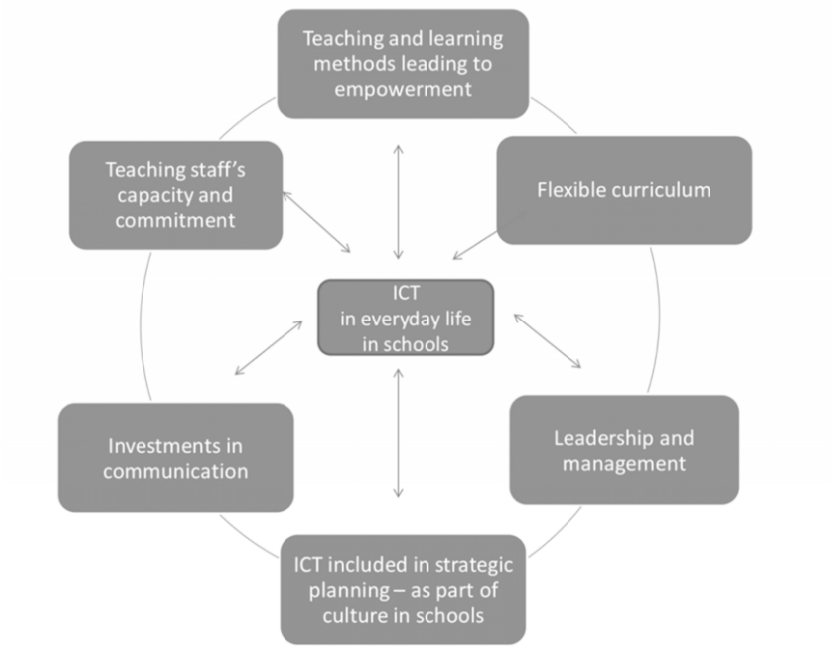

Figure 2. Key factors for successful educational use of technology in the everyday lives of schools. Reproduced from Niemi, Kynäslähti, and Vahtivuori-Hänninen (2013).

Smeds, Krokfors, Ruokamo, & Staffans, 2010). Studies have suggested that ICT changed the whole school community towards a more communicative ecology of daily practices (Säljö, 2010; Niemi et al., 2013).

THE FINNISH EDUCATIONAL ECOSYSTEM IS A LIVING SYSTEM

The Finnish educational system is based on equity, lifelong learning opportunities, flexible educational structures, local responsibilities at the school level, the principle of enhancement-led evaluation, and high-quality teachers and teacher education. These features combine to create an excellent foundation for high-quality learning that has been confirmed by many international measurements (OECD, 2003, 2006b, 2009, 2010b). All the elements are necessary to such a well-functioning arrangement; they must form an ecosystem in which all the different components work in mutual interaction and support of each other. This structure allows all the elements to maintain trust in education, without heavy-handed controls or regulations. This kind of system has evolved in Finland over the last 40 years and will never be completed. When there are changes in society such

as immigration, aging population, new kinds of work, the structure must have the capacity to change. It requires comprehensive reforms in the ecosystem.

We can recognize challenging, even worrying, issues in the Finnish system. One of the most important features undergoing reform is how to see that all learners continue after the comprehensive level and to keep all learners engaged until the end of the secondary level. Even though we are dealing with a small percentage (under 10%), there is a risk that these students will face repeated and many-faceted barriers to employment and other central features of life. There is a second issue with the transition from the secondary to the tertiary level. Students often have to take entrance examinations for higher education many times and thus lose several years before they can begin their degree programs. They have easy access to Open University courses, but for a degree they must attend a university that has the legal right to award a degree. This issue is being addressed under a reform process in which entrance examinations will be revised.

The integration of technology with pedagogy has entered into a new phase. The national Agency of Technology and Innovation (Tekes) has established a national research and development program called "Learning Solutions" (2011-2015) that supports a learning ecosystem in the digitalized age (Tekes, 2013). This program aims to connect technology companies with teachers and other pedagogical experts in order to promote new solutions in learning spaces that are in many ways boundless. New learning spaces are bringing new elements to the system. The aim is to create a value-network between teachers, researchers, and the public and private sectors.

The OECD review team analyzed the Finnish educational system in 2006 and reported as follows (2006a, p. 48; 2006b):

> Finnish strategy has taken a long time to mature and is composed of several interrelated issues …. This is a complex of practices that has emerged over time, but it must be maintained since any weakness in one component will undermine other practices.

All changes at one level or sector have consequences at other levels and sectors. This means that new practices and solutions are needed when some components of the system are changing. The Finnish educational system is undergoing reform: new national core curricula for preschools and basic education is in the renewal process and new local curricula should be ready by 2016. The upper secondary level will be reformed immediately after the basic education process is complete. Adult education and vocational educational programs are also undergoing transformation. Any reform brings new demands on teacher education and teachers have to take new responsibilities. Changes need also enhancement-led evaluation to follow up on how the system is functioning. How to make lifelong learning a reality to different learners is an urgent question in today's continuously changing environment. The Finnish educational ecosystem has thrived as a living system for four decades, and only as a living system it can continue to promote and deliver high-quality learning.

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2. A NEW FINNISH NATIONAL CORE CURRICULUM FOR BASIC EDUCATION (2014) AND TECHNOLOGY AS AN INTEGRATED TOOL FOR LEARNING

ABSTRACT

This chapter describes the Finnish national core curriculum reform process, its values, and how the role of technology in teaching and learning will be emphasized in it. Approximately every decade a novel national core curriculum for basic education is designed under the direction of the Finnish National Board of Education (FNBE). This design process is taking place at the same time as the writing of this book chapter. In comparison to many other countries, Finland has a very open and collaborative system for designing new curricula. A broad range of experts from different fields have been invited to join the process. Local authorities are given substantial flexibility and a great deal of freedom in Finland. The conceptualization and creative design process of the local curricula follows the national process. Moreover, the schools themselves are responsible for creating and carrying out the execution of the new curriculum. The new curriculum will emphasize 21st-century skills and cover a wide range of expertise.

Keywords: *National core curriculum, 21st-century skills, educational use of ICTs*

INTRODUCTION

A new Finnish core curriculum reform process for basic education started in 2012. The Finnish National Board of Education is responsible for the overall process, but the aim is to get many educational and societal partners to contribute to the process. The final documents will be published by the end of 2014, and several draft versions of the curriculum have been publicly available on open websites. Furthermore, dozens of working groups have drafted different parts of the core curriculum for basic education (see Figure 1).

Curriculum development is always associated with internal or external change in society. In the educational ecosystem worldwide, external reform seems to be so frequent that some teachers feel they trapped in a vortex of constant change. In this chapter we discuss the reasons for changing something that is already working reasonably well. Moreover, we will analyze the interactions between national and

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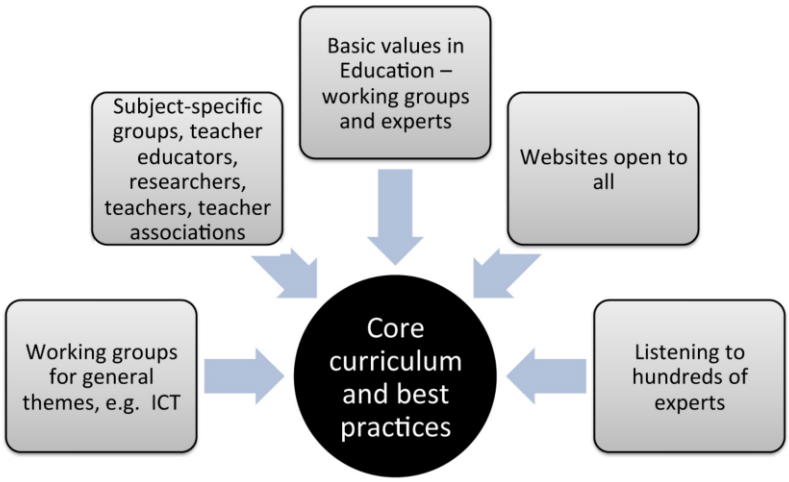

Figure 1. Actors in the Finnish curriculum reform process.

local level curricula and the sharing of review activities between these levels. Finland's curriculum cycle is approximately ten years. The previous core curriculum for basic education on which the municipalities and schools based their planning, implementation, and evaluation of teaching and learning was released in 2004.

The core curriculum is always the product of its time and reflects the current values and philosophies of the political and social situation. Different core curricula contain a variety of assumptions about knowledge and learning, which lead to different pedagogical solutions and learning environments. In curriculum theory literature, there are several viewpoints on the curriculum creation process and whether or not to centralize it or allow for wide local latitude (e.g., Beane, 1997; Pinar, 2004). Schiro (2008) introduces four curriculum ideologies: 1) scholar-academic; 2) social efficiency; 3) learner-centered; and 4) social reconstruction.

In Finland, preparing a national level curriculum has traditionally been based in the context of scholarly academic ideology, although other priorities can be seen. As Schiro (2008) states, a human's essence is summed up by her ability to think, and the curriculum's intention is to excite and stimulate children to explore the world of knowledge and intellect, so that students understand the knowledge that they acquire. The emphasis of the Finnish curriculum has been on the holistic mission of guiding schools' educational thinking. According to Vitikka et al. (2012), the current curriculum system in Finland is has three main driving factors: 1) management by goals supplied in legislation and in the national core curriculum; 2) autonomy of municipal authorities in providing and organizing education, so that local curriculum is the guiding document at the local level; and 3) the utilization of teachers as valued experts who develop the school-based curriculum

as a source of different approaches to schoolwork (FNBE, 2014; Vitikka, Krokfors, & Hurmerinta, 2012).

Values Underlying the Core Curriculum

Curriculum reform is a dynamic process that requires a broad understanding of the current social situation; mere technical modification is not sufficient (Pinar, 2004). New curriculum content development is based on a common understanding of the basic educational mission of Finnish society, and is in that sense grounded in an ongoing evaluation and development process. The values behind the Finnish core curriculum for basic education are human rights, equality, democracy, natural diversity, preservation of environmental viability, endorsement of multiculturalism, individualism (both in terms of responsibility and as part of a community), and respect for rights and freedoms. The roots of the values originate from both Western classical and new humanism, and are incorporated into subject matter and everyday activities in schools (FNBE, 2004, p. 12).

New core curriculum (2014) values will continue to be based on the Finnish tradition, but the curriculum will put a stronger and clearer emphasis on the uniqueness of every child and high-quality education as a basic right. In preparation for the new core curriculum, the FNBE acts transparently and describes a) what conception of humanity, culture, and democracy imbues basic education; b) the cultural variety of both society and the school as a resource to be treasured, with criteria like cultural values a crucial part of the new curriculum design; and c) the necessity of sustainable way of living (FNBE, 2014).

The core curriculum is defined in Finland as a national level document, which is the outcome of a broad and lively national discussion and the concrete teamwork of different stakeholders like national and local education authorities, university professors, representatives from industry groups, the union of municipalities, teachers unions, parents associations, and student unions. During the reform process, teachers and other stakeholders are asked to give feedback and comments repeatedly to the different draft versions of the curriculum. At bottom, creation of the new core curriculum is a dynamic process of interaction of various factors, as is discussed in the following section.

The national core curriculum supports equal and high quality provision of education in all parts of the country. The core curriculum has two parts: 1) the general part of the core curriculum, which describes common goals for education, such as sustainable education or students' healthy development, and 2) the subject-specific parts of the core curriculum, which outline how teaching and the learning process in a given subject will support student development towards the goals. For example, the science section describes how students are supported in learning to formulate questions or draw conclusions based on evidence.

Different pedagogical models, teaching styles, and working methods are not included in the national core curriculum, but there are guidelines on how to construct versatile learning environments and select teaching methods. Still, the final decision is left to the local level authorities and teachers. The Finnish core

curriculum does not use any type of learning outcomes' standards but it describes what are aims of learning in the basic education.

The Finnish core curriculum can be understood as an extensive ecosystem, where different areas are linked to each other, as a teaching-studying-learning environment with myriad dimensions. It includes the very concept of knowledge itself and an understanding of the psychological basis of learning. The core curricula support teachers to understand what is the most essential in each knowledge area and how it is constructed and acquired. It provides pedagogical bases for learning like activities, structures, and methods. It also provides technological foundations for how new technological solutions can benefit education.

Curriculum reform takes into account the social impact of globalization, climate change and environmental issues, technological change, the avalanche of information, and other changes in nature, work, and society. The growth of cultural and linguistic diversity in the country plays a central role. The new draft (2014) makes essential it incumbent to consider how all these changes might impact on children's personal growth and their learning environment throughout the complete lifespan.

Municipalities as Education Providers and Curriculum Creators

Basic education in Finland is provided by local authorities (municipalities), and schools operate under their jurisdiction. The core curricula are prescriptive to the providers of education, who are obliged to draw up the local curricula based on them (Halinen & Holappa, 2013).

However, local education providers have extensive autonomy in Finland; the municipal curriculum is decided by municipal education authorities. They are responsible for planning the local curriculum, organizing assessments, and using the data obtained evaluate how well the curricular goals have been achieved. The local-level curriculum is a dynamic and flexible document, designed at the grassroots level jointly with principals, teachers, parents, and local civil society organizations like athletic and cultural groups. Empowering and involving teachers to undertake this activity and engage in profound discussions are arguably even more important than the final document, because the joint nature of the process commits teachers and stakeholders to the local curriculum. This long-term process has a central role in school improvement and development. According to the PISA 2012 (OECD) school questionnaire, Finnish teachers feel that they are genuinely responsible for broad planning, development, and assessment. Nearly all teachers feel that they are responsible for both curriculum (96.0%) and assessment (97.0%) policies, far more than is the norm in the OECD as a whole, where the averages are 80.5% and 76.9%, respectively.

Teachers as Autonomous Executives of the Curriculum

In Finland, the last 30 years of research-based teacher training devoted extensive effort into educating teachers (e.g. Niemi, 2014a, 2014b), whose expertise is now of such a high level that they are able to make creative and pedagogically relevant choices. They decide which goals and content they emphasize, what kinds of methods and materials they choose, and how they arrange and create innovative learning environments. The teacher's role is especially important in the new curriculum process. While helping to create the new curriculum, teachers share their professional views on teaching, learning, and assessment. Teachers also discuss these issues with students and parents, other professionals working at the school, and stakeholders outside the school. They simultaneously ground their work in national guidelines and take into account the local needs of their students and the special features of their municipality and school. Through school-based planning, every school is connected to municipal and national education strategies.

Finnish teachers are capable professionals, whose role the in the educational context is close to the role of a teacher in "teacher leadership" (Katzenmeyer & Moller, 2009). Lieberman (1992) and Harris (2003) have outlined the knowledge base of this type of teacher. She is goal-oriented and has a clear vision of school development and high-quality teaching, and moreover is able to work collaboratively and in interaction with other teachers towards those goals. She is able to consume research-based knowledge and has the deep understanding of the teaching and learning process needed to act as a curriculum specialist.

CURRENT INTERNATIONAL AND NATIONAL TRENDS INFLUENCING THE DESIGN OF THE CORE CURRICULUM

Education should always promote intellectual excellence. However, Finnish society is hardly alone in having changed rapidly and radically over the last ten years. In response, researchers, national level curriculum experts, and several stakeholders have questioned whether the planning of core curriculum should rely more on the social efficiency, learner-centered or social reconstruction ideologies, rather than only the scholar-academic viewpoint**.** The new core curriculum will place heavy emphasis on the learning process, a collaborative school culture, and communal modes of studying. Several international and national trends have influenced this round of core curriculum renewal, the three most of important of which are: 1) the 21st-century movement; 2) the role of ICT in education; and 3) new environments for learning. These trends are discussed below.

21st-Century Movement

The need for 21st-century skills or competences has influenced the design of the core curriculum for basic education in Finland as in many other countries (Binkley et al., 2012; Kankaanranta & Vahtivuori-Hänninen, 2011; Salo, Kankaanranta, Vähähyyppä, & Viik-Kajander, 2011; Vahtivuori-Hänninen &

Masalin, 2012). The 21st-century movement seeks to redefine of the aims of education and how learning is organized in order to meet the demands of the 21st century. According to Binkley et al. (2012), individuals need both critical and creative thinking, and should learn to use a wide range of tools, like socio-cultural (language) and technological (ICT) tools for interacting effectively with the environment, for developing a sustainable future, to engage with and interact in a heterogeneous group, and to take responsibility for managing their own lives and acting autonomously

There are several examples of how different countries have taken 21st-century skills into account in their national processes. The University of Melbourne has coordinated a large assessment project called *Assessment & Teaching of 21st-Century Skills* (ACT21s, 2011). This international and interdisciplinary project involves six countries and several large companies. The results of the project include a framework for 21st-century skills. ACT21s divides skills into four categories: 1) Ways of thinking (creative thinking, critical thinking, learning to learn, and metacognition); 2) ways of working (oral and literal communication skills, team work, and collaborative modes of working); 3) Tools for working (performance and competence, media proficiency (creative, social, critical), and ICT skills); and 4) living in the world (active global and local citizenship, participatory and active agency as a part of the community, personal and social responsibility) (see ACT21s; Finnish National Plan for Educational Use of ICTs, 2010; Vahtivuori & Kynäslahti, 2012).

The European Council has coordinated a similar competence project at the European level. The project is supported by the European Schoolnet, a network of ministerial-level education authorities from individual European governments. In 2006, Schoolnet launched the Key Competence Network project (KeyCoNet, www.europeanschoolnet.org). The project searched for the key competences of school education that students would need in the near future.

What kind of learning environments and what sort of learning ecosystem are needed to enhance the achievement of 21st century skills? According to the first draft of the new Finnish curriculum framework, it is essential that learning environments take into account that children are living in a complex and globalized world, which is filled with and modified by different ICTs, media services, and games. The draft emphasizes that the skills and competencies (critical, creative, and social) needed for the exploitation of ICTs must enable the student to grow into an active member of society. The student is treated as an active learner. It is important that students learn set goals and solve problems both independently and with others. The new curriculum emphasizes that well-being, balanced development of personality and ability to manage daily life are also important goals of learning. ICTs provide many tools for active and meaningful learning.

The Role of ICT and Media in Education

In recent years, there has been increased debate regarding the notion that ICT and media have a new role in explicitly developing children's knowledge and skills.

They clearly play a major role in the lives of children and adolescents, molding their identities and worldviews in the process (Kangas, Lundvall, & Sintonen, 2008; Kotilainen 2011, 68-70; Livingstone et al., 2011; Vahtivuori & Kynäslahti, 2012; Vahtivuori & Masalin, 2012). What is learned, how it is taught, and how schools are organized must be transformed to respond to the wired realities and social and economic needs of both students and society as we face the challenges of the 21st century.

ICT skills and media proficiency have risen to become one of the main focus areas of our time. They are already a part of modern general education and an important tool for learning. ICT is also a tool of the mind, and can transform and expand learning environments and diversify methods of working. ICT's importance is clear from the fact that students use it to learn a great deal outside of school, in their spare time. ICT and learning should be able to connect better with the content that is the focus at school. ICT also influences the school culture; at its best, it supports communication and a collaborative learning community that includes parents or experts outside of the school. In the new 2014 curriculum, ICT skills are an essential part of general education and civics. In basic education, they are crucial to ensure that all pupils have equal opportunities to develop their expertise, ICT skills, and media proficiency.

The draft (FNBE, 2014) also emphasizes that children should be guided and encouraged into independent and critical search and use of information. Students are to learn skills that employ ICT in diverse and creative ways, and need to practice working with data, information, and knowledge. The aim is that students will be capable of creating new knowledge both on their and together with others, all by utilizing ICT effectively. ICT and digital learning materials are utilized in a wide range of subjects and in boundary-crossing learning. Collaborative working skills and communal modes of studying using ICTs are supported, and the tools that support each student's personal learning pathways are introduced.

Versatile Environments for Learning

The third movement which has influenced the new national core curriculum for basic education is the movement away from closed learning systems and environments towards open systems, of which quintessential examples are social network environments and crowdsourcing, which a form of peer production that is performed collaboratively on the web. Media is no longer only a tool to enhance and intensify education, but rather part of a sustainable and ecological way of living and a collaborative working culture. There has also been an intense debate in schools about a new wave of wireless and mobile media in education; one powerful contemporary trend is the unification of informal and formal education. The use of ICT in both schools and everyday life are converging, coming ever closer to each other. Learning now happens everywhere (Kumpulainen et al., 2010). The rise of games used in education and gamification, the use of game thinking in non-game contexts, is topical. The *2013 Gartner Hype Cycle Special Report* evaluates the maturity of over 2,000 technologies and trends

in 102 areas. According to Gartner's cycle for emerging technologies, gamification is one of the trends which is now in the peak of inflated expectations; i.e., it has reached the top of the interest cycle (Gartner, 2013). At the moment, many Finnish game companies are striving together with teachers and learners to create high-quality, game-based digital learning materials, solutions, and environments. A new viewpoint in the curriculum draft is the importance of discovering the joy of learning, which has a dramatically positive effect on student motivation. Educational games could have a central role in this effort. The curriculum draft (2014) emphasizes that schools need to create learning environments in which students can use a wide range of ICT tools in ever more creative ways. ICT is clearly here to stay; it is utilized systematically in basic education in all grades, in different school subjects, and in interdisciplinary topics.

COLLABORATIVE AND ITERATIVE PLANNING OF THE NEW NATIONAL CORE CURRICULUM IN FINLAND

From 2012 through 2014, several core curriculum documents were already being designed in collaborative and iterative processes. Each process of drawing up a core curriculum document involves broad-based cooperation with educational experts and numerous stakeholders, and includes support for local curriculum development efforts. (Halinen & Holappa, 2013; FNBE, 2014).

In August 2012, the FNBE launched the first draft of the preschool and basic education curriculum. The design of the new core curriculum is expected to be completed by the end of 2014, with local curricula completed before August 2016, at which point teaching and learning are supposed to be organized along the new curricular lines. The design of the new curriculum is based on the analysis of the competences that children and young people will need in the near future in their studies, in everyday life as citizens, and in working life. One of the most important questions in the curriculum process is how to develop teaching and learning that supports students to engage in the process of learning itself and to experience school-based learning in a more meaningful, exciting, and enjoyable way. The curricula will also address how students are supported to make connections between the subject matter knowledge they learn at school and the knowledge that they need for their own lives and futures.

Based on the recently-defined values of the new core curriculum and the national goals stipulated in the *Education Act* and in the *Government Decree*, the seven areas of extended, cross-cutting (common to all school subjects) competencies based on 21st-century skills are described in the core curriculum draft. They are:

1. Thinking and learning to learn;
2. Cultural literacy, interaction, and expression;
3. Taking care of oneself, everyday life skills, safety;
4. Multiliteracy;
5. ICT competence;

6. Working life skills and entrepreneurship;
7. Participation, influence, and responsibility for a sustainable future.

These competences consist of knowledge, skills, values, attitudes and the ability to apply them in different contexts. The aim is that learners have also the will to use their competences for ethical purposes. The objectives for these competencies are described as a part of core curriculum general goals for teaching and learning, and more detailed objectives for each grade group (grades 1-2, 3-6, and 7-9). Learning is defined in the draft curriculum document as a goal-oriented behavior based on the student's prior knowledge, skills, feelings, and experiences. Objectives for competence development are also included within the objectives of every subject. Each school subject promotes the thinking and learning to learn competence or the ICT competence, for instance, in its own specific way.

In addition to learning specifics, the student develops the skills to reflect on the learning processes, experiences, and emotions and at the same time develops new knowledge and skills. At its best, learning awakens positive emotional experiences, joy in learning itself, and becomes a creative activity that will inspire the student's development of her own expertise. Learning is both an integral part of an individual's comprehensive, lifelong growth and the building material for a good life (FNBE, 2014).

The role and status of pupil assessment and evaluation of education in Finland differs radically from most other countries. FNBE 2014 defines the main purposes of student assessment is to promote learning and to encourage the learner. Students are not compared to each other. The teacher is responsible for assessment and feedback but self-assessment and peer assessment are also regarded as crucial elements. There are no national tests or assessments that cover the entire age cohort, so schools cannot be compared to each other either. National assessments of learning results are based on samples of students in two or three subjects every evaluation round. The results of these assessments are used for development purposes, not to create ranking lists of schools.

CONCLUSION

Why is the core curriculum reform important particularly now for the Finnish society? Why should a well-functioning Finnish educational system be reviewed, reformed, and renewed? The world in which schools operate has undergone major changes since the beginning of the millennium, given the increased impact of globalization and the challenges for a sustainable future. The competencies needed for society and working life have changed, requiring new values and skills to confront that future. The content of teaching, learning, and school practices must be periodically reviewed and renewed in response to the changes in the operating environment and the skills it demands.

In the new Finnish core curriculum, schools are learning organizations that form part of the broader educational ecosystem. Schools are strong communities that learn themselves while supporting their students' growth and encouraging all of their members to learn (FNBE 2014). The goal is to strengthen each student's

positive and realistic self-image as a learner. The importance of self-reflection of individuals and the whole school community is regularly reinforced. ICT will serve as a useful pedagogical tool and learning environment to achieve all of the new goals. The features of high-quality teaching and learning defined in the curricula and in the global educational ecosystem are varied working approaches, interaction and empowerment, wellbeing and safety in daily life, awareness of diverse cultures and languages, and responsibility for the environment and the future as a whole.

The ongoing curriculum process will play a key role in the reframing of Finland's educational sector for 21st-century skills and competences. Reform of the national core and local curricula provides a common framework to discuss the changes taking place in today's world and to ensure that schools have a 21st-century teaching and learning ecosystem. Education builds our future by addressing future challenges and the skills that will be needed at that time. This change requires strong strategic leadership, from FNBE experts, local authorities, school principals, and teachers of all kinds. Furthermore, extensive amounts of shared thinking and collaboration are needed. (FNBE, 2014; Halinen & Holappa, 2013). The new national core curriculum crystallizes the vision of education for the future and the necessary expertise that will be needed in Finnish society. The importance of the core curriculum is limited not only to describing what should happen in the Finnish classrooms, schools, and municipalities, but also will voice the ideals, values and endeavors that the nation will undertake in the decades to come.

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PART II

GLOBAL SHARING PEDAGOGY WITH VIDEO STORYTELLING

HANNELE NIEMI AND JARI MULTISILTA

3. GLOBAL IS BECOMING EVERYWHERE

Global Sharing Pedagogy

ABSTRACT

This chapter introduces Global Sharing Pedagogy (GSP), a new pedagogical framework for designing teaching and learning in schools. It provides a model that can be applied when designing, implementing, and evaluating teaching and learning. Changes in knowledge, learning and learning spaces, work, and technology have made our world smaller and seemingly borderless. The need to learn what are known as 21st-century skills is urgent. The aim of GSP is to promote students' engagement in learning and connect formal with informal settings. The model has four elements: (1) active student-driven knowledge creation, (2) collaboration, (3) networking, and (4) digital media competencies and literacies. The chapter draws from empirical data and discusses possible ways to apply the model in schools in digital storytelling projects. It also suggests that elements of GSP should be important in learning spaces outside the school in adult education and working life.

Keywords: *21st-century skills, learning, sharing, agency, engagement*

INTRODUCTION

Technology and social media have dramatically changed knowledge production, work, education, and social structures. The increasingly 'flat world' applies to globally-shared social practices in all domains of life, not only in the global economy. The globalized world connects people through social and virtual spaces where they can share their knowledge, opinions, and experiences at almost any time and any place. The world is also in many other ways without borders. Ulrich Beck described the 1980s using the concept of a risk society (Beck, 1992). The problems that were once local or national have become global. Climate change and other environmental problems, catastrophes, poverty, and the consequences of income inequalities are influencing the lives of people without respect for borders. The danger is that in the midst of so many interrelated transformations, people will lose their agency and not know how to adapt to living and working with the changes occurring around them. The boundless world requires new skills and competences: how to use new communication tools for the creation of innovations and new knowledge, solving problems together, and exploring and executing ideas

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that can improve the quality of life. The concept of agency has become commonly used in connection with new learning environments. In the new learning and communication spaces, learners will need skills to regulate their own learning to make optimal use of those spaces. The concept of agency has theoretical roots both in moral philosophy, sociology, and psychology and at a general level it has a connotation with the idea of freedom to make choices and to have control over one's behavior, with literally being an actor. Daniel Schwarz and Sandra Okita (2013) have commented that agency is often used in an overly simplistic way and not connected enough with the interaction of other people and environments. As an example, they describe how intrinsic and extrinsic motivational components are integrated when students are creating a product that they want to show to their peers. The material product they are creating can be a very important activator to their efforts. They also refer to a highly engaging conversation: "there is an opportunity to express one's original ideas; other people uptake the ideas and add their own element to them", and "one gets to respond with new ideas in return" (p. 11). They call that phenomenon productive agency in learning. They claim that "productive agency yields both motivation and learning, which unfortunately, were separated in the cognitive revolution" (p. 11). In this chapter, the model of Global Sharing Pedagogy (GSP) wants to respond to this challenge. It aims to make visible the need to connect motivational elements and learning together and activate learners to share their ideas when solving problems or producing something together, specifically digital stories or other video productions. The main purpose is connecting learning and sharing with the use of technological tools not only as media but also as products that learners design and comment on.

A BOUNDLESS AND FLAT WORLD: CHANGING LEARNING

Students' motivation to learn is one of the most important conditions for their lives and futures when they live in ever-changing environments. In many countries, there are indications that students are less engaged in learning. 21st-century skills have become an urgent topic on the agendas of educational systems (e.g., Binkley et al., 2012), and schools must seek new forms of teaching and learning for the future. Many discussions and documents propose options for facing this future and delineating schools' and teachers' roles in these changing contexts (e.g., Bellanca & Brandt, 2010; Griffin, McGaw, & Care, 2012).

Indeed, this discussion is urgently needed. For example, in the 2012 Programme for International Student Assessment (PISA), the vast majority of students in OECD countries felt happy at school, but more than 33% of students reported that they had arrived late and 25% had skipped a class in two weeks prior to the PISA test period (OECD, 2013). Many critics have also indicated that schools do not necessarily provide students with the skills and competencies they need in today's world, and that this problem will only become worse in the future (Prensky, 2005; Sharples et al., 2012). In the 21st century, multiple analyses have confirmed that people will need to learn how to create knowledge both individually and collaboratively and become problem-solvers and critical thinkers (Griffin, Care, &

McGaw, 2012). They also need to be competent and literate in digital media to be able to create and share knowledge and media artifacts, and to critically appraise the quality of knowledge representations.

Although definitions of 21st-century skills vary to a certain degree, there are some core commonalities. The most important factor is that students should have the capacity to learn throughout their lives, and that education must provide the skills and mental tools to make that possible. Inquiry and knowledge-creation skills are the most crucial, but they should be connected with analytical and critical thinking skills and creativity. Students should have the skills to ask questions, not simply seeking or repeating ready answers. They need the capacity to work independently but also, increasingly, collaboratively.

Information and communication technologies (ICT) cross borders. Learning spaces have become 'global'. Social media has broken down almost all borders nationally and internationally. The Internet provides learning resources and databases that are accessible across countries and nations. In many areas of life, people depend on international knowledge production, and working environments are increasingly global. Our students will be cosmopolitan learners and workers; even locally, they are connected with international communities. This means that one of the important aims of schools should be to prepare them for a collaborative culture and the idea of sharing. Learning concepts about their agency in a globalized world mean that they should become active global citizens, providing their contributions to a shared world. This agency can be achieved only by having authentic experiences in schools that reach across borders and cultures.

The big question, in Finland and elsewhere, is how to motivate students to learn and to become truly engaged in learning. What kinds of mediators, then, are needed to create truly engaged students?

TOWARDS GLOBAL SHARING PEDAGOGY

In Finland, The Boundless Classroom project (www.finnable.fi) as part of the national research and development program Learning Solutions (Tekes, 2013), has sought new ways to promote 21st-century skills, connecting formal and informal learning through the use of new technology and digital environments. The project drafted a conceptual model of Global Sharing Pedagogy (GSP) that consists of mediators for increasing student engagement in learning. The driving notion is that all GSP mediators must be taken into account when designing teaching (Niemi & Multisilta, 2014; Niemi et al., 2014).

GSP is based on socio-cultural theories (Vygotsky, 1978). Learning happens as a result of dialogical interactions between people, substances, and artifacts (Cole & Cigagas, 2010; Hakkarainen, Paavola, Kangas, & Seitamaa-Hakkarainen, 2013; Pea, 2004; Säljö, 2012). Learners are the focus under GSP; the primary objective is to strengthen student engagement in active learning. Technology is a tool that can motivate learners and provide scenarios in which they can make their own unique contributions. This student-centered approach also means that learners can connect

various learning settings, both formal and informal, and use them all as learning resources.

GSP insists that schools possess a teaching and learning culture that not only allows but also encourages the entire school community to be open to collaboration, networking, active knowledge creation, and digital media competencies and literacies. This requirement also implies active interactions with partners outside the school and being connected with other schools, both locally and globally.

Experience, Technology and Learning

GSP reflects both technology-mediated experiences and experiential learning. An experience can be characterized by the two principles of continuity and interaction (Dewey, 1938). Continuity describes our experiences as a continuum in which each experience will influence our future experiences, so that the continuum of experiences defines a mental context for learning.

Interaction refers to the current situation (physical or virtual context) and its influence on one's own experience. In Dewey's terminology, interaction can also modify a context. Each experience affects the human mind and, as such, a continuum of related experiences can lead to learning. According to Multisilta and Perttula (2013), technologies enrich experiences and thus contribute to the continuum of learning experiences. The use of the particular technology is important an experience in and of itself. In this sense, technology-mediated learning depends on both the experience and the technology used to mediate it to others.

LEARNERS' AGENCY AND ENGAGEMENT IN LEARNING

Engagement has become a key issue in enabling people to remain active learners. Engagement is linked with motivational qualities and has connections with self-regulation (e.g. Pintrich, 2000; Pintrich & McKeachie, 2000 Zimmerman, 1990; 2000; 2001) and self-efficacy (Bandura, 1997). Engagement means that people are involved in a learning process and they have the agency to be able to learn. Engagement has been defined in many contexts. Taylor and Parsons (2011) analyzed the nature of student engagement, and introduce several types of engagement: academic, cognitive, intellectual, institutional, emotional, behavioral, social, and psychological. After exploring dozens of definitions, they conclude that the following criteria of learning environments characterize engagement:

– Learning that is relevant, real, and intentionally interdisciplinary, at times moving learning from the classroom into the community;
– Technology-rich learning environments featuring not merely computers, but all types of technology, including scientific equipment, multimedia resources, industrial technology, and diverse forms of portable communication technology;
– Learning environments that are positive, challenging, and open, also known as 'transparent' learning climates that encourage risk-taking and guide learners

towards co-articulated high expectations. Students are involved in assessments for learning and of learning;
– Student-teacher relationships defined by collaboration and a respectful 'peer-to-peer' attitude.

In the GSP model, engagement is a motivational component comprised of students' emotional states, such as the joy and fun experienced in learning itself, corresponding very closely to a flow concept which means an optimal state of intrinsic motivation where the person is fully immersed in what he is doing (Csíkszentmihályi, 1990, 2005, pp. 68-73). It also has qualities that are typical of self-regulated learning, such as a commitment to learning tasks and a willingness to expend the effort to achieve an objective (Bandura, 1997, 2001; Pintrich, 2000; Pintrich & McKeachie, 2000). Engagement is a key factor in determining whether students would like continue their learning. It is not an objective in itself, but a second-order mediator for effective and meaningful learning. The concept of productive agency (Schwarz & Okita, 2013) calls for both a closer relationship between learning and motivation and for interaction between learners and the products or artifacts they are creating. The GSP model treats all these elements as interacting, a dynamic process that can and must be nurtured.

MEDIATORS OF LEARNING IN GSP

Learning is a mediated activity with tools, signs, and social interaction, according to Vygotsky (1978). He brought the idea of tool, symbolic, and social mediators to the analysis of the learning process. He suggests that the mediators select, change, amplify, and interpret objects to a learner (p. 67). GSP has categorized mediators into four groups:

(1) Learner-driven knowledge and skills creation. Here, learners are provided and coached by symbolic tools, such as active learning methods and metacognitive skills. This is a dynamic process in which learners use and, guided by reflection and meta-cognition, manage their cognitions and resources. Learners need strategic skills to manage their own learning and create new knowledge, individually or collaboratively. Schools and teachers should activate students to this kind of independent learning. Learning touches them cognitively, emotionally, socially, and morally. The more independent and self-regulative students are, the more they also need to be aware of and employ ethics and values. Mediation towards student-driven knowledge creation consists of different kinds of symbolic tools, such as critical thinking, creativity, argumentation, learning to learn skills, and ethics and values.

(2) Collaboration. Collaboration is a social mediator that allows, and even requires, students to work together. It ensures that students can learn and work in the global world of the future. They need to develop the following competencies beyond the purely 'cognitive' level: social skills, cultural literacy and understanding, help-seeking, and help-giving strategies.

(3) Networking. Networking is also a social mediator that uses synergy from the expertise of other people and provides tools for intercultural learning. Learning is a

continuous process of dialogical interaction with other people and cultural artifacts. In distributed cognitions and interaction with different artifacts, people bring remarkable value that enhances their learning and competencies. These processes are mutually constitutive, so that all learners are also contributors. Thus, networking means learning from others as well as sharing ideas and experiences.

(4) Digital media competencies and literacies. Such competencies are mainly tools that enrich learning through new technology environments, but can also consist of social and symbolic mediators though different digital environments. In technological environments, learners are both content producers and consumers. As such, they need the skills to study and work in digital environments. They must also assess critically and validate the knowledge they find and create; they must be accountable to the norms of discourse and argumentation established by the adult communities of practice in each discipline. They also need skills in creating and discussing social media and in promoting ethical behavior in these media environments. Mediation of digital media competencies and literacies consist of the following skills that schools should provide to students: digital content creation, critical content interpretations in digital environments, and social media skills.

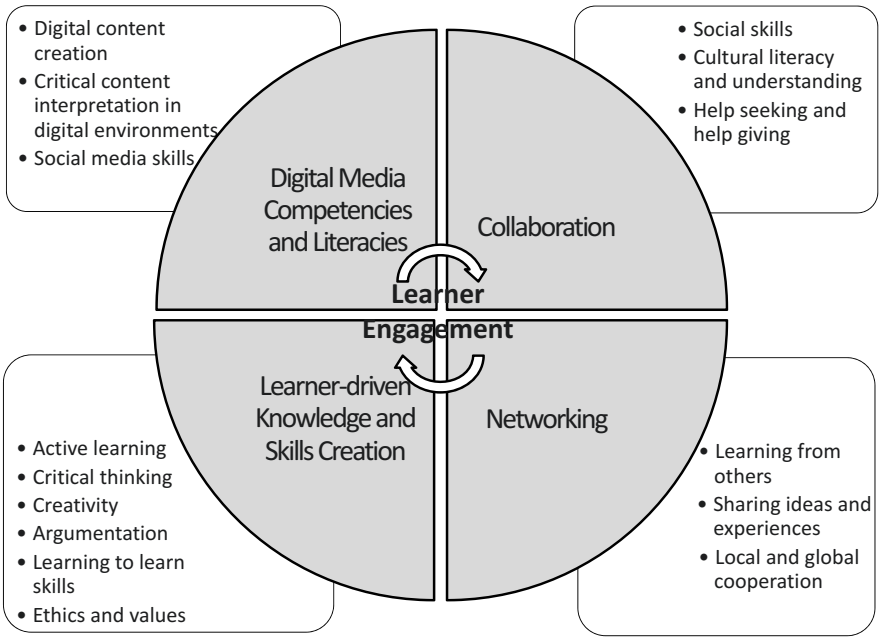

Figure 1. The concept of Global Sharing Pedagogy (GSP).

The GSP model provided the basis to The Boundless Classroom project, in which students co-created small digital stories by shooting and remixing recordings (Niemi et al., 2014). All mediators were applied when planning projects with teachers and students (n = 319) in 28 schools in Finland, Greece, and California in 2012-2013. Topics of videos could be closely connected with curriculum themes or be taken from timely issues, societal problems, and hobbies. Students used the MoViE platform designed for digital storytelling (Multisilta et al., 2012; Multisilta & Mäenpää, 2008)

The Boundless Classroom project created a follow-up survey for measurements of what and how students had learned when creating and presenting their videos. The research group planned a questionnaire that had questions on each component of GSP. Students answered after the project using a 5 point Likert-scale (*Not at all, A little, Somewhat, Quite a lot, Very much*) to questions.

The data was gathered from three regions that participated in the mobile video storytelling study (2012-2013) in The Boundless Classroom project (Niemi et al., 2014). After the pilot, the students were asked to respond to the questionnaire of the follow-up survey. In total, 319 students responded in Finland, Greece and California. The data was analyzed using descriptive statistics, correlations and different reliability techniques. Table 1 presents means, standard deviations, and scales' alpha scores.

Table 1. Means, standard deviations, and scales' alpha scores of the GSP model in the digital story telling project. (N=319).

Categories of GSP	Scales	M	SD	α
Knowledge and Skills Creation	Active Learning	2.96	.89	.81
	Creativeness	2.79	1.27	.67
Collaboration	Group Work	3.76	.82	.80
	Help seeking and giving	2.64	1.14	.74
Networking	School Network	2.14	1.18	.77
	Cross-Cultural Networking	2.35	1.16	.96
Media Competences and Digital Literacies	MoViE-technology platform	3.20	1.15	.94
	Digital Self-Confidence	3.67	1.01	.81
Engagement	Motivation (hard work)	3.40	1.02	.90
	Motivation (fun)	3.60	1.16	.93
Learning Outcomes	I learned …	3.11	1.02	.94

Engagement

Both motivational categories, motivation from hard work and motivation from fun, received very high values from the students. It seems that students had a lot of experiences of fun during the project. They learned new skills and acquired new

knowledge, and were inspired to work hard in the digital storytelling project. In the interviews the students described their experiences as follows:

> It was fun to work with friends in the group. It was somehow fun, you could choose the topic yourself and teach something new to others. (a fifth-grade student)
>
> Yeah, this is more fun than normal studying. (an eighth-grade student)
>
> It was fun because it was a bit different than normal studying. This kind of activity could be done more often. (an eighth-grade student)

In the interviews, teachers described students' work as follows:

> There were no problems in motivating students, but maybe I had to guide a bit [to focus on the activity] (an sixth-grade teacher).
>
> [When working] some students were thinking to leave to eat hamburgers. Together we then discussed what they were going to do there and how they were thinking of presenting it [in the story]. After all, they made very good videos about cycling and basketball. (an eighth-grade teacher)
>
> I believe that motivation for this kind of activity arises from feelings of success. When students, working in a group, can see what kinds of things produce feelings of success, I think that it can somehow generate a spiral that promotes it forward. (an eighth-grade teacher)

Students and teachers gave very positive comments about students' motivation, and feelings of success were an important factor. Students said that setting own their goals is an important condition for committed learning.

Learner-Driven Knowledge and Skills Creation

One of the central goals in the mobile video storytelling pilot was to learn how to design and plan the story the students wanted to create. The students had the responsibility of discovering the knowledge needed for video manuscripts or storyboards. They had to determine which features were most important and the message that they wanted to communicate to their classmates or students in other schools, in some cases even with students in another country. The student's own voice was strong in the final video stories and during the whole process (Niemi et al., 2014).

Collaboration

Students had to plan their projects in peer groups of two to four students. The main objective was that students learn from each other and learn to ask and give help. The aim was that students learn how to work together, how to divide labor, and

how to enable different learners with their own strengths to contribute to the process. The findings of the study revealed that students very much enjoyed the collaboration process, but it was not clear that they displayed collaborative skills. They had to learn decision-making, division of labor, sharing and how to give and receive feedback and help (Niemi et al., 2014). Students' and teachers' interviews confirmed the quantitative results (Niemi et al., 2014). Although the group work variables had high mean values they indicated that learning to work together was not always easy and that it must be practiced (see also Cohen, 1994).

Networking

Networking connected learners with other learners or experts. In this project, students had partner schools in another country. They prepared their video stories for their international peers. They had to consider how others understand their messages. Networking had the lowest means in the study. Both teachers and students said that cooperation across countries would be important and useful but it is not easy to organize and implement in schools' daily life. This is an urgent message to schools and learners about how they could work in a more networked manner, both locally and globally (Niemi et al., 2014).

Media Competencies and Digital Literacy

Students used the MoViE platform (Multisilta & Mäenpää, 2008; Multisilta, Suominen, & Östman, 2012; Tuomi & Multisilta, 2010) to create and share their digital video stories. It was also possible to use other technological tools and applications, such as more advanced video editing tools. In fact, the tool itself was not the main issue. It was important that students learned media competence skills, networking skills, and problem-solving skills by using the tool and grow in self-confidence by using new tools for learning. The MoViE technological platform was assessed as useful by the students, who indicated that the project increased their digital self-confidence. There were some technical problems. In interviews, students noted those difficulties but also described how they tried to solve these difficulties. Even though students had ample experience using technology and social media for entertainment, they still needed support and guidance on how to use similar technological tools for learning (Niemi et al., 2014).

There was a strong correlation between the GSP mediators and the motivational components. Higher values in active learning, collaboration, digital literacy, and networking correlate to high motivation and learning outcomes. In further analysis (Niemi & Multisilta, 2014) when regression analysis was used, we found that the strongest predictor of the mediators was the MoViE platform, which provided an opportunity to plan, shoot, and remix one's own story in collaboration within a peer group. The second strongest predictor was collaborative group work. Students learned about collaborative processes when producing their videos. Productive agency was thus a reality in the project.

Table 2. Zero-order correlations between engagement, learning outcomes, and mediators of GSP.

	1	2	3	4	5	6	7	8	9	10
1. Active Learning	1									
2. Creativeness	.65**									
3. Group Work	.57**	.40**								
4. Help seeking and giving	.52**	.49**	.37**							
5. School Network	.50**	.49**	.27**	.49**						
6. Cross-Cultural Networking	.47**	.67**	.24**	.44**	.58**					
7. MoViE-technology platform	.57**	.54**	.39**	.39**	.54**	.52**				
8. Digital Self-Confidence	.40**	.32**	.40**	.14*	.20**	.25**	.41**			
9. Motivation (hard work)	.57**	.57**	.54**	.45**	.53**	.52**	.76**	.38**		
10. Motivation (fun)	.58**	.50**	.57**	.42**	.47**	.48**	.66**	.37**	.71**	
11. Learning Outcomes	.72**	.66**	.54**	.58**	.64**	.61**	.67**	.39**	.71**	.69**

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

GSP with its mediators also predicted students' learning outcomes very well. The outcomes were mainly generic 21st-century skills such as problem-solving, argumentation, decision-making, and cooperation. All components of GSP (Niemi & Multisilta, 2014) – (1) *Learner-driven knowledge and skills creation*, (2) *Collaboration*, (3) *Networking* and (4) *Digital media competencies and literacies* – showed a high predictive effect on student learning outcomes, giving support for the model. In particular, active learning methods such as learner-driven knowledge creation and MoViE as a digital media tool were found to be highly important.

GLOBAL SHARING IN DIFFERENT LEARNING SPACES

The task of this chapter was to introduce the GSP model for promoting 21st-century skills in schools. Learning is now happening everywhere and informal spaces are more important than ever. Many environments are important learning arenas outside the school, such as working life, free time, hobbies, and online education.

GSP can be applied in any number of technological platforms and learning spaces. The results from the pilot school projects are promising. We learned that learners become engaged in learning and do have agency, specifically a productive agency. All mediators of GSP, namely student-driven knowledge creation, collaboration, networking, and digital media competencies and literacies were important when students created digital stories. The mediators of the GSP model form a wholeness in which different components reinforce each other. From the productive agency viewpoint, we can see that motivation, product creation, and learning are all connected with each other.

The global ecosystem will provide a large, effectively endless range of arenas for learning outside the school and in connection with other schools. The GSP model provides focal points as to which components are important when aiming at motivating by engagement, especially when it is defined as productive agency. Student-driven active learning processes, collaboration, networking, and digital literacies are vital mediators for high motivation and for learning outcomes.

The globalized, flat world is facing both opportunities and threats. They require new openings and new ideas for creating innovations and new solutions. When seeking the major predictors of innovations, we see widely in the research literature (Hülsheger, Anderson, & Salgado, 2009; Rank, Pace, & Frese, 2004) that the most important factor is active and inquiry-based learning with creativity, collaboration, and networking. It creates grounds for new ideas and new artifacts, and new artifacts provide the basis of motivation to learn and create even more new ideas and products. In the current world, technology is a natural tool that people use to work or innovate together. The GSP model provides mediators for advancing new ideas, practices, and artifacts that can be developed in schools, working life, or anywhere people are learning, working together, and sharing their ideas. People will not only develop new products and concepts collaboratively, but also, and more importantly, will work together in a way that strengthens agency which in turn will improve their quality of life.

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4. DIGITAL STORYTELLING IN FINNISH SCHOOLS

ABSTRACT

Instructional strategies that support learner-centered approaches and integrate information and communication technology (ICT) into teaching are effective ways of enhancing learning of both school subjects and 21st-century skills. However, there is still a need for concrete teaching methods with which teachers could implement these approaches in practice. In this chapter, we explore how digital storytelling (DST) can be used as a teaching method and a tool for learning collaboration and ICT skills. In the study presented in this chapter, DST was used in 18 Finnish classes; the data included interviews with teachers and students. Our study suggests that DST can be integrated in many school subjects and that it can enhance students' learning of collaboration and ICT skills in several ways. However, the use of the method may be considered time-consuming and demanding – especially when using it the first time – as it encourages teachers to reject teacher-directed instruction in favor of taking the role of a facilitator or tutor. Thus, DST requires teachers to have project-leading and planning skills, in addition to expertise in using ICT in teaching. We begin by discussing digital storytelling as a method for supporting learning. We also describe how digital stories can be made and shared by the online service Mobile Video Experience (MoViE), which was used in the classes during the research project. After that, we present a brief description of how the study was implemented and then focus on the results.

Keywords: *digital storytelling, student-centered approach, ICT, collaboration*

INTRODUCTION

Learning and Teaching with Digital Storytelling

DST refers to the activity of creating short stories from digital materials, such as video clips, photos, and sounds (Porter, 2005). With personal digital stories, individuals have an opportunity to express themselves by creating stories and sharing them digitally with others (Hull & Katz, 2006). DST has also been viewed as a teaching method that is based on learner-centered approaches (Robin, 2008). When used for educational purposes, the terms personal-educational digital storytelling (Gregori-Signes, 2008) or pedagogical digital stories (Vivitsou et al., forthcoming) have been used. These terms distinguish between the overall DST genre and its specific pedagogical use: the method is not only a tool for personal

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expression but also a tool for teaching and learning (see also Gregori-Signes, 2008). Here, the terms DST and pedagogical digital stories are used interchangeably to refer to the use of DST in educational contexts.

Earlier studies suggest that DST can improve students' learning in multiple ways (e.g. Kearney 2009; Niemi et al., 2014; Yang & Wu, 2012). In this chapter, learning is understood to take place in an interaction between learners and their environments. In formal education, learning occurs in social processes between students and teachers or peers. It also appears in the interaction between individual and different concrete tools like textbooks, computers, or pen and paper. The activity of a learner is essential to the successful learning process: by participating in ongoing culturally-organized social activities, new things and skills can be learned (White, 2011, p. 20). As a teaching method, DST promotes several forms of interaction in class. For example, learners interact with concrete tools like mobile devices, when creating their stories and collecting content for them. Learning together with others takes place when using collaborative methods and watching the stories that other students have made.

Skills essential to a global information society are commonly called 21st-century skills. These skills include, among others, collaboration and ICT (Binkley et al., 2012; OECD, 2013) on which we concentrate in this chapter. Since collaboration and working with others are important in working life and learning, it is essential to explore how skills related to these activities can be enhanced by pedagogical DST. In addition, as ICT skills, such as seeking, evaluating, and managing information and interacting digitally with others, are vital for working as an active citizen both today and in the future, it is also essential to understand how these skills can be enhanced in teaching.

The emphasis on developing 21st-century skills calls for changes in teaching practices (Lee & Hung, 2012). Learning objectives, which stress ways of thinking and working rather than specific information, are best supported with student-centered approaches (e.g. Binkley et al., 2012). Norrena stresses ICT's role in enhancing the learning of 21st-century skills (2013). Both of these imperatives can be actualized when using DST.

Digital Storytelling with MoViE

The Mobile Video Experience (MoViE) is a web-based environment where users can upload and share video stories that can be remixed, annotated, commented, and evaluated. As users perform spatial and temporal re-adjustments to the content of video stories by editing clips and annotating messages, they also become 'authors' of stories told from different perspectives. By responding to other individuals' stories, users also become audiences. As these are features inherent in social media spaces where people connect in order to create and share, we can say that MoViE is a socially-networked environment. The story of MoViE, however, is not new.

The plot of the story was initially weaved around narratives made by mobile phones and for mobile phones (Multisilta & Mäenpää, 2008a, 2008b). And yet, as Mäenpää (2013) explains, it was human activity rather than technology that the

system was designed upon. Nowadays, in addition to the networked space, the overall system involves a client designed for mobile devices with web-browsing functionality. The client uses global positioning system (GPS), collects context data for tag creation automatically, captures videos, and allows for tagging and uploading. While the process of writing the tale of MoViE is ongoing, it is clearly that a story of shaping and sharing, and learning through landscapes and experiences on the digital realm, whether mobile or not, whether wireless or not.

The Mobile Video Experience has already been used for educational purposes in Finland and internationally for learning with storytelling (e.g., Niemi et al., 2014). As students and teachers connect to share stories that catch moments from the narrators' lives, storytelling becomes digital among an audience of peers. By telling digital stories for pedagogical purposes that draw from their own life experiences and historical, cultural, and natural environments, students and teachers build content and relevance, and learn and grow in 'public' (Vivitsou et al., forthcoming). This is the very point at which MoViE as a pedagogically-mediated public sphere intersects with narrative and Aristotelian theories on drama (e.g., mimesis as a creative re-description of the world, a story, a situation, etc.). According to Mäenpää (2013), this design approach emerges out of the need to create a space for sense-making and communication and arises as the response of the digital era to the days of hyperfiction and computer-generated content. It is at this point then where the 'storyfication of learning' (Multisilta 2013) becomes possible. In such learning spaces, the student, as storyteller, becomes an active, collaborating participant who builds knowledge with connected peers in physical and virtual environments.

RESEARCH METHODS AND DATA COLLECTION

The results discussed in this chapter are part of the FINNABLE 2020 research project, in which DST and the ways it can support students' learning were explored. The data for the study were collected in 18 Finnish classes during autumn 2013. The data consisted of 18 interviews with teachers and 34 group interviews with two to five students each. One or two groups of students were interviewed from each class, and the grade level of the participants varied from preschool to upper secondary level. All the interviews were semi-structured and they were carried out during autumn 2012 and spring 2013. The transcribed interviews were analyzed by means of qualitative content analysis.

In the following chapter we discuss the results of the study. First, we describe how DST was used in the classes. After that, we focus on teachers' experiences about using the method in teaching. Then, we describe how teachers and students felt DST enhanced students' learning of collaboration and ICT skills.

FINDINGS

Digital Storytelling Projects in the Classes

Teachers could choose the way they wanted to use DST in their teaching. Some of them connected the project with particular school subjects, while others decided to use the method to discuss more general and student-driven themes, such as school life and students' interests and hobbies. In most cases, the modes of working in the classes were student-driven: students made stories from their own perspectives, using their own voices and creativity. In addition, in every class, digital stories were made collaboratively in pairs or small groups. A summary of the story topics is shown in Figure 1, then discussed in more detail.

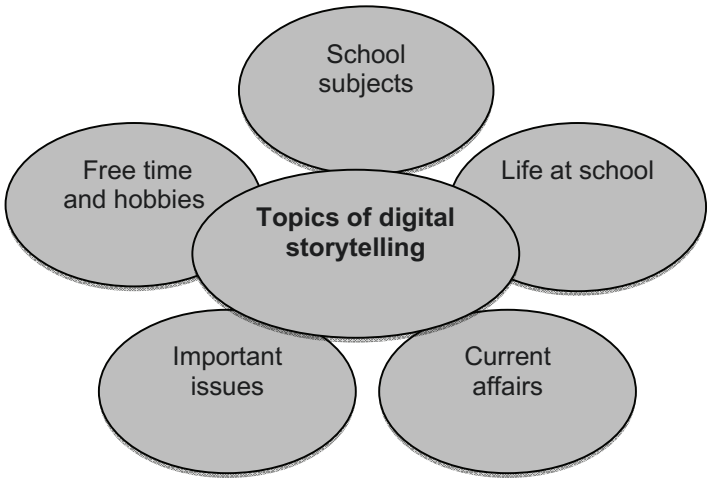

Figure 1. Topics of the digital stories.

DST was used with language learning, physics, chemistry, biology, history, and art. Many teachers integrated the method into two or more school subjects. For example, the students in one fourth-grade class made digital stories about how they came to school every day. With this topic, the teacher combined traffic education, language learning, and art in her teaching. In addition, some of the classes used digital stories as instructional videos where students taught certain topics or skills to others by making a video about them.

Many of the digital stories made by students concerned themes of identity and self. Students made videos where they told others about themselves, their school, or their country. In some classes, stories were also used as 'video notebooks' where students described their everyday lives or where they stored memorable moments from some special event at their school.

With DST, students had a chance to display the world from their own perspectives and tell others what mattered to them. Students also used video stories to describe what they considered interesting or fun. In many classes the students made stories about their free time and hobbies, such as horse riding, photography, playing piano, gymnastics, and skateboarding.

DST was also used as a way to discuss important and current affairs like the environment and sustainable development. Video stories also served as a channel to discuss difficult issues. For example, good manners and preventing bullying were popular digital storytelling topics in many classes. In one fifth-grade class, the students made videos about how to behave well at school. The class had talked a lot about the importance of good manners and respecting others at school, and many students wanted to choose this as the topic of their video stories.

Teachers' Experiences about Using Digital Storytelling in Teaching

The teachers saw that DST activated students. They indicated that the method provided space for learners to work independently and to use their own expression and creativity. In addition, the learner-centered approach enabled teachers to stand aside more in terms of the traditional role, but at the same time it required them to organize, support, and guide work in the class. Teachers felt that the role of an organizer or facilitator required them to have knowledge about making digital stories or movies but also skills for leading a project and making assessments. In addition, teachers emphasized that DST required them to have self-confidence and engage in careful project planning. One teacher described the experience as follows (Hiltunen, 2013, p. 52):

> I think that the teacher's most important task is to consider how to evaluate the process and to teach students to see what their own part was during the activity. Digital storytelling requires tolerance of uncertainly, technical skills, time management, and skills for grouping students.

Most of the problems faced during the digital storytelling project related to the use of ICT. Although the MoViE platform was regarded as useful and quite easy to use (Niemi et al., 2014; Hiltunen, 2013), some problems also occurred. For example, Internet connections in some schools were quite bad, which disrupted uploading and remixing the videos in MoViE, as it was employed online. In addition, computer security settings in some schools were so high that students were not able to upload videos to the school's computer and thus to MoViE. Teachers felt that using DST in teaching required them to have ICT skills, which could support and promote working with the stories.

Learning with Digital Stories

Both the teachers and students felt digital storytelling supported students' collaboration skills. In order to create a good story, students needed to work together, and practice interaction skills and mutual respect with each other. When

making stories in small groups, students had the possibility of developing their communication and collaboration skills in a natural context. One seventh-grade teacher described the process as follows:

> What students learned in this project – I think group skills definitely. Doing things together, planning and organizing, all these kind of skills.

One 6th grade student considered working in groups both fun and educational:

> It was fun to do the stories in groups. I think we learned a lot and our group work got stronger.

When developing stories together with others, a wide number of different ideas and perspectives can arise. Teachers described how students learned to justify and share their own ideas and to negotiate and solve conflicts:

> It's inevitable to have conflicts when working in groups, even when you are good friends and get along well together. When the time schedule is tight and the technology is not always so easy to use, then unexpected situations happen when they don't know what to do. This is when the social competence is measured, and I think that's what develops with this. (fifth-grade teacher)

In addition, teachers and students felt digital storytelling enabled students to develop ICT skills. Teachers indicated that students learned how to search for information from the Internet, how to evaluate and use information, and how to present it to others. By watching their own and others' stories, students could also practice how to give and receive feedback:

> I think that they learned how to search for information and how to manage it. Information search and processing, sharing information, commenting on other students work, this kind of mutual expertise. (eighth-grade teacher)

Students were also learned more about sharing information and privacy issues. In addition, they learned meaningful technical skills during the project: how to make videos, how to download files to the computer, and how to edit videos into a story. A student from the ninth grade described:

> I'm not very good with computers or downloading video clips. I haven't edited videos before, but now I learned how to do that on the MoViE platform.

DISCUSSION

The learning environment and its culture influence the ways in which learning is supported. Since the activity of a learner is essential to the learning process (White, 2011), it is essential to favor student-centered approaches in teaching. Digital storytelling offers a meaningful alternative to support this kind of activating

learning in formal education as it lets students create and edit stories from their own perspectives and comment and respond to other learners' stories.

In this chapter, we described how DST can be used in a classroom. As our study suggests, it is possible to integrate the method with many different subjects and educational themes. The use of DST and other methods where students' active role in learning is emphasized, teachers often need to take on the role of a facilitator, which may differ from the way they traditionally teach (e.g., Hmelo-Silver & Barrows, 2006). Teachers that participated in the study felt that using DST in teaching required them to have ICT and project-leading skills in order to support effectively students' efforts and interactions in the ICT-enriched learning environment.

We also examined how the use of DST in teaching can support children's learning of collaboration and ICT skills, which are important for the 21st century. According to the teachers and students that participated to the study, the use of digital storytelling in class does in fact promote students' learning of collaboration and ICT skills in several ways. For example, making stories in pairs or groups enhanced students' interaction and teamwork skills, and enabled students to justify their own ideas and solve conflicts together. Teachers also described students learnt how to search for and manage information and how to evaluate and share it with others.

As described in this chapter, DST can support and enrich a learning environment in the classroom. In our study project, stories were made in the Internet-based environment MoViE, which offers a simple tool for editing and remixing videos. In addition, it works as a channel to share and comment on others' stories. With this kind of setting, DST can expand the learning environment of a class to beyond the walls of an actual classroom. At the same time, it promotes collaborative learning as it allow students to learn from each other and build joint understanding of different phenomena of the world.

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5. SCIENCE THROUGH THE CAMERA LENS

ABSTRACT

The focus of this chapter is to discuss how recording videos and generating digital stories promote the learning of science from the perspective of students. To do so, we have examined 12 group interviews of 44 Finnish 5th grade students who participated in our teaching experiment in autumn 2013. The results indicated that recording and generating digital stories added value to the learning process in five ways. First, the students enjoyed filming their inquiries on various physical phenomena during the lessons. Second, the videos offered support for the students to remember the things that they did and learned during the lessons. Third, the mobile technology itself brought variety to the learning process, especially allowing the students to handle the tablets and to be responsible for them. Fourth, students found joy in using technology, partly because it seemed fun and interesting and partly because it allowed them to entertain themselves in between the learning tasks by, for example, surfing the net and chatting with friends. Fifth, through the camera lens, students gained a wider perspective of motion as a scientific phenomenon in their everyday surroundings.

Keywords: *science, learning, video stories*

INTRODUCTION

The decreasing trend of engagement and motivation to study science, technology, engineering, and mathematics (STEM-subjects), students' lack of personal relevance of science as well as the declining rate of learning results in these disciplines are among the key concerns of today's education (Krapp & Prenzel, 2011; Lavonen & Juuti, 2012). Even though Finnish students have achieved top results in international PISA Scientific Literacy Assessments, which chart the science competencies of 15-year-olds (OECD, 2007, 2013), trends of diminished interest in science have to be taken seriously universally. Thus, Finnish educators and public decision makers are making an active stance and are looking for ways to increase and strengthen the students' interest in science in order to promote positive learning results now as well as in the future. For example, effort is made to discover new pedagogies and tools that integrate information and communication technologies (ICTs) into the classroom activities (CF, 2013).

H. Niemi et al. (eds.), Finnish Innovations & Technologies in Schools, 57–66.

The Mobile Video STEM Inquiries (MoViSTEM) project has been conducting design-based research and development to establish a broadly scalable approach for students and teachers to record videos of events and phenomena that spark questions, foster engagement, and serve as seeds for inquiries in the STEM disciplines. The project is part of Science Across Virtual Institutes (SAVI), a joint program of Finland and the United States (US) that is run by the Academy of Finland, Tekes, and the National Science Foundation (US). The overall goal of SAVI is to understand, theorize, and test learner engagement in order to advance science learning and teaching.

This chapter discusses a teaching experiment carried out as part of the MoViSTEM-project during the autumn of 2013 in two Finnish primary school classes with 11-year-old students. All the activities in the experiment were included in the curriculum. The aim of the experiment was to study how students see mobile video recording and digital storytelling as learning methods from a motivational point of view. During the experiment, students investigated various scientific phenomena, particularly physical ones, by conducting practical inquiries and filming them. Based on their video clips they remixed longer stories, added annotations to them, and discussed them with their peers. As a medium for their filming and editing the students, used Mobile Video Experience (MoViE), a password-protected mobile video sharing platform (Multisilta et al., 2012; Tuomi & Multisilta, 2010; Multisilta & Mäenpää, 2008) that is described in more detail in Harju, Viitanen, and Vivitsou in this volume.

Discovering a New Pedagogy

From a pedagogical standpoint, the teaching experiment described in this article combined inquiry-based learning, mobile learning (m-learning), and digital storytelling. Together they form a pedagogical approach that in this study is called learning science by doing digital stories (see Figure 1).

Inquiry-based learning is a widely used pedagogical approach in the field of science, and it retells the principles of an authentic scientific investigation. It provides a learner-centered and motivating learning environment through which the nature of science and scientific endeavor can be understood and perceived from a more realistic perspective (Kubicek, 2005). Inquiry-based learning originates from the work of John Dewey (1964), who considered inquiry as an effective method for science instead of ready-made knowledge and facts. Banchi and Bell (2008) divide the use of inquiry in learning into four levels. In the lower two levels, confirmation and structured inquiry, students are provided with the research questions and methods in advance. At the most basic level, they also know the results beforehand. These two levels of inquiries are more common in elementary science curricula. They are intended to introduce students to conducting investigations and practicing inquiry skills, such as collecting and recording data.

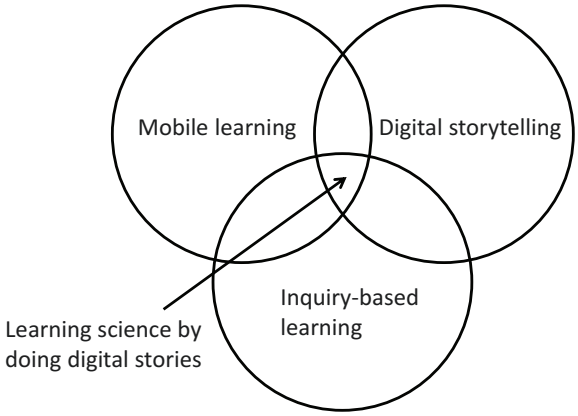

Figure 1. Learning science by doing digital stories.

At the third and fourth level of inquiry, students are more autonomous in their investigations. According to Banchi and Bell (2008), at the third level, guided inquiry, students are provided with a research question, and everything else is student designed. The fourth level of inquiry is the most open one. In it, students formulate both the research question and the methods. Open inquiry includes for example the following phases: defining and investigating problems, formulating hypothesis and planning the inquiry, collecting data, and drawing conclusions (Lavonen et al., nd). According to Kubicek (2005), ICTs can facilitate inquiry-based learning and provide new tools for representing the nature of science in the classroom. In this case, ICTs were introduced in the form of mobile learning and digital storytelling.

Mobile learning (m-learning) means learning and teaching processes that utilize mobile devices such as smartphones, tablets, or laptops (Kearney et al., 2012). Because mobile technology, especially smart phone and tablet technology, is rather new and rapidly developing, the pedagogical approaches for mobile learning are also evolving. One way to describe m-learning is to understand it as a continuation of e-learning and to consider the situatedness of learning as one of its key elements: a mobile learner can take a device out in an authentic context with an emphasis on ownership, informality, and spontaneity, whereas in conventional e-learning, the time and place of the learning are usually dictated by a computer (Traxler, 2009, 2010). At school, the informal and flexible aspects of m-learning both challenge and adapt to the classroom boundaries, curriculum and school rules. Examples of these include firewalls, software designed to support the curriculum, or limitations in the use of students' own mobile devices (Sharples, 2006).

Digital storytelling complements the earlier two views by bringing about the aspect of storytelling as a form of cooperative and shared learning (Sadik, 2008). Robin (2008) divides digital stories into three types: personal narratives,

stories that inform or instruct, and stories that examine historical events. Personal narrative is the most widely applied type of digital story. Other types are gaining popularity as the use of digital storytelling for pedagogical purposes is increasing. According to Robin (2008), informative or instructive stories can be used to present information on subjects ranging from math and science to art and technology. Typically these are made by teachers, but they can be student-generated as well. In this case, students recorded videos from their inquiries at lessons with a tablet provided by the school. Later they edited and remixed those videos into informative stories about their topic. The practice of creating stories is presented in more detail in upcoming chapters. The present research continues the work of earlier studies in using the MoViE platform as a learning environment for creating digital stories (Multisilta & Mäenpää, 2008; Tuomi & Multisilta, 2010).

FRAMEWORK OF THE TEACHING EXPERIMENT

Implementation in the Classroom

The topic of the experiment was motion. The learning objectives for the students were to learn to identify and classify different types of motions, such as linear, curvilinear, and constant motion, and to understand the concepts of velocity, acceleration, and force (NBE, 2014). Technologies were there to mediate and promote learning by letting the students capture their inquiries made during the lessons in videos and transfer them for further processing into a web-based MoViE-platform that was used in regular classroom settings via computers and laptops. The school provided the students with tablets (iPads) for video recording purposes. It was a prerequisite for the experiment as the students generally do not have a possibility to use their own mobile phones or tablets at school. However, students were encouraged to capture videos and use the platform in their free time from their own devices, but only few of them did as it wasn't, as they put it, "… *a compulsory homework*".

The teaching experiment consisted of three types of lessons: 1) pre-task, 2) inquiry-based lessons and 3) video editing lessons. Pre-task and inquiry-based lessons were teacher-led, whereas editing lessons were researcher-led. Students recorded their videos during the pre-task and inquiry-based lessons. Lessons were phased so that after the pre-task and inquiry-based lessons, there were one or two editing lessons remaining for video remixing and editing. All the activities were part of the curriculum, and it took 11 lessons (each lasting for 45 minutes) altogether to complete the experiment. One lesson was for the pre-task, and four of the lessons were inquiry-based. The remaining six were editing lessons.

The pre-task consisted of one lesson at the beginning of the experiment during which students recorded videos freely in the school yard. The aim of the pre-task was to let the students observe motion in their immediate surroundings and probe their preconceptions on the topic.

During the inquiry-based lessons, students filmed their own inquiries relating to motion. Inquiries included the testing of the influence of force by dropping different kinds of objects from varying heights and measuring the velocity of various motions between points A and B. In addition, students observed different forms of motion, such as when circulating a rope, crawling on the floor, and letting go of a full-blown balloon and allowing it to deflate while flying in the air. During these inquiries, students also gathered quantitative measurements by calculating the average speed using the time and distance of the motion. After doing a series of inquiries, students discussed their findings and defined the observed concepts collectively with their teacher.

At the editing lessons, the goal for the students was to produce informative digital stories about motion based on their learning during the inquiry-based lessons. All the editing took place in the MoViE-platform. The task for creating digital stories was iterated along the course of the experiment according to the principles of a design-based research (Sandoval, 2004). At first, the task was very open: participants could just compose remixes from the videos recorded during the lessons and add instructive and informative annotations to them. As the students did not seem to progress enough with that type of assignment, a more concrete framework was offered: a short story that consisted of six parts, each describing a sequence from a day of two imaginary school children and their observations and experiences of various motions from the time they woke up to the time they got to sleep. Sequences were divided between the student groups so that each group had one sequence to work with (Kallunki, Penttilä, & Ojalainen, 2014).

Short stories significantly promoted the activity of the students, and as a result they produced 17 digital stories by working in pairs or groups of four. As material for their films students used both their own videos captured during the lessons and videos shot by the researchers outside of the school. Some students also recorded new material inspired by the short story. All in all, the final digital stories were mostly metaphorical in nature rather than exact replications of the given stories, which fit well with the topic (motion) and the learning objectives of the experiment in general. On average, students' digital stories lasted for 47 seconds, consisted of seven video clips, and had three annotations in them.

Challenges and How They Were Met

Challenges encountered during the experiment were mainly technical in nature. Vivitsou et al. (forthcoming) refer to these problems as Pandora's Box of technology, which means that the box has invisible challenges embedded in the use of technology; they often relate to bandwidth issues and connectivity. In this case, video uploading from mobile devices and remixing in the MoViE platform were quite slow from time to time. This delay created frustration among the students and made some of them lose their focus. After limiting the duration of the video clips and uploading students' videos to the server during the breaks between lessons, the process eased up a bit.

It also seemed that technology complicated the classroom activities to some extent no matter how thoroughly it was implemented. Students were so fascinated about mobile devices and computers that it became difficult to grasp everyone's attention collectively. Thus, a lot of individual guidance was needed to advise the students to use the technology purposefully. These kinds of reactions can pose a challenge to the general working pace of the classroom. At the same time all the stir and clamor can be seen as signs of enthusiasm that are required in the active learning process.

RESEARCH METHODS AND DATA COLLECTION

The results of this paper draw from 12 group interviews of 44 students from two 5th grade classes in an urban school in Southern Finland. Group interviews were carried out after the teaching experiment during autumn 2013. Students were interviewed either in pairs or in groups of three or four. For the analysis, data were transcribed, and worked further with Atlas.ti. The target of the analysis were the students' answers to the questions: "What was it like to learn science with MoViE?" and "How (and if) was learning different compared to the more ordinary learning situations of today?" Our analysis also touches upon what students learned about their topic, motion, during the experiment.

JOY OF FILMING

Our results indicate that learning by doing digital stories added value to the learning process in five ways (Table 1). First, the students enjoyed learning by making inquiries and then filming them. They considered this kind of learning to be more appealing than regular learning methods involving textbooks and

Table 1. Main and sub classes of added value derived from the data (N)

Learning by doing (13)	*Memory enhancement (7)*	*Using technology (6)*	*Joy of learning (4)*	*Better analytical skills (4)*
Text- and notebooks play only a minor role in lessons.	Possibility to revise things from the videos.	Learning new things about technology.	Fun and interesting learning experience.	Wider perspective of the surrounding scientific phenomena.
Exploring things in practice.	Filming gives a better recalling.	Recording videos.	Possibility to surf the net.	

notebooks and stated, for example, that: "*I'd rather study like this than read from the books*". This finding fits very well with the study of Niemi et al. (2014) where the aspect of pupils' enjoyment in creating their digital stories also appeared.

Second, videos offered support for remembering things done and learned during the lessons. Students stated that with the possibility to revise things from the videos, they had been able to refresh their memories in a way that hasn't been possible before:

> [By using videos] you probably saw the motions a little more often, and you had to think them through a little bit more.

Third, using technology itself made the learning different from the ordinary. The possibility to use the tablet and film the inquiries had an impact on the students. On the one hand, it provided them with filming skills. On the other hand, the students felt they were responsible for the school's equipment, which increased their sense of accountability and commitment to the learning tasks:

> You have this ... Kind of a greater responsibility. You cannot, like, break the equipment or anything.

Fourth, students found joy in using technology. From a pedagogical standpoint, the joy was two-fold in nature; students considered learning funnier and more interesting than in their usual settings, but at the same time, emphasis was placed on entertainment rather than the tasks at hand. As one student put it:

> The benefit of [this kind of learning] is that it's nice if you can be on the internet.

In practice this meant, for instance, surfing the net and chatting with friends while editing videos. As this type of behavior might be unwanted, it may not be eliminated, either. Instead, the freedom that comes from when working with the social mobile technology needs to be harnessed to increase the students' engagement in learning. According to Resnick (2006), that could be done by giving the students an opportunity to modify their learning tasks to accommodate their personal interests.

During the experiment, students learned to name and classify different kinds of motion. This is in line with the learning objectives of the experiment in general and with Finnish National Core Curriculum for Basic Education in particular (NBE, 2014). In practice, this meant that students adopted scientific concepts to describe motion or, as they put it themselves, "*New words for familiar phenomena*", such as constant motion to tell if something is moving at the same speed all the time. Students pointed these new concepts out from their videos during the interviews. This is where the fifth additional value of digital stories becomes visible. Motion was a phenomenon that students saw everywhere around them, but they rarely stopped to analyze it. Thus, by observing their surroundings through the camera lens, students learnt to recognise motion as a scientific phenomenon more widely

and deeply than with ordinary learning methods. One student described it as follows:

> I've never thought that if someone is scooting, that okay, this motion is of course something like … When I'm outdoors, I haven't been thinking on how to name the ways in which others are moving.

CONCLUSIONS

This chapter presents a pedagogical model for teaching and learning science using videos and digital stories. This kind of inquiry-based learning can be applied at a primary level as well as in other levels of education. According to the educational purposes, one can vary the orientation towards the topic (scientific vs. practical), the use of a frame story (teacher made, student made, readymade, or none), surroundings and settings of filming (formal school environment vs. informal settings), and editing processes (e.g., contents of the annotations and discussions) as well as the level of inquiry (Banchi & Bell, 2008).

The results showed that students enjoyed recording and generating videos from the inquiries they had made even though the border between using technology for purely entertainment and for purposive learning sometimes wavered. This is a dilemma that many educators face these days when applying technology. However, experience has proved that the more familiar the students become with a certain technological tool, the more they are able to focus on their learning tasks and the more thoughtful they will become with their working habits without losing the pleasure of a nice tool. Therefore, it seems that this type of learning can easily correspond to current policy level goals set for education that, among others, stress the joy of learning (CF, 2013).

All in all, this research study indicates that mobile technology and student-generated videos could be integrated into the learning of hard sciences, such as physics. With careful planning and implementation, there are several benefits it offers to students and the learning process as a whole.

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PART III

GAMES FOR LEARNING

Learning with Motivation and Engagement

VILHELMIINA HARJU AND JARI MULTISILTA

6. ANGRY BIRDS FOR FUN IN LEARNING[1]

ABSTRACT

Student interest and engagement play a central role in learning. Hence, when considering the ways learning is best enhanced, it is essential to direct attention to activities and materials that learners find interesting and fun. In this chapter, interest and engagement in learning activities are explored in the context of playful learning. The playful learning environment consisted of Angry Birds Playground learning materials that were produced by Rovio Entertainment Ltd. These materials were used and tested in Finnish preschool and first-grade classes. The data for the study were collected during interviews with the children and their teachers and also by observing class activities. In addition, questionnaires were used to measure the children's experiences with the use of the learning materials. The results indicated that the children found it to be fun and engaging to work in the playful learning environment. Particular features of the materials, such as familiar characters, use of mobile devices, and certain games, were considered as particularly fun and engaging.

Keywords: *engagement, interest, playful learning, education*

INTRODUCTION

The basis for learning and motivation to learn begins to form in early childhood. When considering the ways children's learning can best be enhanced, it is essential to direct attention to activities and materials that children find relevant and stimulating. In Finland, both the national curriculum guidelines for early childhood education (THL, 2004) and the national core curriculum for preschool education (FNBE, 2010) emphasize the importance of play as an essential method for learning. Play and playful activities are seen as central ways of making sense of the world and for practicing new skills (Rice, 2009). By bringing interesting materials into teaching, the learners' enthusiasm to participate in different activities can increase (Schiefele, 2009). In addition, subjects and activities that are considered interesting or fun are more likely to engage learners and improve learning (Hu & Hui, 2012). Positive learning experiences can also improve learner's self-efficacy; this can, in turn, promote a learner's motivation to learn (Zimmerman, 2000).

In this chapter, interest and engagement in learning activities are explored in the context of playful learning. We discuss the ways playful activities and playful learning can motivate children to learn and thus improve their learning. The chapter is based on a pilot project in which Angry Birds Playground learning materials produced by Rovio Entertainment Ltd. were used and tested in Finnish

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kindergarten and first-grade classes. The data for the research project were collected by interviews with the children and teachers and also by observing class activities. In addition, questionnaires were used to measure children's experiences with the learning materials.

In the beginning of the chapter, the role of play in early learning is discussed. We also describe how interest and engagement can be seen as essential elements in playful learning environments. After that, the methodological process of the study is described, and the ways playful activities and learning materials can enhance students' interest and engagement are presented.

THEORETICAL BACKGROUND

Play and Learning in Early Childhood

In early childhood, new experiences are usually acquired through play activities. For children, play is a natural way to explore and learn new things in their environment. Play can be seen as a complex concept, so it is difficult to define it (Samuelsson & Carlsson, 2008, p. 626). In some contexts, play is primarily seen as children's free and spontaneous activity, whereas other definitions also include adult-driven playful activities and games (Hyvönen, 2008) as different forms of play. The latter way of seeing play is used in this chapter.

Despite the way play is perceived, different definitions have at least one thing in common; they all emphasize play's central role in enhancing enjoyment and pleasure (Caillois, 2001). Games and play produce joyfulness that can motivate people to take action. Playful activities that are considered fun and interesting can act as a trigger to start the learning activity (Rice, 2009, p. 96) and promote engagement in working with certain activities and tasks.

Playful Learning Environment

The concept of playful learning has been connected to adult-supported play (Gordon, 2012), learning through games (Spikol & Milrad, 2008) and to creativity and co-creation used in teaching (Kangas, 2010). Here, playful learning is understood as a social process that occurs in the interaction between learners and their environment in a specific learning context that consist of playful learning materials. Sociocultural theory is the basis for how learning is understood in this study. Learning can happen when working with different artifacts like educational games, books, or musical instruments but also occurs in social collaboration with others, for example, in physical games or imaginative play (Vygotsky, 1978).

In this study, the playful learning environment consisted of Angry Birds Playground learning materials produced by Rovio Entertainment Ltd. The materials included activity books, game cards, a kantele (a traditional Finnish five-string instrument), e-activity books, mobile math games, and educational posters. The content of these materials was based on but not limited to the Finnish national

curriculum for preschool education. The aim of these materials is to support children's learning in a playful and exciting way (Rovio Entertainment Ltd., 2014).

During the study, teachers could freely decide how they wanted to use these materials in their teaching. Most of them scheduled certain hours or classes every week to use the materials. Often, they were used as an initial topic in a class; kanteles were played in music class, and games were played in physical education. Assignments in activity books were usually done during a class dedicated to that activity. In some groups, a teacher had chosen the assignments beforehand, with a focus on math or language skills that would be done in a particular class. Alternatively, in some groups, the children were able to decide what assignments they wanted to do during the class. In addition, materials were sometimes used as a complementary activity within a certain class. Thus, the children used the materials after they finished their primary assignments or activities.

Interest and Engagement Improve Learning

In education, it is important to find ways that can trigger learners' interest and motivation to learn by offering them activities that are considered rewarding for their own sake, based on intrinsic motivation. Hence, working with a topic does not depend on external control. Instead, some activities are triggered by extrinsic motivation, which means they are guided by external rewards, regulations, or persuasion (Ryan & Deci, 2000).

Activity that is based on intrinsic motivation includes feelings of interest, happiness, and satisfaction (Ryan & Deci, 2000). An optimal state of intrinsic motivation is often called *flow*, which refers to a special kind of task where learners are engaged because of the pleasure they can get from the activity itself. To maintain interest, learners must work on activities that are perceived to be just challenging enough to motivate them to complete the task (Csikszentmihalyi, 1990). When intrinsically motivated, learners work persistently at activities that can enhance learning (Fulmer & Frijters, 2009). In formal education, engagement and interest can be associated with particular materials, the way the teacher is presenting the topic, or the learner's personal interest towards the subject (Schiefele, 2009, p. 198).

RESEARCH METHODS AND DATA COLLECTION

Learners' interest and engagement play a central role in efficient learning processes (Hu & Hui, 2012). Thus, this study explored how learners concentrated and were engaged when working in a playful learning environment. Because the feelings experienced in a certain learning context are linked to the learner's interest and engagement (Fredricks, Blumenfeld, & Paris, 2004; Schiefele, 2009), the aim was also to investigate how the learners in this environment experienced the Angry Birds Playground learning materials and how they used them. In this study, interest and engagement were measured using the children's feelings towards materials and activities, their willingness to use the materials, and their level of involvement

during the activities. The following signals (Laevers, 1994; Pascal & Bertram, 1995) were considered to be a sign of engaged work in a playful learning environment:

- Concentration
- Energy
- Complexity and Creativity
- Facial Expression and Posture
- Persistence
- Precision
- Reaction time
- Language
- Satisfaction

The data for the project were collected during spring 2013 in Finnish kindergartens and elementary schools. Four kindergarten groups (children aged 5-7 years) and six first-grade classes (children aged 7-8 years) participated in the study. In all, 183 children and 12 teachers were involved.

The study project continued for three weeks in the kindergartens and elementary schools. The groups were asked to use the materials at least four hours each week. In addition, each material was requested to be used at least once. Otherwise, the teachers could freely decide how to use the learning materials in their classrooms. The materials could be used, for example, as a part of a structured group activity or in children's free play. The groups had all the materials, except the e-activity books and the mobile math games, available for their use at any time during the entire three-week period. Mobile devices could be used only once during the project.

The data were collected by means of interviews with the children and teachers and by observing class activities. In addition, specific questionnaires were used to measure the children's experiences with the learning materials.

FINDINGS

Children's experiences regarding the materials and the activity in the playful learning environment were explored partly using questionnaires. After each occasion that they used the materials, the children filled out a short questionnaire that consisted of a *Smileyometer* and an *Again-Again Table* (Read, 2008). The Smileyometer is a five-point Likert-type scale that asks children to choose from five faces the one that best represents their feelings about the activity. The faces vary from very sad to very happy. In the Again-Again Table, children are asked to answer whether they would like to do same kind of activity again. Possible answers are yes, maybe, and no (Read, 2008).

The results from these questionnaires indicated that the children found the activity to be very fun. The happiest smiley face was chosen 754 times, which was a rate of 72.6%. The second happiest face was picked 140 times (13.5%), and the neutral option was the answer for 90 occasions (8.7%). The second saddest face was chosen 16 times (1.5%), and the saddest one was picked 38 times (3.7%). Figure 1 indicates the children's answers regarding how much fun the activity was.

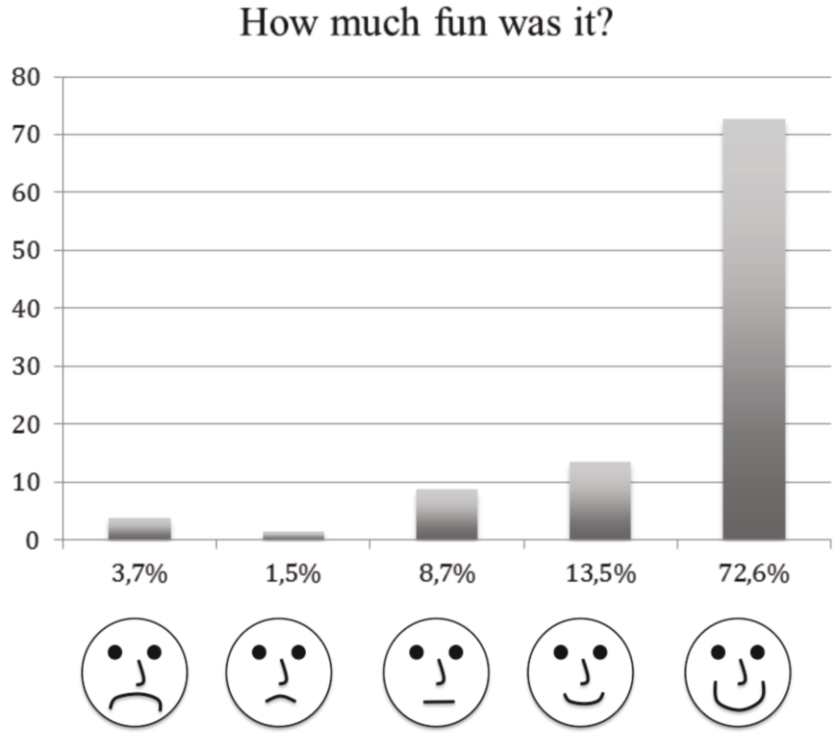

Figure 1. Children's answers about how much fun the activity was.

When asked if they would like to do the same kind of activity again, the children answered "Yes" 743 times (70.8%), "Maybe" 213 times (20.3%), and "No" 93 times (8.9 %).

The students' experiences with the activity were also collected by means of group interviews. In these interviews, some children associated fun with new kinds of activities that they had not played before at home, in kindergarten, or at school. For example, the mobile math game was described as fun as it was a completely new kind of game and activity. In the game, children raced against time by running in the yard or gym, looking for the Angry Birds characters that had to be "caught" with a mobile phone. Many children found it fun to move and run while playing the game. The game-like features were also seen as pleasant, as one preschooler described:

> It was the funniest when I showed our teacher how many birds I had got and then I tried to beat the score.

Also some features of the materials were described as pleasant. For example, certain plays in the game cards and particular activity book assignments were considered fun. In addition, the use of the mobile devices and the familiar Angry Birds characters were often described as pleasant.

Children also mentioned features that they considered unpleasant or dull when working in the playful learning environment. Usually, negative feelings were connected with tasks or materials that were hard or difficult to use. For example, drawing the Angry Birds characters or playing the mobile math game was described as unpleasant if the children felt they did not have the skills needed in that activity. Conversely, activities that were perceived as too easy were often also described as boring or unpleasant.

Both the observations made during classes and the interviews with teachers indicated that children were engaged in the activity in the playful learning environment. This engagement was observed as focused working behavior and concentration when doing assignments in activity books and as energized participation with the kanteles and games.

In the study, teachers were also asked to describe, why they thought the children liked the activities in the playful learning environment and what enhanced, in their opinion, children's engagement with the activity. In their answers, teachers connected engagement to the following features:

- Angry Birds characters that were familiar from free time and the children's culture.
- Activity that the children considered entertaining instead of studying (for example when working with an e-activity book on a tablet computer).
- New kinds of tools in a formal learning environment, such as a mobile phone, a tablet computer, and a kantele.
- New types of activities and games, such as the mobile math game.
- Activities that generally interest children, such as playing music, physical exercises, and mobile devices.
- Feelings of success caused by the use of the materials.
- Collaboration and interaction as a part of the activities.

DISCUSSION

New methods and materials in teaching can trigger an interest towards the subject matter (Schiefele, 2009). In addition, materials and devices known from free time, such as mobile devices and characters from mobile games, can improve interest and engagement in formal educational environments. Almost every child who participated in the study was already familiar with the Angry Birds characters. Teachers felt that using these well-known birds in teaching might trigger an interest and promote persistent effort with different tasks in class. Some of the teachers felt that tasks and assignments that children generally consider boring, such as coloring and copying letters, might be more motivating if they included familiar and fun characters.

Maintaining interest and engagement requires working with tasks that are challenging but not too difficult (Csikszentmihalyi, 1990). This trend also emerged in our study. The children described an activity as boring or unpleasant if the assignments were too easy or difficult. Thus, it is important that learning materials are diverse and that they meet the needs of all learners. This goal can be reached with digital learning materials, where the difficulty level of the assignments develops dynamically according to the learner's performance.

Children's motivation to learn is strengthened by positive experiences. Feelings of success and accumulation of knowledge and skills promote learners self-efficacy (Bandura, Caprara, Barbaranelli, Gerbino, & Pastorelli, 2003), which increase their self-confidence and can further affect their enthusiasm and motivation towards learning and studying (Zimmerman, 2000).

Early experiences build a base for children's development and learning. The learning to learn skills and the way the self is seen as a learner begin to form already in early childhood. Hence, it is important to pay attention to the methods that support learning in young children.

Although learning, at its best, is fun, it is not always necessarily easy. However, fun and joy can inspire learners to explore different subjects and topics. In addition, feelings of joy can feed enthusiasm and the intrinsic motivation to learn.

NOTE

[1] Major parts of this chapter are based on an article in the Finnish book *Rajaton Luokkahuone* that was published in 2014 by PS-kustannus.

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7. LEARNING BY TEACHING

A Game-Based Approach

ABSTRACT

Games are a new form of storytelling and social interaction for the younger generation. Furthermore, learning has always been about storytelling and social interaction; infants learn from their parents, children learn from their siblings and friends, and even formal education is based on narration. Furthermore, children are ready to do more work for their game characters than what they are willing to do for themselves. Based on these facts, we developed methods and technologies to enable users to teach their game characters. In this chapter, we show how these user-generated behaviors can be recorded and shared in educational games. According to the ideas in this chapter, game- and media developers can design extensions that enable users to easily construct behaviors. Furthermore, we can demonstrate how user-generated behaviors can provide teachers and parents with very detailed information about individual children's learning processes.

Keywords: *Educational games, character behaviors, learning analytics*

INTRODUCTION

Internationally school systems seem to be in crisis (Kembel, 2010; Välijärvi, 2013). In international public debates, we continuously hear that running a school is very expensive, dropout rates are far too high, and the total school hours are not enabling children to take part in natural play anymore. The only remedy is said to be smaller group sizes, but that increases costs. Therefore, we face a controversy between scale and quality. Finnish researchers have sought new solutions that focus on two main themes: 1) the need for changes in learning environments, and 2) the need for changes in the learning process.

Technology provides novel tools for learning, and these new options will be part of future learning environments. The leading digital content providers, in general, have defined that future classrooms will consist of 1) cloud computing and mobile devices, 2) learning analytics, 3) game-based learning, and 4) adaptive environments. These main themes have been the technical framework for Finnish researchers when developing new learning environments, with a particular focus on games as a new form of storytelling and social interaction for the younger generation. Not only are games more popular than TV or movies, but gamification is everywhere (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011; Huotari &

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Hamari, 2012). This means that children live inside gaming culture, where games are much more than just interactive exercises.

In this context, it is not enough to give just drill types of exercises with a scoring mechanism; games are much more than a scoreboard. However, learning has always been about storytelling and social interaction (McDrurya & Alterioa, 2001; Ryokai, Vaucelle, & Cassell, 2002), and with games we can combine all the expectation of future classrooms with a storytelling format that is familiar to children. Furthermore, the positive relationship between cognitive and motivational themes has been widely studied (Murayama, Pekrun, Lichtenfeld, & vom Hofe, 2013; Mason & Scrivani, 2004; Lapointe, Legault, & Batiste, 2005; Rao, Moely, & Sachs, 2000). We also know that teachers can strongly influence students' motivation and engagement in learning (Lukin, 2013; Aunola, Leskinen, & Nurmi, 2006). Therefore, it is important to produce tools that support the teacher in this task.

SMARTKID MATH – TEACHING THE GAME CHARACTER

The pedagogical idea of SmartKid Math is to put a learner (player) into a role of a teacher. The player gets her own virtual pet that wants to learn mathematics. In the beginning of the game, the virtual pet does not know anything; its mind is an empty set of concepts and relations. The pet learns inductively; each teaching procedure increases and strengthens the network of concepts. The background of the game is in Learning by Doing (Dewey, 1938), Learning by Teaching and Learning by Programming (Papert, 1999).

Children are usually eager to do more work for their game characters than they are willing to do for themselves (Chase, Chin, Oppezzo, & Schwartz, 2009). The game produces the motivation to teach the game characters (Figure 1). According to the story, mice can get cheese only by going through the mathematics labyrinths faster than the cats can. Initially, the cats are better at mathematics than the mice, so the cheese-loving mice need the players' help to learn the mathematics. The player's task is to teach the necessary skills to his or her pet: that is, to a mouse. The game includes several mice that the player can choose from, which facilitates a bond between the player and his or her pet. When a player has taught enough skills

Figure 1. Smartkid Math in short: Teach your favorite character, and gain all the trophies.

to the pet, the player can send it to the labyrinth to survive on its own against the cats. In general, the gameplay can be divided into two main functions: 1) teaching the agent behavior (i.e. mathematics skills to the pet) and 2) running (reproducing) the agent behaviors (i.e. running a labyrinth simulation that is based on knowledge that the mice have been taught).

The framework behind the game is based on the authors' previous work; research articles have been published in this area from the perspectives of cognitive science (Ketamo & Kiili, 2010; Ketamo & Suominen, 2010; Kiili & Ketamo, 2007) as well as from a technological point of view (Ketamo, 2009; Ketamo, 2011). According to cognitive psychology of learning, our thinking is based on conceptual representations of our experiences and the complex relations between these concepts and experiences. When the mental structure changes, it is called learning. The game emulates the human method of learning in the same way by connecting concepts to a conceptual network and strengthening relationships in the existing conceptual networks.

The player helps his/her character with different tasks by teaching it math skills. In Figure 2, the owl presents the character with questions about multiplication tables. The character enlists the player's help because it does not know the answer. The pet learns inductively; the answer is not either correct or wrong. It builds semantic connections between concepts, such as "3*10" and "30".

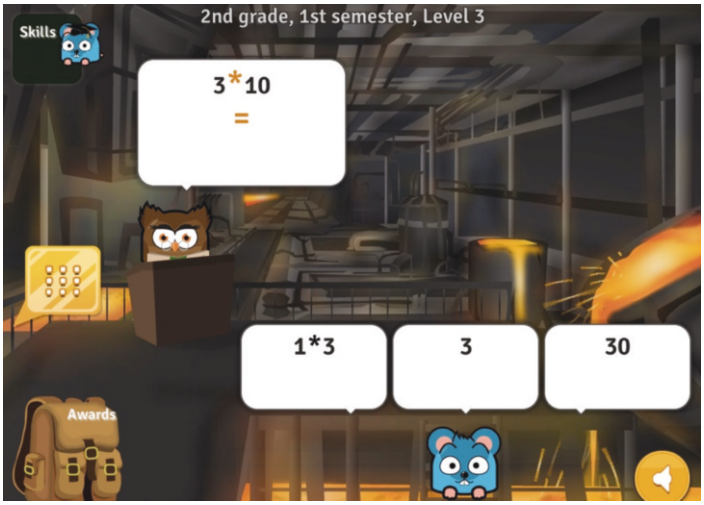

Figure 2. Screenshot from the teaching area.

The character can also be taught incorrectly, so when controlling the character's behaviors, the multiplication of "3*10" is wrong. Teaching incorrectly is an important part of the gameplay, and it is applied in the story. Some characters

should be taught to be as stupid as possible in order to proceed. The game AI also has the ability to analyze the character's performance.

Players can send their characters to compete against any other non-player character or the characters of their friends. Competitions are held in different labyrinths (Figure 3), where decisions are made is based upon the behavior that the player has taught the character. In competition, the character is on its own, and its performance is based on previous teaching. In other words, the character does have a memory, and it solves problems using procedures taught by the player.

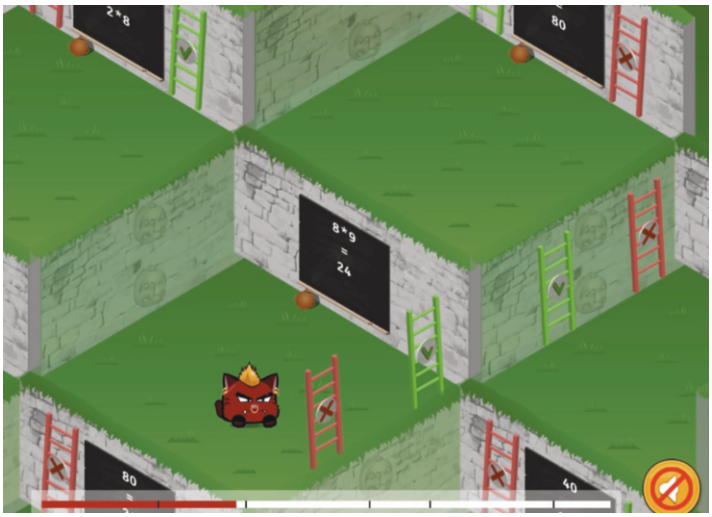

Figure 3. Screenshot from the competition area.

The reasoning behind applying user-taught behaviors as a part of the game is that players can compete against any other player, even when they are not online; the character that they have taught is always online. The same ideas have been applied to sports games in previous studies (Ketamo, Nurmi, & Kallama, 2011).

The progress (level of knowledge) is controlled by the game. Players cannot access the next level until the required knowledge has been learned. However, they can discover future content from the SmartKid Elements channel. The arts and crafts material enables kids at different levels to share their knowledge and creative ideas with others, which is an optimal way to deepen the social learning experience. Naturally, each individual will progress at a different pace, which is one of the objects of SmartKid Math: adaptive and highly individual learning experiences.

GAME-BASED ANALYTICS OF LEARNING

Games and other virtual environments can provide relevant and meaningful information for individual learners, his/her parents, teachers, and finally for the educational system at a national level. In the following section, we focus on 1) in-game analytics for players, parents, and teachers and 2) an analytics tool for national curriculum development.

The in-game analytics tool (Figure 4) allows parents or teachers to quickly observe what the learner has taught his/her pet. The visualization shows correctly taught concepts in the upper part of the area and incorrectly taught concepts in the lower part of the area. The size of the bar indicates the quantity of the teaching, which is the number of taught relations in the pet's conceptual structure. Concepts that have not been taught do not appear in the area at all.

When focusing on dependencies between the taught conceptual structure and pupils' achievements as measured with traditional paper tests, we found that the quality of the taught conceptual structure was correlated ($0.4<r<0.7$) with the paper test scores earned on tests given after game play with all tested content on mathematics and natural sciences (Ketamo, 2009; Ketamo & Suominen, 2010; Ketamo, 2011). Therefore, the game data were just as reliable as a paper test to evaluate learners' skills and their progress.

Figure 4. In-game analytics tool.

In the game, units of math content for the different grade levels represent approximately one Finnish school week in the same grades (1st and 2nd grades). Players can earn one to three stars when completing each level. A bronze prize represents satisfactory skills, and golden prize stars indicate good skills. However,

the results of the gameplay could be somewhat inaccurate; a player might just have good luck and be given easy questions, receiving a golden prize for a performance more worthy of a silver prize. Naturally, this situation can go the opposite way as well, and the player could get questions on content that he/she has never taught to the virtual pet and loose even though his/her overall performance is good. Therefore, the evaluation/assessment with SmartKid Math for a single level is only a rough indication of a student's performance, but completing an entire grade requires skills that would be needed to pass the same grade in a Finnish school.

Analytics outcomes of the learning process can be used when developing national curricula or learning materials. When summarizing the individual game achievements, schools and national level policy makers can receive analyses about competences and skills at a general level. They can apply this knowledge in order to develop their teaching instructions or formal curriculum. Our goal is not to rank countries but instead to provide information for developing the practice.

We carried out a demonstration of applying games-based data to global learning analytics: Our sample (N=49,080) was collected with the SmartKid Math online version, between 1.8.2013 and 31.12.2013. This online version was targeted especially for school piloting, which leads us to believe that most of the players were 1st and 2nd grade pupils. Because all collected data were completely anonymous, we can only be sure about the country from which the data were obtained. From this large sample, we randomly selected 1000 pupils for the final analysis from Finland, the United Kingdom, the United States, Malaysia, and Australia. In other words, the sample size for all the countries in Tables 1-5 was 1000.

We compared differences in the participants' understanding of the core concepts of numeracy: counting objects, number symbols, and places on a number line. The game recorded data continuously during the game play. Therefore, it is easy to see how many players faced difficulties or recorded misconceptions during the game play. The left sides of Tables 1-5 show the percent shares of pupils who 1) faced no difficulties (less than 5% misconceptions on any stage of the gameplay), 2) faced minor difficulties (5%-20% misconceptions on any stage of the gameplay), and 3) those who have had a lot of difficulties.

There were small differences between the countries in percent shares of the no-difficulties and the minor-difficulties group. However, the percent share of critical-difficulties was almost the same, approximately 0.5%. When focusing more on a conceptual level, we observed that in all countries, the number symbol was the easiest concept in basic numeracy, while the number line seemed to be the most challenging skill. In fact, all countries in this example were in this situation. This type of conceptual analysis can help teachers, administrators, and curriculum designers focus on real-world learning outcomes.

Table 1. Outcomes in basic numeracy in Finland.

	Any time during game play			After the game play		
	no difficulties	minor difficulties	critical difficulties	no difficulties	minor difficulties	critical difficulties
count	74.3%	25.4%	0.3%	99.6%	0.4%	0.0%
number	80.5%	19.5%	0.0%	99.9%	0.1%	0.0%
number line	72.1%	27.4%	0.5%	99.2%	0.8%	0.0%

Table 2. Outcomes in basic numeracy in the United Kingdom.

	Any time during game play			After the game play		
	no difficulties	minor difficulties	critical difficulties	no difficulties	minor difficulties	critical difficulties
count	73.5%	25.8%	0.7%	99.2%	0.8%	0.0%
number	81.8%	18.2%	0.0%	99.9%	0.1%	0.0%
number line	71.5%	28.1%	0.4%	99.9%	0.1%	0.0%

Table 3. Outcomes in basic numeracy in the United States.

	Any time during game play			After the game play		
	no difficulties	minor difficulties	critical difficulties	no difficulties	minor difficulties	critical difficulties
count	64.0%	35.3%	0.7%	98.8%	1.2%	0.0%
number	72.9%	27.1%	0.0%	100.0%	0.0%	0.0%
number line	59.4%	40.2%	0.4%	99.0%	1.0%	0.0%

Table 4. Outcomes in basic numeracy in Malaysia.

	Any time during game play			After the game play		
	no difficulties	minor difficulties	critical difficulties	no difficulties	minor difficulties	critical difficulties
count	63.8%	35.8%	0.4%	99.4%	0.6%	0.0%
number	76.5%	23.5%	0.0%	100.0%	0.0%	0.0%
number line	59.6%	39.9%	0.5%	99.2%	0.8%	0.0%

Table 5. Outcomes in basic numeracy in Australia.

	Any time during game play			After the game play		
	no difficulties	minor difficulties	critical difficulties	no difficulties	minor difficulties	critical difficulties
count	67.6%	32.1%	0.3%	99.4%	0.6%	0.0%
number	80.4%	19.6%	0.0%	100.0%	0.0%	0.0%
number line	66.2%	33.5%	0.3%	99.5%	0.5%	0.0%

Educational games in general are meant to provide good learning outcomes. This has been the most important goal for SmartKid Math. The right sides of Tables 1-5 show the shares of pupils who 1) faced no difficulties (less than 5% misconceptions at any stage of the gameplay), 2) faced minor difficulties (5-20% misconceptions during any stage of the gameplay), and 3) those who experienced many difficulties while playing.

Because SmartKid Math is designed to provide adaptive and personalized learning, it can ensure all the basics have been mastered before pupil are allowed to continue. One interesting observation was that almost all the pupils moved into the no-difficulties group after playing the game. In other words, when analyzing the latest performance, almost all the children had learned basic numeracy skills during the gameplay.

CONCLUSIONS

According to our research, users can relatively quickly and easily teach their game characters basic math skills. Behavior modeling makes it possible to emulate conceptual learning and thus uncover the frequencies, dependencies, and patterns behind conceptual change and learning transfer. The learning effect is very promising for this kind of learning-by-teaching method. Games can make a difference in learning, especially because the results were similar all over the world. The biggest challenge that lies ahead is that students who still lack the motivation to play the game will not attain a similar learning outcome.

These results also show the strengths of sharing behaviors: without the ability to share and interact from within the game, the kids likely would not spend much time on school disciplines. On the other hand, if the children like the idea of sharing capabilities in an educational game, they would definitely love it in an entertaining game.

Furthermore, constructing different behaviors for different tasks requires strategic thinking. Teaching behaviors for entertaining purposes could be valid from an education point of view when the context is appropriate. For example, politics is a difficult subject to teach. If learners can teach complex decision-making processes to virtual members of a parliament or other governing body, they will be able to learn about politics, especially the big picture of political decision making.

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8. LEARNING BY CREATING EDUCATIONAL EXERGAMES

Creative Pedagogy That Gets Students Moving

ABSTRACT

With the rapid social, economic, and technological changes currently taking place in our society, collaboration skills and creativity are nowadays seen as basic survival and success factors. Technology-driven changes are also generating new challenges in the knowledge society. For example, the widening gap between daily information-centered activities carried out inside and outside school is undermining students' engagement in school studies. What's more, they are leading increasingly sedentary lifestyles and consequently obesity is becoming an increasing problem in many countries. So there is a clear call for educators to introduce innovative learning solutions and practices that engage students, support the development of 21st century skills, and increase the level of physical activity performed in schools.

In this paper we propose a new pedagogical approach, learning by creating educational exergames, an approach that entails user-generated content and gets children moving during school hours. We report the results of a pilot study in which students created educational exergames for their peers. The aim was to explore what happens when the learning-by-creating-educational-exergames approach is introduced in primary school and how students experience the creation of educational exergames. The results clearly indicate that this innovative approach can be successfully implemented in classroom teaching, it can make the school day more physically active, and help to engage and motivate students.

Keywords: *creative pedagogy, exergames, learning*

INTRODUCTION

Over the past decade, digital gameplay has become a very popular activity with a variety of audiences. Although academic debate continues on the effectiveness of game-based learning, researchers have increasingly argued that the meaning-making practices that occur when people engage with digital games define a form of literacy that is potentially better suited to address the needs of 21st Century learners (Gee, 2003; Squire, 2008; Devlin, 2011). However, recent research has

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proposed that learning by creating games could be a better way of addressing these needs than simply playing games (Robertson, 2012; Bottino, Earp, & Ott, 2012; Bermingham et al., 2013). While the amount of scholarly work on serious games and educational games has grown steadily over the past decade, a recent literature review (Bermingham et al., 2013) revealed that studies on learning by creating games are still uncommon; more research on this theme is clearly needed.

On the other hand, the popularity of digital gameplay as a pastime has generated other problems. Traditional video games are seen as one of the main causes of physical inactivity (Vanderwater, Shim, & Caplovitz, 2004; Sothern, 2004), a phenomenon which is leading to concerns about rising obesity rates in many countries (Rokholm, Baker, & Sørensen, 2010). For example, the percentage of overweight children in the United States since 1970 has more than doubled (Hedley et al., 2004).

The emergence of movement-based game platforms like Nintendo Wii, Microsoft Kinect and Playstation Move has opened the way to a new game genre, exergaming, which is seen as a potential countermeasure to the above issues in that it encourages players to engage in physical movement during gameplay. According to Mueller et al. (2011), exergaming leverages sporting activity and exercise in order to support physical, social, and mental wellbeing.

The positive impact of exergaming indicates that bodily learning environments can also provide engaging solutions for schools. In some schools, exergames have already been integrated into physical education classes. However, the time dedicated to physical education in schools in generally quite limited. Although research results have shown that physical activities can enhance learning (Donnelly & Lambourne, 2011; Castelli, Hillman, Buck, & Erwin, 2007), students spend the majority of their class time sitting still, which is detrimental from both the learning and health perspectives. Time constraints and curriculum demands make introducing exergames in schools very challenging. It would thus appear opportune to integrate bodily interaction into other learning activities, such as educational gaming.

The combination of education and exergames can provide schools with new opportunities for raising students' physical activity levels, in part because exergaming is an alternative learning solution that can be applied without interfering with curriculum objectives. However, the take-up of educational exergaming in schools has been slow, and the current financial state does not make the situation any easier. This is the background for the new pedagogical approach we propose in this contribution called *learning by creating educational exergames.* This approach is based on user generation of content and, at the same time, it encourages children to move. The overall aim of the study was to explore what happens when learning by creating educational exergames is introduced in primary school and how students experience the creation of educational exergames.

THEORETICAL BACKGROUND

This section presents the theoretical background of learning by creating educational exergames. First, the theoretical rationale for designing educational exergames is discussed and subsequently the foundations of learning by creating games are presented.

Theoretical Foundation for Educational Exergames

The design framework for educational exergames (Kiili & Perttula, 2013) forms the foundation for designing effective and physically involved educational games. The major challenge is to balance the physical, cognitive, and sensomotoric workloads in order to optimize learning and health benefits. According to Tenenbaum (2001), exercise intensity impacts the focus of a person's attention. Thus, the integration of learning content and exertion interfaces raises new game design challenges. Sports research has shown that when the physical workload increases, attention allocation shifts from dissociation to association (Tenenbaum & Connolly, 2008; Hutchinson & Tenenbaum, 2007). Dissociation can be defined as focusing outwards and away from body sensations (Scott, Scott, Bedic, & Dowd, 1999), while association regards focusing inwards toward bodily sensations. This natural attention change disturbs the processing of game elements as well as learning and problem solving. In other words, during phases of high physical workload, it is hard to concentrate on problem-solving and game stimuli designed to enhance learning. Generally speaking, the higher the sum of the cognitive and physical workloads, the greater the likelihood that the participant will fail in the game. Thus, the need arises to develop solutions that take players' physical and cognitive constraints into account and ideally find a way to adapt to them.

Theoretical Foundations for Learning by Creating Games

Learning by creating games appears to be an active learning treatment because it is intended to induce learners' generative processing (Mayer, 2005) by challenging them to select and organize information about the subject of the game as they actually define game rules and construct a new game. In general, the pedagogical idea of learning by making games relies on an assumption that the construction of games helps learners to reformulate their understanding of the subject and express their personal ideas and feelings about both the subject of the game and the constructed games (Kafai, 2006). Furthermore, game creation has been argued to support 21st century competencies like creative problem solving, collaboration, ICT literacy, and systems thinking, as well as having a positive effect on engagement in STEM subjects (Zimmerman, 2007; Clark & Sheridan, 2010). There is a certain degree of evidence pointing to the effectiveness of learning by creating games, but sound empirical evidence is still lacking.

A study by Kangas (2010) showed that game playing and computer game making in a playful learning environment provided children with opportunities to

practice their group work skills. Game creation activities offer the chance to learn to be a better communicator, while game development can support the development of students' reading and writing skills, as well as their use of spoken language and visual communication aids. Creativity can also be successfully promoted by developing games (Kangas, 2010; Eow, Ali, Mahmud, & Baki, 2010). For example, Robertson and Howells (2008) state that user-generated game content can empower learners by enabling them to express their creativity. Robertson and Howells (2008) also emphasized that in order to facilitate creativity, students should be allowed extensive play opportunities before they begin game making activities.

MAGOS LITE: AN EDUCATIONAL EXERGAME-MAKING PLATFORM

Game creation embraces a wide range of activities, and the tools to be employed should be carefully selected with regard to both learning objectives and learners' skill levels. When we set out to study the learning that occurs through educational exergame creation, we were unable to find any accessible tools that were suited to the purpose. So, as part of activities carried out within an EC project called MAGICAL (Making Games in Collaboration for Learning), we developed a game creation platform targeted specifically at primary school pupils (Bottino, Earp & Ott, 2012). Called Magos Lite, this is an easy-to-use tool that requires no programming skills. Learners can create side-scrolling educational exergames, where the action is portrayed in a side-view; the player's avatar stays on the left side of the screen, while backgrounds and other game entities move from right to left to simulate forward movement. The game maker can choose between game types in which the avatar either flies in the air or moves along the ground and jumps. To win the game, the player needs to collect or avoid on-coming entities, depending on the game objectives.

The game making process mainly consists of: deciding game type (fly or run) and game mode (time, distance or survival); selecting characters, backgrounds and other elements; creating learning tasks (word matching, calculations, fractions, memory tasks); setting speeds and control sensitivity; and defining rules and scoring for collectibles, hazards, and tasks. Game engagement can be tweaked with a variety of add-ons.

Games can be controlled either by traditional computer clicking or by physical movement (jumping or running) detected by motion sensors on tablet computers. Technically, Magos Lite is a web browser application that in its first incarnation was designed to run on iPad tablets, but it also works well on most current desktop browsers. The Magos Lite game editor is integrated into the Magos web portal, which manages user authentication and authorization, and also provides access to user-produced games.

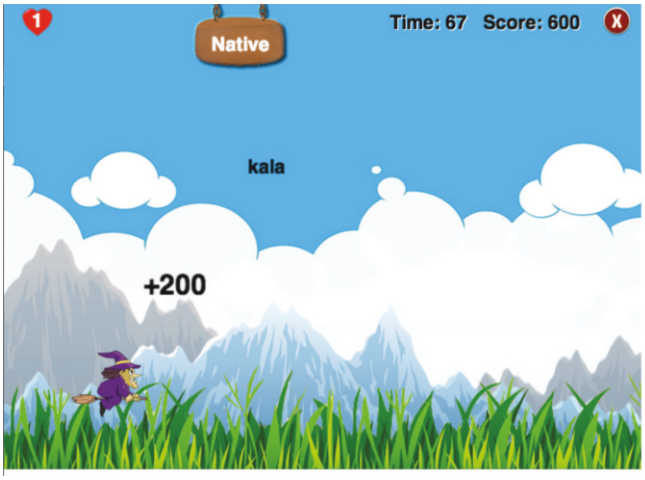

Figure 1. An example of a game created with Magos Lite.

CASE STUDY IN LEARNING BY CREATING EDUCATIONAL EXERGAMES

The aim of this study was to explore the deployment of a learning-by-creating-educational-exergames approach in primary school and how students experience the creation of educational exergames.

Method

Participants. The case study was conducted in a primary school with approximately 300 pupils that is located in the Finnish city of Turku. Seventy-nine fourth to six graders (10- to 13-year-old pupils) participated in the study (answered the final questionnaire). The gender distribution was almost equal (42 boys and 37 girls), and the average age was 11 years. As to background, 33% of the participants declared that they frequently play games of different types.

Procedure. This case study took place over a period of one week. During that time, each class used Magos Lite for approximately 3-4 hours. Most students used iPads but, due to the limited number of tablets, some used laptops instead. One of the aims of the study was to ascertain the way/s teachers approached and implemented game creation in their classroom practice, so no pedagogical models were presented to them beforehand. The experience started with a short introduction in which the teacher showed the class how to make a game using Magos Lite. After the introduction phase, the teachers initiated hands-on game creation activities in their classrooms. After the one-week period, the pupils filled out an online questionnaire about the experience. This consisted of 15 items graded on a 5-point Likert-type scale (Totally agree – Totally disagree). Debriefing discussions were also held with the teachers at the schools.

Results

The results are divided into two sections. First, findings about students' and teachers' experiences about game creation activities are presented. Second, the pedagogical use of Magos Lite is discussed, and the quality of the games that the students created is also considered.

Students' Experiences with Game-Creation Activities

Table 1 shows how students experienced the educational exergame creation activities. In general, students seemed to greatly enjoy creating games, considering it a fun activity (M = 3.75, SD = .79). They stated that Magos Lite was easy to use (M = 4.01, SD = .95) and believed they had sufficient skills to create games with it (M = 4.06, SD = .81). Most of the students appreciated the opportunity to control games with physical movement (M = 3.98, SD = 1.14) and to share games with others (M = 3.65, SD = .98).

According to the teachers' feedback, students were eager to create and play exergames. Teachers appreciated the simplicity of Magos Lite because they could easily include short game creation tasks in their lessons. Similarly, students saw that game-creation activities fit well into the school environment and that game creation could be used to learn new things (M = 3.42, SD = .99). An interesting finding was that most of the students would like to learn how to create more complex games (M = 3.66, SD = 1.13) as well as the art of game programming (M = 3.62, SD = 1.10). It seems that game creation interests students, and they have confidence in their game creation abilities. Furthermore, the analysis revealed that prior game playing experience did not affect students' game creation experiences, and no statistically significant gender differences were found.

Table 1. Descriptive statistics about students' game creation experiences (N = 79).

Item	*M*	*SD*
Game creation was really fun.	3.75	.79
I had sufficient skills to create games.	4.06	.81
I learned new things when I created games.	3.42	.99
The Magos Lite game creation tool was easy to use.	4.01	.95
Sharing and showing my own games to others was important.	3.65	.98
Controlling games with physical movements was fun.	3.98	1.14
I would like to create games in school.	3.85	1.15
I would like to create exergames in school.	3.66	1.20
I would like to learn to create more complex games.	3.66	1.13
I would like to learn how to program games.	3.62	1.10
I believe that I can become a good game creator by practicing.	3.91	1.03

Our results show that an accessible (easy to use) game creation tool facilitates students' user experiences ($r = .29$, $p < .05$) in terms of the opportunity to share games ($r = .45$, $p < .01$), the desire to create exergames ($r = .40$, $p < .01$), and the desire to learn to make more complex games ($r = .49$, $p < .01$). Analyzing these findings, we maintain that when introducing game creation in primary school, accessible tools are required to ensure that all students can manage game creation satisfactorily, a condition which may trigger motivation for more challenging game creation activities. The results also reveal that the sharing of games correlates with the learning of new things ($r = .41$, $p < .01$). Thus, it is pedagogically meaningful to allow game sharing between students and to set activities that foster the sharing of students' creations and game-creation procedures.

Pedagogical Models and Quality of Games

During the one-week period, teachers utilized game creation to revise familiar topics that had already been taught and also to introduce new learning content. In practice, the games were mainly created for revising mathematics and introducing new foreign-language words. One of the teachers introduced Magos Lite to her class by asking students to develop games for younger students – for example, simple mathematical tasks in game form. After this introduction phase, students created games aligned with their own curriculum. It became evident that teachers also understood the importance of sharing games, and they allowed students to play and comment on others' games. Because of the limited number of iPads available, some of the students created games with laptops. Furthermore, games were also created in small groups. The teachers thought that group work was a good pedagogical approach to game creation. The teachers also provided several good improvement suggestions for Magos Lite, which indicated that they had carefully considered how they could achieve maximum benefit from a simple game creation tool in their teaching.

The students created 146 games altogether. The subjects of the games included mathematics (division, multiplication, decimal numbers, etc.), foreign languages (vocabulary), and native language (grammar). The published games were analyzed with a focus on 1) quality of instructions – how students introduced their games to others and how well the preconditions and rules were explained; 2) the role of educational content; and 3) how additional game elements (collectibles, hazards, etc.) were used. The analysis showed that the majority of the games (116/146) included an educational objective. However, most games (103/146) also lacked a decent description of the game and its aims. This was a big problem, in that student-generated games will be difficult to use if the game instructions are not clearly written, which is a point teachers need to bear in mind and emphasize when deploying game making. The writing of instructions is also meaningful from a learning perspective because the game designer has to briefly describe the point of the game, which requires logical thinking and a solid ability to express ideas. However, there were also good examples of well-thought out and well-described games. Almost all games included collectibles and hazards. It seems that students

really enjoyed adding collectibles and hazards into the games, and most of the students used these to a point that obscured the educational aspect of the game to some extent.

DISCUSSION AND CONCLUSION

In this chapter we considered how the creation of educational exergames fits into classroom and reported the results of a case study in which the Magos Lite game creation tool was introduced at one Finnish primary school. The results clearly indicate that the learning-by-creating-educational-exergames approach can be successfully implemented in classroom teaching. It can make the school day physically more active, and it seems to engage and motivate students significantly. The students managed to adopt tablet computers as exergame controllers very quickly, and the intensity of physical activities was quite high. The students were also very creative in selecting the movements for controlling their created games; these included running, standing still, jumping, squatting, and twirling around.

Although it is reasonable and perhaps desirable to introduce game creation activities to students with simple tools, as in this study, more complex tools will be needed to maintain motivation in the longer term. In fact, the teachers requested more game elements that facilitate curriculum-based teaching, and students asked for more options to be included so they could create different types of games. We wish to emphasize that in the learning-by-creating-games approach, the creation of games is the main learning activity; the created games are only byproducts. Nevertheless, schools that adopt this approach can create their own educational game repository, and student-generated games can be widely used in teaching.

The user interface of the current version of Magos Lite is controlled by mouse or by touch; physical activities are involved only when previewing game prototypes or playing published games. In the future, we will integrate motion-based input in the user interface of the game editing tool as well. In particular, we will focus on developing game creation features for mathematics learning that are based on the embodied interaction approach. Embodied interaction is grounded in theories of embodied cognition that try to explain how perceptual, motor and higher-order processes, including language and mathematics, are bound to each other (Antle, 2013). This idea is based on two assumptions: that abstract concepts can be rendered as bodily experiences; and that movement can help children to think. For example, Link, Moeller, Huber, Fischer, and Nuerk (2013) show that embodied number line training with whole-body movements results in better learning outcomes than control training with a mouse-based user interface, especially for children with lower general cognitive abilities and lower working memory capacities. This finding supports the use of embodied interaction in game creation tools as well.

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PART IV

TECHNOLOGY AND COLLABORATION IN & BEYOND THE SCHOOL

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9. THE INNOVATIVE SCHOOL AS AN ENVIRONMENT FOR THE DESIGN OF EDUCATIONAL INNOVATIONS

ABSTRACT

Teachers' engagement in *Design Based Research (DBR)* is analyzed in the context of the *Innovative School (ISC)* model. The ISC model emphasizes the development of *students' learning and learning environments, teachers' professionalism, leadership and partnerships*. The model engages teachers, students, school principals, parents, and actors of the local community in the design and adoption of educational innovations. Three Finnish teachers who had participated in DBR projects focusing on the use of Information and Communications Technology in education and collaboration in an ISC context were interviewed in order to understand how they experienced 1) the operations of the school and 2) DBR projects carried out by teams of teachers and researchers. All the interviewed teachers agreed that DBR projects in the context of ISC supported them in the design and adoption of educational innovations. As key success factors, they emphasized the importance of equality and the sharing of the same world between teachers and researchers as well as the commitment to collaboration.

Keywords: *Innovation, innovative school, design-based research*

INTRODUCTION

The context of this chapter involves three Design Based Research (DBR) projects in which teachers and researchers have engaged in the design of educational innovations that can be easily adopted by other teachers. The outcomes of these three projects are innovations that focus on the use of Information and Communications Technology (ICT) in teaching, learning, and collaboration. The school culture in the project school has been supportive for the design and adoption of innovations. Based on this culture, a model for a school environment, the Innovative School (ISC) model, has been developed. The ISC model emphasizes *students' learning, learning environments, teachers' professionalism, leadership and partnerships*. Consequently, the ISC and DBR models together form a foundation for designing widely adoptable educational innovations. The project partners include researchers at the Department of Teacher Education at the University of Helsinki and teachers at a school in the Helsinki metropolitan area.

The versatile use of ICT in teaching, learning, and collaboration is considered here as an educational innovation. According to Rogers (2003), an innovation is an

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object, idea, or practice that appears new to an individual or a group. An innovation may also be something one has known for some time but has not developed an attitude towards, adopted or rejected. As totally new ideas are rare, we also consider a modification of an existing idea an innovation. For example, a novel use of an ICT tool can be an innovation to the group of people who have come up with the new use.

There are two main categories of factors affecting whether or not an educational innovation is adopted by teachers (Fullan, 2007). First, *the properties of the innovation*, in this case, the properties of the ICT tools, which consist of hardware, software, and services, may influence its adoption by teachers and students. For example, an ICT tool will probably not be adopted into use if its use is too complex for the classroom environment or if the use of the tool is too difficult to learn. The properties of an innovation can be approached from the usability point of view. The usability of an ICT tool indicates the extent to which a user can employ it in order to achieve the particular goals the designers of the tool have set for its use (Nielsen, 1993). Nielsen (1993) suggests that the usability of the innovation could be defined by quality metrics, such as learnability and the ease of use experienced by users.

Second, *the local characteristics* of the school site where the innovation is being adopted may influence the adoption of the innovation by teachers and students. These characteristics include the teachers' pedagogical orientation and their beliefs regarding teaching and learning, as well as the leadership and support available to them in the school. In addition, the professional level of teachers' pedagogical and subject matter knowledge may influence adoption (Fullan, 2007). Referring to Rogers (2003), when a teacher is determining whether to accept or reject an innovation, he or she will seek information about the innovation and actively process that information, typically with other teachers at his or her school. The adoption of an innovation is an individual mental process that begins with an initial awareness of the innovation and results in the actual adoption of the innovation.

THE INNOVATIVE SCHOOL MODEL

The ISC is a holistic model of a school environment that provides the enabling factors for supporting the learning and teaching of skills for the 21st century. The model is based on the description of Finnish school operations in the National Core Curriculum for Basic Education (NCCBE, 2004), on the outcomes of long-term collaborative development at several Finnish schools, and on the collaboration between the authors and the teachers and principals of these schools.

The ISC model, outlined in Figure 1, consists of four *interdependent* main factors: *students' learning and learning environments, teachers' professionalism, leadership,* and *partnerships* (Figure 1). A key guiding principle in the model is the comprehensive and versatile use of ICT in learning and teaching, in a school's daily operational processes, and as an enabler for both educational and operational innovations aimed at school development.

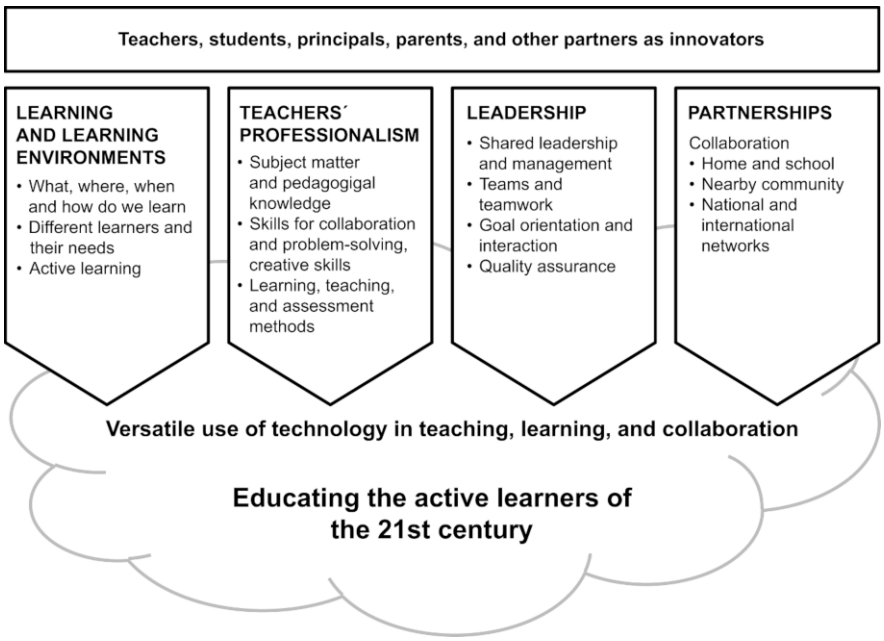

Figure 1. The Innovative School model

In addition to teachers and the school management team, key actors in the ISC model include the students of the school and other school personnel, as well as individuals in the school's internal and external partnership networks. The external partnership networks include parents, local community organizations, and companies as well as national and international networks. ISC emphasizes the role of all of these actors as innovators and encourages them to collaborate in the planning, implementation, and further development of the school's activities. These developmental activities are ongoing, iterative, and cyclic; are based on assessment and are aligned with the latest technological and societal development.

Learning

Teaching and learning in ISC focuses on supporting the development of 21st century skills. The 21st century movement refers to the redefinition of the goals of education and the way learning is organized to meet the demands of the 21st century (Trilling & Fadel, 2009). In the 21st century, individuals need to be able to think critically and creatively, make use of a wide range of tools in creativity and interaction, engage and interact in heterogeneous groups, and act autonomously and take responsibility for managing their own lives.

Due to students' diverse backgrounds, choosing appropriate teaching and learning methods to support the learning of 21st century skills is not

straightforward. It is important to utilize a variety of teaching methods to engage students in learning that allows them to create meaningful knowledge structures. Meaningful learning is grounded on activity and intention, reflection and self-evaluation, collaboration and interaction, construction, contextualization, and cumulative learning (Bransford & Donovan, 2005).

A learning environment refers to the diverse physical locations, contexts, and cultures in which students learn (Fraser, 1994). In the ISC, students learn in a wide variety of settings, including out-of-school locations, such as a library, and outdoor environments, including parks where mobile ICT tools are used for learning. Thus the term "learning environment" is used instead of the term "classroom" with its traditional connotations: a room with rows of desks and a chalkboard. A learning environment does not need to be a physical place; it can also be virtual, online, or remote. Goal orientation and interaction are supported through the ICT tools available in the learning environment, including basic writing and drawing applications, social media environments, and various types of mobile devices and other tools that facilitate flexible, remote, and mobile learning. High-quality learning materials, including digital learning materials such as learning games and other interactive learning content, are essential components of the learning environment.

Teachers' Professionalism

Many researchers agree that teacher behavior and practices are important school-based factors in improving student learning. Therefore, professional teachers are at the heart of ISC. A professional teacher has a profound and versatile knowledge base (Shulman, 1986, 1987). Professional teachers are seen as academic professionals who are committed to their work and are able to plan, implement, and assess their own teaching as well as their students' learning. They formatively monitor the progress of their students, particularly those with special needs, and try to support all students' learning (DuFour, 2004). Professional teachers collaborate with other teachers as well as work in teams.

A key idea in ISC is that professional teachers assume new roles as researchers, meaning makers, scholars, and inventors (Lieberman & Miller, 2004). In fact, professional teachers can be seen as leaders in their work, as Lieberman points out;

> Central to this expanded vision of teaching is the idea that teachers are also leaders, educators who can make a difference in schools and schooling now and in the future. (Lieberman & Miller, 2004)

Professionalism is also supported by political decisions. There have been no inspectors in Finland since the mid-1990s, nor is there national or local testing of students. To summarize, professionalism describes not only the characteristic of a teacher but of the entire school as well (Krzywacki, Lavonen, & Juuti, 2013).

Leadership

The professional culture in a school plays a major role in supporting teachers' collaboration and classroom operations, such as teaching and assessment (Chong, Huan, Wong, Klassen, & Allison, 2010). The role of the school principals and their leadership approach, such as the sharing of responsibilities, or shared leadership, influences teachers' collaboration and classroom operations. Teachers are positively influenced when school leaders encourage collaboration among teachers, students, families, and other school personnel. (Caprara, Barbaranelli, Borgogni, & Steca, 2003; Caprara, Barbaranelli, Steca, & Malone, 2006). Therefore, school principals in the ISC have an important role in facilitating a school culture that supports teachers' collaboration. In practice, this collaboration manifests itself in various school teams and networks, such as grade level teams and multi-professional teams.

In the Finnish context, the role of the principal is central to school development and to the implementation of the NCCBE in the school. Principals are also responsible for the allocation of the school budget, as well as for quality assurance and school improvement. Goal orientation, interaction, and the sharing of responsibilities (shared leadership) are key characteristics of school leadership (Huber & Muijs, 2010). The characteristic effects of leadership that employees should demonstrate are participation, empowerment, and commitment.

Partnerships

In ISC, parents are partners in education. A fruitful partnership with parents facilitates the sharing of responsibility for students' weekly activities. In practice, family events and personal meetings with teachers are organized. ICT offers a multitude of opportunities for enhancing home and school collaboration (HSC), and is applied to enable continuous interaction between the school and families (Korhonen & Lavonen, 2014, Mazza, 2013). The aim of HSC is for parents and teachers to share educational values and goals, with the important consequence that mutual trust is established in each other's ability to work towards supporting the child's growth and education.

Further along the road, the goal of ISC is a wider view of partnerships that also welcomes other members of the local community, such as school support personnel, daycare providers, public librarians, and senior homes as well as actors in national and international networks. An essential part of all partnerships is respect for the thoughts, opinions, and wishes of all stakeholders. Through long-term collaborative development, more families, teachers, and community members can learn to work with each other as parts of a community for the benefit of the children (Epstein, 2009).

DBR SUPPORTED SHARED ACTIVITIES IN THE INNOVATIVE SCHOOL

The design of educational innovations is approached through Design Based Research (DBR). A key principle in conducting DBR is that the researcher is not separated from the study subject but instead works together with practitioners, sharing their world (Juuti & Lavonen, 2006). This common world could support the researchers and teachers in collaborating to identify the challenges in teaching and learning and in the use of ICT and, moreover, support them in creating innovative solutions to meet these challenges (Reeves, 2006).

DBR methodology is iterative; research is conducted through cycles that cover design, implementation, and evaluation of activities. A DBR project produces three types of outcomes: knowledge of teaching and learning, knowledge regarding a successful iterative design process, including collaboration strategies between researchers and teachers, and knowledge on successful design solutions, educational innovations (Edelson, 2002).

Engeström (2011) has criticized DBR on the basis that it lacks participating teachers' agency. He argues that DBR researchers have ignored the role of teachers in the design process. In addition, Engeström suggests that DBR is actually linear when it is said to be iterative. This linearity in particular is argued to cause problems for the adoption of educational innovations. To address this critique, we have approached the collaboration with teachers by emphasizing Dewey's idea of a shared activity. In shared activity, all participants have the same interest towards the accomplishment of the activity. They also share their ideas and emotions (Dewey, 1916/1980, MW 9:17).

In educational DBR, shared activity means that teachers and researchers design, implement, and evaluate educational innovations together. Shared activity requires communication between teachers and researchers. Biesta and Burbules (2003) characterize communication as a process of the mutual coordination of action, and therefore, it is not a process in which a teacher simply reacts to a researcher's movements, after which the researcher reacts to the teacher's reactions, and so on. Dewey's point here means that successful coordination requires that the teacher reacts to what the researcher intends to achieve with his activities, just as the researcher reacts to what the teacher intends to achieve with his activities. Successful coordination requires that the partners in interaction try to anticipate the other's actions (Biesta & Burbules, 2003, p. 41).

By engaging in shared design, by being exposed to similar experiences in the learning environment, and by anticipating each other's intentions, the researcher and the teacher could reach a stage where they share the same world. Through reflection with others who share the same world, new knowledge concerning teaching and learning is constructed.

In 2010-2014, three DBR projects focusing on the development of ICT use in education were organized in a school aligning its operations to the key factors of the ISC model. Following the principles of shared activity and actors as innovators, participants of the project activities included researchers from the University of

Helsinki, teachers, students, and school leadership from the school as well as parents and local community actors.

The aim of the first DBR project was to develop the use of smartphones in science education with the aim of personalizing learning, especially in situations where students were to analyze the information they collected in their science inquiry activities. Together the teachers, students, and researchers designed and implemented ways to use smartphones in personalized science learning in both in-school and out-of-school contexts (Sormunen, Lavonen, & Juuti, 2014).

The aim of the second DBR project was to discover how the ICT facilities already available at homes and in the school can be utilized in HSC. Novel ideas and innovations regarding the use of existing technology in learning, assessment, and in the overall collaboration between home and school were created by students, parents, and teachers (Korhonen & Lavonen, 2014).

In the third DBR project, a new model for School-community Collaboration (SCC) was developed and researched. The project emphasized the use of ICT and was realized in collaboration with a kindergarten, a library, a senior home, and a school. An Action Team for Partnership (ATP) was created and activated within the framework of Epstein's (2009) theory for school partnership programs (Kukkonen, 2014).

TEACHERS' EXPERIENCE OF ISC AND COLLABORATION THROUGH DBR PROJECTS

In January 2014, we asked the three participating teachers about their experience during their participation in the DBR projects to learn how teachers experience the operations of an ISC and their participation in DBR projects. The questions focused on a) the operations of the ISC and b) the teachers' experiences of their participation in the DBR projects. The answers were analyzed using inductive content analysis (Elo & Kyngäs, 2008).

Teachers' Experiences on ISC and its Support for the Design of Educational Innovations

Learning environments. The teachers were asked to evaluate the school's learning environments, considering both the physical and virtual environments available at the school. The development of both types of environments should be based on strategic planning:

> It is important [that] the teachers share a common goal on the use of ICT in teaching and learning and support each other in approaching these goals. (Teacher 2)

The more ICT tools and resources are taken into use, the greater the need for practical co-planning, organizing, and support. In addition, versatile physical and virtual environments require new types of caretaking, such as making sure that there are charged batteries available for the ICT tools.

The school building is rather traditional, providing standard classrooms as well as special ones, such as a workshop for handcrafts, a small science and technology lab, and a music class. The teachers feel that the structure of the physical environment does not sufficiently support the versatile grouping of students and that there are not enough spaces for individual or small group activities:

> Only in one area of the school can two classrooms be connected or disconnected to support co-teaching. (Teacher 3)

However, the teachers and students used their creativity to create learning spaces all over the school building. For example, they used curtains and bean bags to create spaces in the corridors and other common areas of the school:

> Bean bags are easy to move and offer flexibility for the creation of learning spaces. (Teacher 3)

> It is important that there are versatile learning spaces where students can engage in learning either alone or in a small group. (Teacher 2)

In addition to the development of the spaces, a special relationship and trust has been established between teachers and students regarding the use of the spaces. Special activities have been developed for breaks between lessons; students can check out equipment for sports, games, or learning activities for a break, and there are hobby activity clubs that the students have organized themselves.

The teachers agreed that there are sufficient basic ICT tools, such as computers and data projectors, in the school. Due to this particular school's involvement in development activities on the use of ICT in education and collaboration, the school may have more tools available than an average school. In addition to basic ICT tools, there are several interactive whiteboards and, moreover, special tools such as robotics kits. However, the Internet connection and wireless network is underdeveloped. The city faces challenges in offering these services as the number of mobile devices introduced for personalized learning overwhelms the capacity of the wireless network. Furthermore, the teachers feel that not enough technical support is available to teachers. Moreover, the currently available web-based learning environments do not support the use of mobile devices; therefore, tools such as cloud storage services are used as workarounds. From the learning personalization viewpoint, not enough basic laptops or mobile devices are available:

> From a personalization point of view, each student would need his or her own equipment. (Teacher 3)

Teachers' professionalism. The teachers were asked to analyze the competence and operations of the teacher cadre at the school. The outcomes of the analysis were classified into three main categories: teachers' pedagogical competence, their skills in partnership, and their willingness to engage in lifelong learning.

The teachers and classroom assistants in the school possess a versatile pedagogical and subject matter knowledge base that enables them to act as professionals in the school: to plan and organize their work, to take into account the diverse needs of students, and to evaluate learning and learning outcomes:

> Teachers have a high level of competence, and they use this competence in the teaching and supervision of students. (Teacher 1)

The school's teachers are also skilled in the use of versatile learning environments and other ICT tools.

Teachers of the school are adept at taking part in partnerships and at networking. This includes networking inside the school in multi-professional teams, networking with organizations and companies external to the school, and partnering with parents. Teachers understand the school as an institution that is part of the community, and they are continuously developing the school's connections with the community.

Teachers of the school are eager to learn from each other and are oriented towards lifelong learning, with support provided through common meetings:

> We share experiences and know-how in team meetings and in so-called pedagogical coffee meetings. (Teacher 1)

The school's teachers want to develop their own work and are interested in learning new knowledge and skills. They are especially eager to learn about new innovations and technology and their potential uses in education, while recognizing that staying on top of continuous change introduces new challenges.

Leadership. The teachers were asked to describe leadership at their school. All three teachers emphasized in their answers the importance of goal orientation and versatile interaction:

> You can recognize goal orientation in the operations of the school. (Teacher 2)

> All topics are discussed with teachers. (Teacher 2)

Teachers' main interaction, as a part of leadership, is organized through monthly meetings, weekly team meetings, and info breaks, with special emphasis placed on openness and the sharing of information about forthcoming issues. A natural consequence of this engaging leadership approach is that all teachers assume an active role in the planning and implementation of innovations in the school.
An important aspect of leadership in ISC is shared leadership:

> The strength in leadership is shared leadership. (Teacher 1)

The teachers are aware of the sharing of duties between the principal and the vice principals. The idea of teamwork is also applied at the teacher level. Teachers and classroom assistants at a grade level form a team. This grade level team is responsible for co-planning and evaluation:

> A grade level team has common tasks and aims. (Teacher 3)

The versatile use of ICT extends to the administrative operations supporting school leadership; the principals, teachers, and classroom assistants work together to develop ways to use ICT to support teachers' professionalism and co-teaching. When these education professionals find ways to make use of ICT in various professional learning, collaboration, and operational situations, they are unknowingly also acquiring skills in the use of ICT to support their teaching. For this aim, it is important that the school encourages keeping up to date on technology development already at both the teacher and the classroom levels.

Partnerships. The teachers also analyzed the networks and partnerships of the school. They identified the presence of networks on five levels, with ongoing activities to develop ICT use for supporting networking on each level. There are several networks inside the school, such as grade level teams and a multi-professional team:

> The multi-professional team (school nurse, social worker, special needs teacher, and principal) supports the welfare of students. (Teacher 3)

All teachers emphasized that HSC, organized through the parents' association and the class parents' committee, is an important form of networking for the school.

> Parents are very interested in having an impact on school operations. The parents' club organizes various kind of activities for students, parents, and teachers in the evenings. (Teacher 1)

> Networking with families is a partnership and a resource for our school. (Teacher 3)

The teachers of the school also take part in several networks at the city level, including the local curriculum development team, the in-service training team, the special needs education network, and the consulting teacher network. The school also networks with several other schools in Finland, for example on the development of ICT use in education and collaboration:

> We belong to a broad network of schools and aim to develop the use of technology in education through these networks. (Teacher 3)

The school is collaborating with several other local organizations, including the library, the kindergarten, and the senior home. This collaboration provides students with possibilities to extend their learning environments into those organizations. Students have, for example, introduced the use of mobile devices to senior citizens at the senior home and also to preschoolers at the kindergarten.

In addition, the school networks with several companies. Teachers of the school have tested ICT tools, such as educational robotics, educational games, and whiteboards, in their classrooms and discussed the outcomes of these tests with representatives of the companies. One teacher (3) thinks that the success in networking is a consequence of a bottom-up approach:

> Networking should start from our needs – not come as orders from the city level. (Teacher 3)

The teachers emphasized that the most challenging aspect of networking is to continue networking with all important parties. Especially the updates to ICT tools require continuous learning, such as when parents voice complaints about the usability of new software introduced for HSC. One challenge in the use of ICT in networking is the varying readiness of the parties involved. Not all families can currently benefit from ICT support in HSC due to missing ICT competence, lack of tools, or lack of support for a common language in the tools. Finding the resources needed for coordinating the networks is also a challenge. One teacher feels that the school has too many networks:

> In my opinion, there are too many networks and we do not utilize them as much as we should. (Teacher 2)

Experiences with DBR Projects aiming to the Design of Educational Innovations

All three teachers reported that their engagement in DBR has increased their teacher competency. One teacher explained:

> Through DBR it is possible to contribute to the actions at the school … especially my understanding of the adoption of innovations has especially increased. (Teacher 1)

DBR has guided teachers to start a new project or action with a literature review and an analysis of the needs of the participants, to encourage all participants to work through collaborative and iterative planning and implementation and finally, to evaluate their actions and learn from mistakes. DBR has offered the teachers tools for arguing why a certain way of working is successful. DBR thinking has permeated all actions;

> I follow the DBR way of working without actively recognizing it. (Teacher 1)

> Now, I do not give up, I start a new iteration cycle after failure. (Teacher 2)

> All my actions and Professional Development Programs (PDPs) are more like iteration cycles. (Teacher 3)

All three teachers emphasized that, at least in the beginning of their collaboration in the DBR projects, they felt that the participating university researchers were analyzing actions in the classroom rather theoretically. Collaboration within a DBR

project is an interaction where both parties are needed and benefit from the collaboration;

> Sometimes theory and practice are far away from each other. Patience, iteration, and trust in the collaboration are needed to succeed in designing innovations that work in school practice. (Teacher 3)

> In an optimal situation, the collaboration is the sharing of different competencies. (Teacher 1)

The teachers understand the benefit of the DBR collaboration after a few design cycles;

> As a trainer, I have learned how to look at situations in the classroom from the point of view of different theories (Teacher 3).

This indicates that DBR is supporting researchers and teachers in sharing the same world.

Typical DBR projects are holistic and long in duration. DBR needs commitment from both the teachers' and the researchers' side. All the teachers see that additional resources are needed to free teachers from their classroom role for meetings and joint DBR activities. Moreover, school principals need to be committed and supportive for the DBR project. To prepare them for their in-service role, student teachers should also become familiar with the basics of iterative school development and research orientation, such as DBR:

> School development projects await new teachers after their graduation. (Teacher 2)

> DBR orientation should be included in teachers' pre-service training. (Teacher 1)

DISCUSSION

Educational research is criticized on the premise that the outcomes of the research do not transfer to educational practice or to initial teacher education or Professional Development Programs (PDPs). In particular, research outcomes suggesting the versatile use of ICT tools in education have not been adopted by teachers in Finland and many other countries (European Commission, 2013; OECD 2004, 2006). Due to the lack of collaboration between researchers and teachers, PDPs focus too often on just the use of new ICT tools without a link to current research on the pedagogical use of ICT tools. Here, we have analyzed and argued how the ISC model and the DBR approach could be combined in order to support the design and adoption of educational innovations; here the use of ICT in teaching, learning, and collaboration. This combination creates a novel collaboration model for researchers and teachers.

According to teacher interviews, the teachers and researchers did share the same world through their engagement in DBR projects. However, this was not the case at the beginning of the project. Over time, the teachers learned to plan, implement, and evaluate DBR project activities. Especially, they adopted the iterative thinking of DBR. In addition, as they gained knowledge of everyday school practice, the researchers were able to move closer to the teacher's world.

All three interviewed teachers emphasized the common value base between teachers and researchers that allows them to collaborate successfully on DBR projects. The versatile use of ICT in ISC as an educational innovation is challenging as it sets new requirements, poses new challenges for school activities and, moreover, requires common planning. Therefore, it is important for ISC to establish permanent collaboration practices and to encourage the shared leadership approach, versatile environments, and functioning networks and partnerships that support the collaboration. The teachers emphasized that shared leadership with clear structures and role descriptions, openness in administration, and teacher collaboration provide support for DBR and other activities in ISC. In addition, it is important to establish a culture of sharing and trust.

We analyzed the teachers' experiences regarding shared activities in the context of three DBR projects. According to the interviews, it is important to start a DBR project with common planning or by co-writing a research plan. In the beginning of the project, participating teachers should be introduced to research literature in the field of the project. The researchers and teachers should also carry out a mutual reflection on current activities in the teachers' classrooms. In addition to the planning, design, and implementation phases, the teachers should also take an active role in the reflection session to discuss the outcomes of each DBR cycle. These characteristics emphasize the teachers' agency in a DBR project, which Engeström (2011) has criticized to be missing in DBR.

A key underlying idea in DBR is the aim to design innovations that are widely adoptable. From the participating school's point of view, the DBR project would support teachers in making permanent positive changes, or progress, on the school. This progress can manifest itself in the development of teachers' professionalism or as enhancements to the school's learning environments. The innovative nature of ISC supports the adoption of designed educational innovations. At the same time, ISC itself is also further developed through DBR projects, encouraging teachers who want to change school operations to be active in these projects. The essential part of both the ISC model and the DBR model is collaboration, the sharing of experiences in the school and in school networks that enables the design of new educational innovations for learning and teaching 21st century skills.

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10. BUILDING AN ECOSYSTEM FOR DEVELOPING EDUCATIONAL USE OF TECHNOLOGY IN FINNISH SCHOOLS

ABSTRACT

The use of ICT in education can be situated to the enhancement of 21st-century skills, like critical thinking, working, collaboration, and global action. From the perspective of the educational sector, the question is on enabling all children an equal possibility to gain the skills and readiness necessary for their personal life, studies, and upcoming working life. This article focuses on describing and analyzing the implementation and results of the national project Educational Technology in Everyday School Life (EdTech). A research consortium used its networks to create models and solutions for the innovative use of ICT in Finnish schools. The article concludes with some major findings of large-scale research undertaken in 13 research institutes at 8 Finnish universities. It also evaluates the success factors of multi-party national development.

Keywords: *Educational use of ICT, 21st-century skills, pedagogical models*

INTRODUCTION

For children and young people, the use of digital technologies – smart phones, social media applications, digital games, and YouTube – is a natural part of their everyday life. At the same time, many of them attend schools with only restricted ways of deploying information and communication technology (ICT) in learning and studying. Underpinning the use of ICT in teaching and learning are considerations of equality, a sense of community, and developing a capacity for collaboration and active participation.

From the perspective of the educational sector, the question is in regards to enabling all children with an equal opportunity to gain the skills and readiness necessary for their own lives, studies, and careers. This principle of equality raised concerns at the end of the latter part of the 2000s as international comparative studies indicated differences between schools and geographical areas but also within schools regarding the extent and quality of the pedagogical use of ICT as well as the possibilities of each child to gain understanding and skills in ICT use (Kozma, 2003; Tella, Ruokamo, Multisilta, & Smeds, 2005; SITES, 2006; Kynäslahti, 2008; S. Kotilainen, 2011; Binkley et al., 2012; Kankaanranta & Vahtivuori-Hänninen, 2011; ACT21s 2010; Niemi, Kynäslahti, & Vahtivuori-Hänninen, 2012).

H. Niemi et al. (eds.), Finnish Innovations & Technologies in Schools, 115–128.

In essence, the use of ICT in education can be associated with the enhancement of 21st century learning. According to Binkley et al. (2012), the skills for 21st century learning are related to four particular functional skill areas: ways of thinking, ways of working, tools for working, and living in the world. School can be an active component of society and a place where children and adolescents learn these topical skills and competences. With the help of ICT, schools, children, and teachers can better participate and work within the immediate community while at the same time acting as an involved agent of the global world. The multi-dimensional use of ICT can bring the whole world within the reach of students (Kankaanranta, Palonen, Kejonen, & Ärje, 2011; Vahtivuori-Hänninen & Kynäslahti, 2011; Niemi et al., 2012).

The enablers and challenges of ICT use – such as the rapid development of technology, existing digital divides between students and teachers, and controversial trends of ICT use – inspired Finnish decision makers to develop several strong nationwide and multi-field efforts to enrich and widen technology use in the educational system. This paper focuses on describing and analyzing the results of one such effort, namely the national research consortium, "Educational Technology in Everyday School Life". The EdTech Program was funded by Tekes, the National Agency for Innovation in Finland. The Program created new knowledge, innovative models, and practices for ICT use at schools. The research project was closely based and linked to another national project, "Teaching Technology in Everyday School Life", which developed and shared pedagogical models and practices for ICT use at 20 pilot schools (National Plan for Educational Use of ICT, 2010; Niemi et al., 2012; Vahtivuori-Hänninen & Kynäslahti, 2012). The combined efforts of these two national projects resulted in recommendations and guidelines for ICT use at Finnish educational institutions.

The EdTech Program aimed at developing the following:

– Innovations linked to educational technology
– Processes and contents for the use of ICT in schools' learning environments
– Operations models and service concepts for implementing the use of ICT in Finnish schools
– Functional collaboration models for research departments, schools, and businesses
– New business activities

The EdTech Program had a topical role in 1) collecting Finnish researchers interested in the educational use of ICTs from diverse disciplines around common research tasks and data, 2) summarizing existing research literature, and 3) producing school-based research knowledge (Kankaanranta & Vahtivuori-Hänninen, 2011; Ilomäki, & Lakkala, 2011). The research methods varied from large-scale surveys to qualitative case studies of innovative practices and developmental design-based research of ICT tools. The research groups in the participating universities enriched EdTech research activities by linking their previous and other current research practices to the research knowledge base. The EdTech Program was implemented from 2009-2012, and the consortium gathered research teams from 13 research institutes at 8 Finnish universities – about 20

researchers altogether – for exploring and reflecting on the developments related to the following four work packages: 1) pedagogical models and technological innovations, 2) ICT and different school subjects, 3) mobile learning and content creation, and 4) business models, infrastructure, and effectiveness. In the sections that follow, we focus on summarizing key research findings related to these four work packages.

PEDAGOGICAL MODELS AND TECHNOLOGICAL INNOVATIONS

The aim of the first work package was to explore, develop, and support the innovative use and application of ICT in teaching and learning. The work package consisted of three sub-projects with more specific aims: 1) analyze the prevailing status of ICT use at Finnish schools (University of Jyväskylä), 2) develop a theoretical framework for technology-enhanced learning (University of Oulu), and 3) model for school development (University of Helsinki). The work package utilized research methods varying from large-scale surveys to data collection in pilot schools through interviews, observations, and pedagogical teacher discussions, and to modeling of teaching practices.

The prevailing visions and status of ICT use in teaching and learning were explored through three large-scale surveys: two road mapping surveys and one school survey of ICT use. In the spring of 2010, experts from diverse fields related to technology, learning, and working life were invited to roadmap the near future of education in Finland (Salo, Kankaanranta, Vähähyyppä, & Kajander, 2011). One of the main themes was 21st century skills or the knowledge and skills needed in the near future. Foresight indicated that the experts associated 21st century skills with the adoption of continuous change, learning in a constantly changing world, and social skills both at work and in other areas of life. Also, skills for sustainable development, well-being, and life management were considered highly important.

Another road mapping survey was conducted for students in regards to their perceptions of future skills and ICT solutions, as well as their experiences in the use of ICT (Palonen, Kankaanranta, Tirronen, & Roth, 2011). Students' ICT use centered on mobile phones, as 92% of students used them daily. Additionally, about 50% of students used computers and laptops each day. The most popular applications were YouTube, diverse web browsers, Facebook, different instant messaging systems, and email. Most (69%) of the students regarded themselves as normal ICT users (i.e. similar to most of the students at their own school). About one-fifth (23%) of the students evaluated themselves as advanced users, and 8% reported themselves to b more fledgling users (i.e. less able than their peers).

The school survey for principals examined the role of ICT at schools in three components: ICT as a tool for 1) school administration, 2) planning of teaching, and 3) teaching and learning. The majority of school principals weighed the role of ICT very positively in school administration (89% of principals indicated that ICT has a very important role) and as a teachers' tool for planning and management (62%). Only 36% of the principals indicated its particular relevance as a tool for learning and teaching (Kankaanranta et al., 2011). In general, the principals were

satisfied with how the existing infrastructure responded to the schools' needs. The trend was similar with the experienced role of ICT use as the existing infrastructure responded best to the needs of administrative staff and was less suited for teaching and learning practices.

Further examination of the last component, ICT use for teaching and learning, indicated more promising aspects. Almost all schools included the pedagogical use of ICT as a natural part of their goals, and in about 60% of schools, ICT was integrated in a majority of teaching and learning practices. Nevertheless, the results indicated that there was still a large variation – between schools, educational levels, and different regions of Finland – in the ICT access, in the actions as well as obstacles related to pedagogical use of ICT as well as the ways of ICT use (Kankaanranta et al., 2011). This result confirmed that the students were still in unequal situations regarding the possibilities of ICT use and acquiring knowledge society competences and skills.

According to school principals, the most common way for teachers to develop ICT knowledge and skills was independent study (Palonen et al., 2011). Most of the in-service teacher training offered seemed to be short-term and technology-focused. It was accentuated that future investment should provide technical and pedagogical support for teachers as well as peer mentoring and collaboration.

To summarize, one favorable development was that most of the principals had a more positive view of the importance of ICT in the every day work of the school than they previously had. These administrators recognized the need for change and were committed to implementing the school's shared visions and a functioning working culture in order to improve pupils' future skills. At the same time, there were still school principals who were not sufficiently aware of the applicability of the ICT solutions to teaching and learning. This is challenging with regards to school development, as the role of the principal is significant in inspiring the school community to change processes and adopt novel practices (Norrena et al., 2011).

At the time of the EdTech project, Finland also participated in the Innovative Teaching and Learning Study (*ITL research*) initiated by one global company that was also a member of the EdTech consortium. A major finding was the strong relation of innovative teaching practices with the learning of 21st century skills at schools (Norrena et al., 2011; ACT21s). Innovative teaching practices were conceptualized to consist of factors of learner-centered pedagogy, learning outside the classroom, and the use of ICT in teaching and learning. A deeper analysis of school practices revealed that innovative teaching methods were not widely used at schools. Innovators were most typically single teachers or small groups of teachers. The school factors most closely related to innovative teaching practices were collaboration between teachers, access to ICT, support of ICT use, and support of school leaders.

A research team at the University of Oulu analyzed what happens in the every day life of a school as students deploy ICT (Järvelä, Järvenoja, Simojoki, Kotkaranta, & Suominen, 2011). The study was conducted in six pilot schools. The analysis of ICT and its use was based on a learning theoretical evaluation

framework that consisted of three learning components (technology, self-regulated learning, and collaborative learning) and three evaluation categories (1 = early stage of development, 3 = advanced practices). According to Järvelä et al. (2011), teachers and students had knowledge and skills to apply ICT in support of learning, but versatile and knowledge-generating use of ICT was not widely evident. Teachers and students had different insights about the ICT tools they preferred to use. Teachers were more likely to use ICT tools that enabled unidirectional and repetitive work, and students preferred ICT tools that were also entertaining. The use of ICT for collaborative and self-regulated learning was still in an early stage or, at most, at the development level (Järvelä et al., 2011). For example, at the early stage, ICT practices repeat students' knowledge and focus on tasks that require students to work alone. At a more advanced level, ICT practice supports both personal and social learning. The study indicated that there is a need for situational adaptive technology that supports personal learning strategies. It is also essential that schools enhance access to such ICT tools that promote collaborative knowledge building and interactive tasks.

A research team at the University of Helsinki set out to design an innovative school model as a practical tool for structuring school development discussions between teachers, school leaders, and a researcher (Ilomäki & Lakkala, 2011). This comprehensive model examined the use of ICT from the perspective of the whole school's culture. The results of six schools indicated that the schools had different school cultures. Ilomäki and Lakkala (2011) underline that this necessitates the identification and sharing of methods and practices that aid the school community to develop using the possibilities afforded by technology. The more advanced schools operated as functional pedagogical communities with commonly agreed on goals and principles of school development. Such schools supported diversified activities and competences as well as experimentations with diverse technologies. This model has been utilized successfully in many schools, and it is available for schools at the National Board of Education website.

DESIGN OF ICT TOOLS FOR SCHOOL SUBJECTS

At the time of the EdTech project, there was still only a restricted number of quality ICT tools that had been specifically designed for learning and teaching purposes. Thus, many research teams and companies were inspired to conceptualize and prototype ICT tools based on the needs and experiences of the schools or based upon disciplinary research. The second work package collected research teams from four universities to enhance the use of ICT in different subjects, especially in mathematics, science, and the native language. The work package consisted of two sub-projects: 1) development of mathematics teaching with the use of open-source applications, and 2) the deployment and sharing of ICT innovations in mathematics, science, and the native language.

The research team at the University of Turku and Åbo Akademi identified the need to provide interactive learning experiences in mathematics and recognized the motivational effects of online teaching for students. In contrast, a crucial

observation has been that mathematics teachers have traditionally experienced the use of ICT as challenging (Sallasmaa et al., 2011). Thus, they aimed at designing a mathematical tool for teaching structured derivations that consists of four components: 1) a systemic way of writing mathematical text, 2) a text editor for mathematical text editing, 3) a platform for learning material, and 4) interactive learning material (e.g. examples, exercises). The user trials during the development process revealed students' and teachers' positive attitudes towards the new system, as it was regarded to support the teaching and learning of mathematics. The additional value of ICT for mathematics learning is increased with interactive examples and exercises, individual exercises, and automatic feedback. However, there is a need for the creation of new pedagogical models and practices as the teaching practices remained traditional in the trials.

The second sub-project was intended to advance the innovative uses of existing ICT applications in the teaching of mathematics, science, and the native language, but it also aided in the development of new applications for mathematics and science. The research team at the University of Helsinki utilized Rogers' (2003) theory of spreading and adopting of innovations as a basis for analyzing teachers as users of innovations and for developing two ICT-based innovations. A user-driven innovation is a process in which inspired members of a school community look for novel practices and ways of acting, as well as ICT tools (Korhonen & Lavonen, 2011). The research team developed two ICT-based innovations, namely a tool for home-school interaction and an assessment tool to support teachers' work.

The challenge in home-school interaction is in how to pay attention to the different needs of teachers, students, and parents. This challenge inspired the research team to identify the possibilities of ICT for enhancing collaboration between home and school. A design process of ICT innovation for home-school interaction was conducted at one primary school with teachers, students, and parents and also in close collaboration with a company that focused on the technical design (Korhonen & Lavonen, 2011). The parents appreciated the easiness and fastness of technology-supported interaction. Teachers agreed with the parents, but they shared a concern about the additional work caused by possible weak usability of tools. Korhonen and Lavonen (2011) emphasized that ICT can act as a catalyst for intensifying home-school interaction. It can also enable novel forms of partnerships in children's upbringing as it opens and shares children's schoolwork and daily life more transparently for the people at home.

The development of an assessment tool focused on the principles of building the data source, the description of assessment tasks with meta-descriptions, and the features of the user interface (Krzywacki et al., 2011). Teachers emphasized that the most important factors for the use of innovation were technical usability and the feasibility of the user interface. They wanted the assessment tool to offer new means alongside familiar ones. At its best, the assessment tool could be utilized flexibly according to a teacher's own needs and situations, and it should be tailored for the students' needs.

To summarize, ICT solutions need to be clear, satisfy the experienced needs, and conform to the school culture so that they apply to the teacher's personal needs

in different school environments. Krzywacki et al. (2011) highlighted that a meaningful technical innovation is not always a new solution, but it can be an existing ICT tool that is utilized in a novel pedagogical way.

MOBILE LEARNING AND CONTENT CREATION

The aim of the third work package was to investigate mobile learning and content creation in a primary school context. The work package included four sub-projects with more specific aims: 1) mobile content creation and sharing in pre-school education (University of Tampere), 2) creating mobile video clips and designing a social mobile tool for sharing videos (Tampere University of Technology), 3) learner-centered content creation with portfolios (University of Helsinki and Lapland), and 4) learning the native language with mobile videos (University of Oulu). The work package mainly utilized qualitative design-based research in the pilot schools through interviews and observations. Mobile learning was explored particularly from the perspective of content production and sharing.

According to Kynäslahti and Seppälä (2004), three crucial dimensions of mobility in learning are 1) convenience/rationality, 2) expediency, and 3) immediacy. Convenience refers to rational time management and related issues. A person is moving while being involved in educational activities using mobile technology. When rethinking expediency, we can clearly identify two particular uses—we learn something from the local context and transmit this knowledge elsewhere using mobile device. We may travel with educational purposes in mind and transmit knowledge to be utilized locally. We can also perform an educational act immediately, regardless of where we are, even if it requires access to the Internet or a connection to digital learning resources and environments. Mobile technology offers new opportunities for activating learning practices since it has the power to change the nature of the physical relationships between teachers, learners, and the objects of learning (Kynäslahti & Seppälä, 2004; Mylläri, Kynäslahti, Vesterinen, Vahtivuori- Hänninen, Lipponen, & Tella, 2011).

The first sub-project focused on learner-centered mobile social media content production in a pre-schools context (Sairanen, Syvänen, Vuorinen, Vainio, & Viteli, 2011). The project designed a sharing tool for early childhood and primary education. The study applied Zhao and Frank's (2003) ecological metaphor in the analysis of interactions between teachers, pre-school pupils, and technology. Schools and classrooms were seen as a vivid ecosystem where everything is linked to each other. Teachers are viewed as a key species, and the external educational innovations and tools are invasive species. In the classroom, educational technology is always competing for scarce resources, such as the teacher's attention and resources and the attention of the children. Diverse tools, uses of and roles for ICT were conceptualized and understood in more profound way when they were discussed as different species of the ecosystem.

Sairanen et al. (2011) identified four requirements for successful mobile content production and sharing in the school environment: 1) The mobile device must be enabled for sharing and needs to save user-created content on a network server,

2) the tool must be very user-friendly, and new media content should be easy to add and edit, 3) the user must be able to control who reads his or her output (individual items and overall user management), and finally, 4) the tool needs to be flexible with respect to different pedagogical methods and ways of use. It was found essential for an efficient educational ICT tool to have a clear added value on the teacher's work and to be compatible with a school's and the classrooms' technical ecosystem. Sairanen et al. (2011) identified some minor challenges for schools concerning mobile phone costs, maintenance resources, and attitudes of teachers and other stakeholders that make decisions about teaching at schools.

The second sub-project developed and experimented with a mobile video service, the MoViE platform (Tuomi & Multisilta, 2011). Mobile videos proved to be a complex and beneficial educational tool (Tuomi & Multisilta, 2011; Niemi et al., 2012). It was realized that mobile social media is applicable as a tool for school projects, as the social and creative elements engage students in learning and create opportunities for authentic learning situations. Children learned how to produce their own digital learning material and to utilize such learning material in class to teach each other. An interesting feature of students' videos was that they mixed fictive and factual (produced at school) types of content. There were clear, visible signs of stimulus gained from YouTube videos. This was a fine example of mixing informal and formal learning as well. This method challenged the teachers to pay close attention to possible collisions of informal and formal content when integrating mobile devices and applications for students in informal contexts in teaching (Tuomi & Multisilta, 2011).

According to Tuomi and Multisilta (2011), over one-third of the pupils who participated in the mobile learning study felt that it was possible to learn to use a mobile video distribution service; well over one-half preferred mobile learning to traditional ways of working in school. Fun and creativity should not be suppressed; they should be encouraged. Incorporating mobile devices into teaching requires smooth operation of the technology involved as well as the appropriate training and motivation of teachers (Tuomi & Multisilta, 2011).

The third sub-project surveyed mobile learning in learner-centered content production with portfolios (M.-R. Kotilainen, 2011). The results indicated that the key elements in mobile content production at schools are practicability, rationality, and adaptation to the purpose of each teaching and learning activity. The elements of practicability and rationality are closely intertwined in enabling flexibility and diverse possibilities for students to study in different physical and virtual spaces. This is necessary to lead students toward self-directed content production and independent decision-making.

The fourth sub-project confirmed the meaningful role of mobile videos and narrative storytelling at schools (Palmgren-Neuvonen, Kumpulainen, & Vehkaperä, 2011). It indicated that the use of mobile digital video content production activities aided pedagogical practices and developed students' subject and content knowledge. The study found positive effects on children's motivation to study their mother tongue and communication and in advancing their 21st century skills, especially social relations in the classroom, as well. There was also

an intriguing discovery about differences between genders and teams. Gender differences were found in thinking, interaction, and social relations. Team differences were related to 21st-century learning and more specifically to communication skills such as discussion, negotiation, and argumentation with others.

To summarize, the studies indicated that mobile social media is a beneficial content production tool for different school projects. There were also several efforts to develop user-oriented and easy-to-use mobile tools, especially mobile videos, for primary schools and specifically for content sharing purposes.

PUBLIC PRIVATE PARTNERSHIP AND BUSINESS PRACTICES

The aim of the fourth work package was to analyze Public Private Partnership (PPP) models and business practices in the school context. The work package included three sub-projects: 1) models for public-private partnership (Aalto University), 2) open-source programs in schools (Tampere University of Technology), and 3) evaluation of the impact of information services (VTT). The research investigated novel ways and means for collaboration between businesses, schools, and research (Huhta, Väänänen, & Smeds, 2011). The research collaboration offered the participating companies fresh ideas and knowledge about the educational use of ICT and know-how regarding the basic principles of learning solutions. For many companies, the project was a kind of start-up to become producers of educational services and materials for schools. However, there were differences between companies in both the form and the amount of participation in the project network. Some of the companies were interested in non-commercial collaboration (e.g. school-company partnerships, internships, parent collaboration, and content provision), while other companies wanted to develop long-term commercial collaboration (such as product development, ICT services, support services, or other educational services).

According to Huhta et al. (2011), successful collaboration requires shared goals as well as resources and motivation for co-development. The basis for co-operation should lie in the benefits to students, teachers, and other school staff. For successful co-operation, companies need to understand school practices and processes as well as the schools' specific needs to develop a working schedule and be ready for long-term development. Huhta et al. (2011) modeled a well-functioning school-business collaboration's prerequisites as follows: 1) common goals and visions, 2) mutual understanding and benefits (tangible benefits for students), 3) resources and motivation, 4) long-term relations of cooperation, 5) and joint planning and development of the partners of the network (producers, users, teachers, children) (Huhta et al., 2011).

At the school level, the focus was on developing operational cultures, i.e. management competences, peer-support networks, and inclusion of ICT plans in the school curriculum. School principals were encouraged to build a communal working culture in all the schools. At the teacher and student levels, emphasis was focused on competences, activating and participatory working methods and

building of individual learning paths. Improvement of the technical and pedagogical support in the use of ICT was crucial. Finally, a public-private partnership was identified as an important strategic component for enabling new innovations and promoting employment and well being in Finland.

In their sub-project, Wideroos and Pekkola (2011) concentrated on developing sourcing models and processes for the companies or company networks that wanted to provide software, information technology (IT) services, and infrastructure for schools. One of the key results of this study was that it seemed to be very challenging to supply user-oriented ICT services and infrastructure to schools. The main problems were the municipal sourcing system and also the lack of an active culture of communication. According to Wideroos and Pekkola (2011), solving the situation will require the resolution of the following issues:

– Communicating key concepts and aims between the different partners
– Developing know-how and expertize in ICT sourcing
– Creating common guidelines, examples, and best practices
– Formulating an intentional ICT strategy of schools
– Maintaining clarity regarding the costs

The third sub-project compared and analyzed different ICT services and sourcing models for schools. The basic plan of was to transfer the ideas from a transport logistics sourcing model into the educational sector. They also tested an ICT model of the Kauniainen School. The model has been in operation since autumn 2007 (Hautala et al., 2011). In this model, the focus is on ICT services and maintenance instead of buying equipment and hardware. The school itself actually determines it own ICT needs and acquires the services from companies using competitive bidding. Furthermore, the effective use of an older equipment base was found to be important. In the tested model, the majority of workstations were controlled over the network. The open source software and applications were centralized on school servers. This new sourcing model and its implementation improved the reliability of workstations and also reduced power consumption and the start-up time.

CONCLUSION

The EdTech research program invited a large consortium of researchers, schools, and companies to combine their expertise. A key feature of the EdTech program was its multidisciplinary nature and deep mutual collaboration. This enabled the rise of a network, which built a creative educational ecosystem. A common task was to build a thorough and research-based understanding of the principles and factors that act as theoretical and practical enablers of the innovative and efficient use of ICT in teaching and learning. The consortium also explored, designed, and modeled concepts, prototypes, and frameworks for ICT-enhanced tools. The major outcomes of the entire consortium can be summarized as follows.

There have been several developments in the issues of access and pedagogical use of ICT in Finland. However, children and young people are still in unequal situations in regards to their opportunities to use ICT and learn 21st century skills.

This is caused by the existing differences between schools, school levels, and school regions but also occurs within schools concerning ICT access and methods of ICT use.

The key factors in enabling positive change and development at schools are 1) the attitudes and will of the principals, 2) the intertwining of ICT and pedagogy, 3) the development of teacher competences in the educational use of ICT, and 4) commitment of the entire school community to change processes and actions. It is not enough to have a single teacher or a small group of teachers who are responsible for school development. A promising finding was that the demand for changes in the processes set for schools by the educational administration (such as the National Board of Education) had finally reached school leaders and principals. They recognized the need for change and perceived it as an essential school-level goal. They were devoted to building a common vision and an operative working culture. However, teachers reported that they lacked concrete pedagogical models and ideas for diversifying and enriching teaching. Teachers also brought forth an ample need for on-site pedagogical and technical support. A positive indication that the change processes had already started was that each research school had a small group of teachers who had advanced and created innovative teaching practices.

At its best, the educational use of ICT can be a catalyst for renovating teaching and at the same time building novel networks for schools. It can also motivate and encourage students to put effort into learning, as ICT tools already have an essential role in everyday life. A networked school also advances students' capabilities and well-being. The use of ICT has effects in many levels and forms in the school ecosystem. It can support school-home interaction and diversify and motivate the learning of different subjects, The EdTech program showed strong evidence of the possibilities of mobile learning and self-directed and volitional content production because it can add flexibility and freedom to learning and increase the learning and studying that takes place outside schools. Mobile learning was found to be a natural part of a school's technological ecosystem, even for very young children.

The EdTech program also included many design and product development efforts for innovative and user-oriented ICT tools and applications. Some global companies provided specific devices for the project schools as part of their corporate social responsibility programs. Several companies created either general devices or tools, which were piloted in educational environments to determine their applicability for teaching and learning purposes. Some companies entered the educational field with service concepts for communities and schools, offering a complete service for the devices. As the research consortium was multidisciplinary in nature, there were also research teams with more technical and design goals. The various design efforts indicated that the development of innovations requires multidisciplinary and inter-organizational collaboration.

The results of the EdTech project have been exploited at Finnish schools, municipalities, teacher education, decision making, and product development companies. The early results of the EdTech project have already been employed as

a justification for actions in the national plan for ICT use at teaching and learning (NBE, 2010). The members of the EdTech consortium have also been active in supporting the launch of new research programs, both academic and business-oriented, and in continuing with their research and development efforts.

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LAURI VIHMA AND MAIJA AKSELA

11. INSPIRATION, JOY, AND SUPPORT OF STEM FOR CHILDREN, YOUTH AND TEACHERS THROUGH THE INNOVATIVE LUMA COLLABORATION

ABSTRACT

The collaborative LUMA ecosystem encourages universities, schools, teachers, students, guardians, and the industry to collaborate and engage children and young people from age 3 to 19 in science, technology, engineering, and mathematics (STEM) and teachers at all levels in life-long professional development. LUMA Center Finland, the coordinating body, is a highly valued partner for schools and other groups. Its model for collaboration is internationally regarded as innovative, bringing together schools, guardians, the scientific community, teacher education, and the business sector. This chapter presents (i) a background of the LUMA collaboration, (ii) some successful LUMA activities, and (iii) some teachers' in-service training models, such as using ICT to increase interest, foster collaboration, and strengthen teachers' technological pedagogical content knowledge.

Keywords: *LUMA, STEM, collaboration*

INTRODUCTION

Finland became known for its students' exceptionally high-level mathematics and science competence on international assessments like PISA and TIMSS during the 2000s (Kupiainen, Hautamäki, & Karjalainen, 2009; Martin & Mullis, 2013; Organization for Economic Co-operation and Development [OECD], 2013). Many researchers have explained the success in these assessments with top-level Finnish teacher education (Jussila & Saari, 2000; Simola, 2005; Välijärvi et al., 2007).

There are, however, challenges for science, technology, engineering, and mathematics (STEM) education, especially in many European countries like Finland. Students' interest in STEM is quite low (Arinen & Karjalainen, 2007; Kärnä, Houtsonen, & Tähkä, 2012; Lavonen, Byman, Uitto, Juuti, & Meisalo, 2008; Osborne & Dillon, 2008; Osborne, Simon, & Collins, 2003). This disinterest has caused concern regarding the level of scientific literacy and knowledge of STEM and the sufficient number of skilled experts in STEM fields (Rocard et al., 2007) since students have a tendency to choose to engage only in activities related to their target of interest (Hidi & Renninger, 2006). In addition, students do not see the relevance of their STEM studies to their future working lives (Cleaves, 2005).

Thus, in order to encourage students to study STEM subjects, systematic efforts should be made to instill and support their interest towards these subjects

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(Education, Audiovisual, and Culture Executive Agency, 2011a, 2011b) at the earliest possible stage. Recent research suggests that influencing the direction of the child's interest should begin before the age of four (Alexander, Johnson, & Kelley, 2012).

In this chapter, the collaborative *LUMA* ecosystem (abbreviated from "LUonnontieteet", the Finnish word for natural sciences, and "MAthematics"), coordinated by the LUMA Center Finland, is introduced. Some successful examples of non-formal LUMA activities for children and youth – the scientists and the decision makers of the future – are described. The aim of these activities is to cultivate their interest in STEM subjects and to support the already existing interest among the many talented students. We also present some examples of teacher training with the aim to support teachers' lifelong learning and competence in inspiring relevant education choices in their students.

One viewpoint of this chapter is the versatile use of information and communications technology (ICT) as a tool to raise interest, increase support, strengthen collaboration in the LUMA ecosystem, and foster teachers' technological pedagogical content knowledge (TPCK) through in-service training. ICT is a natural part of life for today's children and youth in developed countries (Finnish National Board of Education, 2011; Passey, Rogers, Machell, & McHugh, 2004). The use of ICT can motivate youth to study because of its interactivity (Passey et al., 2004), but the use of ICT is still at too low a level in mathematics and science education in Finnish schools (Finnish National Board of Education, 2011).

STEM FOR ALL

A Short History of LUMA

The Finnish Ministry of Education organized a mathematics and science education development program called *LUMA* between 1996 and 2002 (Allen, Black, & Wallin, 2002). The aim of the program was to raise the standards of Finnish mathematics and science education and competence on an international level. Other important goals were to improve education practices and to promote interest in mathematics and science.

After the development program ended, enthusiasm for progress and innovation in the area continued. The first *LUMA Center*[1] was established at the University of Helsinki in 2003, and it was named Finland's Science Education Center LUMA. Its board consisted of members from the Finnish Ministry of Education, the Finnish National Board of Education (FNBE), the University of Helsinki, the City of Helsinki, industrial associations, and teachers' unions. The main goal of the LUMA center for its first decade was to build a national ecosystem for the collaboration on STEM education (Aksela, 2008).

Since 2007, nine other regional LUMA Centers have been established within different universities. The most recent milestone was celebrated in November 2013 by the opening of *LUMA Center Finland*,[2] the umbrella organization for all

regional centers. The new organization ensures a national and international collaborative ecosystem to develop STEM education by providing activities and accessible resources throughout the country.

The current LUMA ecosystem coordinated by the LUMA Center Finland is a social innovation in which universities, schools, teachers, students, guardians, and industry are collaborating to engage children and young people from age 3 to 19 in math, science, and technology and supporting research-oriented teachers at all levels for life-long learning.

The LUMA Center Finland promotes and fosters both national and international collaboration between educational institutions from kindergarten to universities, the business sector, educational administration, science museums and centers, teachers' associations, and the media, as well as all other relevant organizations. In addition, guardians are one of the collaborators.

The center has a board with representatives from all regional centers, and an advisory board with delegates from all collaborating organizations (e.g. industry). Together, these boards have composed and are regularly maintaining the joint national LUMA strategy as well as annual action plans. The LUMA Center Finland is administered by the University of Helsinki.

The core value of this collaboration is shared expertise. The LUMA Center Finland encourages all collaborating partners to share their ideas, experiences, and practices freely, in the spirit of open education. The center supports communality among the children, youth, and teachers. Their natural interaction with the scientific community in the universities and industry is fostered, and their voice is a part of the design process of the LUMA activities.

In 2012 the University of Helsinki granted its first *University in Society* award to the LUMA Center for its diverse collaboration with society and its long-term focus. The center was selected from among 29 candidates.

Goals of LUMA Activities

Most LUMA activities for children and youth are extra-curricular, usually taking place after school or during holiday seasons. The activities provide children and youth with positive experiences, the joy of understanding, and the advancement of learning in active and involving, cooperative, student-oriented, phenomena-based, contextual, and relevant learning environments: various places, facilities, communities, procedures, tools (like ICT), and materials. This kind of learning has been found to support students' interest (Hidi & Renninger, 2006).

The aim of the LUMA is STEM for all. The primary goal of STEM education at its inception was to educate future scientists and/or engineers, so it was quite irrelevant for many students. Only later has the focus shifted to teaching about the role of STEM in the context of an individual's life and in society (Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013). When three different dimensions of relevance – individual, societal, and vocational – are implemented together through non-formal LUMA activities, it improves the skills that students will need in the

future, and shows them what a career in science could look like (Tolppanen, Vartiainen, Ikävalko, & Aksela, in press).

LUMA activities strongly emphasize the relevance and significance of STEM subjects for the well being of individuals, society, and the environment, and STEM-related careers are presented as a meaningful choice for youth. One of the goals of relevant education is to increase interest in pursuing STEM careers, so collaboration with the industry is integrated into LUMA activities (see a later example of ChemistryLab Gadolin). However, the students are not pressured to enter these fields (Wang & Decol, 2013).

ICT is utilized as much as possible in the LUMA activities for children and youth since ICT is a natural part of life for today's children and youth in developed countries, and the use of ICT interests and motivates them (Passey et al., 2004). Another role of ICT in the LUMA activities is to support interaction and collaboration in multiple ways. ICT also offers virtual activities all around the country. Some examples of ICT usage in the activities for children and youth are given in a later section.

Teachers' roles at all educational levels, from early education to universities, are extremely important in developing a positive attitude towards STEM subjects among students. Therefore, many kinds of LUMA activities have been developed and are intended to inspire and support teachers in their everyday work and in maintaining and cultivating their lifelong learning and competence in inspiring STEM teaching throughout their careers.

To answer the challenges of a constantly evolving information society, high-quality LUMA in-service training and teaching materials, in which ICT has a significant role in supporting teachers' lifelong learning, are organized, since teachers have to stay up-to-date with the latest applications of the educational technology and find the best ways to use them. Many teachers need more in-service training to be able to use modern, relevant technology, like ICT, in their classrooms (FNBE, 2011).

Educational Research at the Core of LUMA

Research on STEM and its education is at the core of the development process of LUMA activities, which have been planned and designed according to previous studies on interest and support. The aim of the research is to design advanced ways to teach STEM—both formally and non-formally—and to evaluate the effectiveness of LUMA activities. For the most part, research projects linked to LUMA activities are carried out using an educational design research approach (Edelson, 2002; Design-Based Research Collective, 2003; Pernaa & Aksela, 2013; Plomp & Nieveen, 2009), so teachers, for instance, are encouraged to be active partners in research. Many projects relate to the use of ICT in STEM education.

The results of development and research projects are disseminated not only to the scientific community through various national and international publications but also to teachers at all levels of education. The latest research is currently being applied in pre- and in-service STEM teacher education at Finnish universities.

The LUMA Center also organizes an annual *International Symposium on Science Education (ISSE)*[3] in which researchers, teachers, student teachers, and people from partner organizations, like the business sector, from all over the world can meet up and learn from each other.

SOME SUCCESSFUL EXAMPLES OF LUMA ACTIVITIES

There are dozens of successful LUMA activities, such as STEM clubs, camps, days, other events, and web magazines for children and youth aged 3 to 19 years. The main goal of these non-formal activities is to raise interest in STEM by presenting its relevance to the participants and informing them how the activity can enhance social interaction and collaboration among children and young adults.

ICT is utilized during the clubs and camps in many ways, including as a tool to take photos, record and edit videos, make simple animations, and study phenomena through modelling and visualizations. Children and youth who take part in the LUMA activities also contribute articles, photos, and videos to the three interactive web magazines.

One renowned example of these activities is the international Millennium Youth Camp (MYC), which has been organized for 16- to 19-year-old students from all over the world since 2010. The aim of the MYC is to increase the youth's interest towards STEM as well as to spread information on Finnish expertise and innovations in the field and familiarize the campers with the study and career opportunities in Finland and with each other (see Chapter 13).

In addition, there are many kinds of STEM training courses, workshops, consultations, classrooms/labs at universities, borrowable equipment, web magazines, and interactive resource portals for teachers at all educational levels.

Only the most successful activities are presented here as examples.

Clubs for Children: Little Jippo Clubs for 3-6 Year-olds as an Example

The LUMA Center organizes very popular STEM clubs for primary school children (aged 7 to 12 years) and also for lower secondary school students (aged 13 to 16 years). For example, many after-school, free-of-charge STEM clubs are organized every year in schools around the Greater Helsinki area. The clubs acquaint children with STEM through many kinds of activities and games.

The clubs offer positive experiences both for mathematically or scientifically talented children and for children who face difficulties and motivation problems in learning mathematics or science at school. One club consists of 6-10 sessions, and each session typically takes 1-1.5 hours.

Student teachers participate in a special course on STEM club pedagogy so they may work as guides in these clubs. The course has a virtual learning environment where student teachers plan their club night, reflect on their experiences after each club session, and get feedback from the experts at the University of Helsinki and the *Opinkirjo* Association, which the is main partner of the LUMA Center for organizing clubs.

The newest and most popular forms of STEM clubs are the innovative *Little Jippo* clubs, which are organized at the university campuses in Helsinki. Little Jippos target children from 3 to 6 years of age. They are hands-on STEM clubs in which STEM subjects are integrated with the arts. Club offerings have been expanded to pre-school children since it was noted that if a child is provided with the opportunity to learn STEM non-formally during the pre-school years, he or she is also expected to be interested in activities involving STEM in the future (Alexander et al., 2012).

The aims of a Little Jippo club are to shape the inquiry, thinking, and discussion skills in small children and support social and emotional learning through the joy of learning and achievement. The six sessions of each Little Jippo club are interlinked by an inspiring fictional frame story. Between club meetings, the children interact with guides through the *Jippo* webzine and carry out experiments at home with their guardians with the help of videos posted in the *Jippo* webzine.

The frame story motivates the children to explore everyday life themes, like colors, states of matter, density, and space, using their own observations and thinking skills. The club model combines science, technology, art, and emotions through stories, inquiry, role-playing, and music. Each hired club guide plays the role of a certain character (Jippo, Fairy, Dino, and Pippi) that engages children in the world of inquiry through special emotional experiences. Education takes the form of a certain kind of play. Based on the collected feedback from the guardians, the clubs have increased their children's positive attitude and interest towards STEM (Vartiainen & Aksela, 2013).

Dyna-meets Support the Interest of Youth

Dyna-meets are a type of non-formal education in which young people typically between the ages of 14-19 years have the opportunity to familiarize themselves with Finnish expertise in STEM. In addition to the STEM content and its relevant applications, the participants also become acquainted with like-minded peers.

The free meetings or club sessions are held once or twice a month from August to May at universities, as well as in separate research institutes and collaborating companies around the Greater Helsinki area. One club session lasts two to three hours and is led by experts who introduce different research methods and equipment and discuss current research projects, their own work, and study possibilities in the field. For example, some computer programming-themed Dyna-meets have been organized in conjunction with top experts of the Department of Computer Science at the University of Helsinki and specialists from the world-leading Finnish ICT industry.

Between meetings, the youth are allowed to share and discuss their experiences and ask questions of the experts in the Dyna-meets group via social media platforms. If they attend at least eight meetings and report on what they have learned and experienced to the LUMA Center using an online forum, they are eligible for upper secondary school course credits.

Authentic STEM Laboratories and Classrooms at Universities – ChemistryLab Gadolin

The LUMA Center supports formal STEM education at schools by providing teachers with opportunities to take their students to authentic STEM laboratories/classrooms located at nearby universities, free of charge. There are eight different labs altogether: the *ChemistryLab Gadolin*, *ComputingLab Linkki*, *MathLab Origo,* and *PhysicsLab F2k* within the University of Helsinki, the chemistry laboratory *Teknokas* at the Chydenius University Center, the *LUMARTS* laboratory within the Aalto University, the physics and robotics laboratory at the University of Eastern Finland, and a physics laboratory within the Lappeenranta University of Technology.

ChemistryLab Gadolin[4] is the oldest of the LUMA labs; it was built in 2008. It is an active learning environment that supports and enhances relevant chemistry instruction and learning. The class is named after Johan Gadolin (1760–1852), the Finnish discoverer of the element yttrium. ChemistryLab is supported by the Finnish Chemical Industry Federation and various international and national chemical companies and equipment manufacturers as well as the University of Helsinki. These companies collaborate to show their corporate social responsibility by offering their support via financial funding or equipment donations.

The study visits for students aged 7-19 vary from 2-hour-visits to longer study courses. The sessions can include experimental laboratory work, molecular modelling, simulations, and visits to research groups, where the visiting students can talk about their research with scientists. During these sessions, the students learn about the research done at the university and its related academic and career directions, and they also conduct laboratory experiments or other activities guided by trained university student teachers.

Different learning environments meet in ChemistryLab Gadolin, where learning takes place in authentic university facilities. In addition to the physical learning environment, ChemistryLab offers a virtual learning environment. In this lab, ICT-based modelling and visualization applications recreate the sub-microscopic world of chemistry in a meaningful way and connect the models to the practical experiments (Pernaa & Aksela, 2009).

ChemistryLab is located at the Department of Chemistry of the University of Helsinki. The ChemistryLab operates within the Unit of Chemistry Teacher Education. Chemistry student teachers are developing new chemistry education research-based activities in their courses and also as the write their theses. In addition, design is carried out in close collaboration with supporting companies using educational design research.

Teachers who bring their students to labs like ChemistryLab Gadolin are expected to integrate the visit into their curriculum. The teachers may influence the content and methods used during the visit to support their educational purposes and curricula. The basics of the topic can be studied at school before the students visit the lab and then continued afterwards to support meaningful STEM learning and higher-order thinking (Aksela, 2005).

LUMA labs are very popular. For example, about 4,000 students visited the ChemistryLab in 2013. These STEM labs are also used as venues for teachers' in-service training courses and workshops, and they even serve as research and development centers for LUMA activities.

Webzines as Virtual Learning Environments for Children, Youth, and Teachers

The LUMA Center publishes various freely available interactive web magazines, or webzines, for different groups with the aim of inspiring and supporting children, youth, and teachers.

Jippo[5] is for children aged 3 to 10 years, and it introduces the marvels of STEM in an interesting and enjoyable way. Children are encouraged to wonder, conduct experiments at home with their guardians, and ask questions of the *Jippo* mascots. They can experience the joy of learning and build interest in their surrounding world and STEM. The content available online can also be used in schools and clubs. Jippo has been available online since 2003.

Luova[6] helps people from 11 to 19 years of age to discover the joys of invention and creativity associated with STEM research and innovation. Luova strives to be an interesting and constantly developing meeting place for young people, researchers, and teachers and a source of information that motivates the youth to seek more. The youth can interact with each other through blogs and social plugins. Luova emphasizes the involvement of young people, encouraging them to do their own thing and tell others about it. Luova has been hosted online since 2007.

MyScience[7] (in English) is for youth aged 16 to 19 years all over the world who are interested in STEM. It publishes news, feature articles, fascinating photos, and inspiring videos. Blogs about student life and research are also an important part of the webzine. The goal is to provide the reader with the opportunity to explore the STEM fields and introduce Finnish research and innovations to international readers. MyScience also covers the application process of the annual Millennium Youth Camp and publishes news, photos, and videos during the camp.

LUMA-sanomat,[8] a service for teachers at all educational levels, is the national portal for all relevant information and content related to STEM education. The LUMA-sanomat portal provides teachers from kindergarten to the university with current, relevant, and interesting information on STEM teaching and tangible ideas to use in their everyday work. LUMA-sanomat publishes teaching materials, videos, and news articles related to STEM education and STEM education research. An inclusive list of upcoming events is also available in the webzine. The contents emphasize the possibilities that the ICT provides and vocationally relevant information about STEM academic and career options (Stuckey et al., 2013) so that teachers can better address the lack of interest in STEM subjects among their students. LUMA-sanomat has been available online since 2010.

LUMA News[9] (in English) is a webzine for teachers, educators, and researchers around the world. It promotes the Finnish miracle of education (Niemi, Toom, & Kallioniemi, 2012) internationally from the viewpoint of STEM and with the collaboration of STEM teachers.

The aim of all these webzines is to get the readers to interact with each other and with editorial teams, which include content experts at universities, companies, etc. In this case, the 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. The webzines are constantly being developed, and currently they are designed to serve mobile home users.

These webzines have reached thousands of children, youth, and teachers over the years. The most frequent visitors frequently return to the webzines. Visitors are satisfied with the content and interaction the webzines provide. Most of the webzines have multi-disciplinary editorial boards, which have members from various collaborating organizations, and casual editors are warmly welcomed to contribute to the webzines. The 2009 *State Award for Public Information* was granted to the LUMA Center for the Jippo and Luova webzines.

In addition, the LUMA Center publishes two international, open-access peer-reviewed research journals: *LUMAT – Research and Practice in Math, Science and Technology Education*[10] (in English, Finnish, and Swedish) for researchers and teachers of STEM education, and *EJYSE*[11] (in English) for young researchers aged 14 to 21.

Teachers' Lifelong Learning through a Continuum Model

The LUMA Center supports teachers' lifelong learning through a continuum model (Aksela, 2008, 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 the training of pre-service teachers. LUMA activities have been integrated into the training of both classroom and subject teachers at Finnish universities. STEM subject teacher training at the University of Helsinki has the longest track record for establishing lifelong learning. During their studies, pre-service teachers are provided with an excellent opportunity to practice interacting with children and youth by leading different activities. Authentic and regular experiences with students build skills to guide and manage children and youth. Pre-service teachers also use the latest research information to actively produce teaching materials and ideas to benefit all teachers of STEM subjects in Finland. Many thesis and publications have focused on the topics of LUMA activities (Aksela & Boström, 2012).

In the induction stage that follows, newly graduated STEM teachers collaborate actively and closely with their *Alma Mater*. There are possibilities for networking with other recent graduates and for self-development through the online services of the LUMA Center.

In the third stage, experienced STEM teachers receive support through various LUMA activities (webzines, newsletters, workshops, in-service training courses, consultation, webinars, etc.) that the LUMA Center organizes around Finland. Dozens of in-service training courses are offered each year on different themes,

including "STEM's relevance for the individual, for society, and for the environment", and "Using ICT in STEM education". Teachers' requests are considered by those who design in-service training sessions, which makes them more meaningful. All partners can learn from each other; for example, universities and industry leaders are learning from schools and teachers, and teachers obtain the newest knowledge in their fields from the universities and industry. The feedback gathered from collaborating teachers is mostly excellent and very supportive.

IN-SERVICE TRAINING COURSES FOR STEM TEACHERS TO SUPPORT THEIR ICT USE AT SCHOOL

ICT should be diversely integrated into education to produce a positive impact on learning and student interest (Passey et al., 2004). In many countries, such as in Finland, there is a tendency to steer STEM education towards inquiry-based activities and learning. In modern STEM inquiry, many kinds of ICT applications, such as probeware, modelling, visualization software, and communication applications, are required. In addition, forthcoming Finnish STEM core curricula heavily encourage and demand utilizing ICT in versatile ways (FNBE, 2014). However, studies indicate that teachers, including those in Finland, only use computers to support the location or transmission of knowledge (FNBE, 2011; Gao, Choy, Wang, & Wu, 2009; Lim & Chai, 2008).

According to the FNBE (2011), Finnish teachers need more suitable pedagogical models and skills for utilizing ICT in their classrooms since teacher education programs have not traditionally provided future teachers with the experiences necessary to prepare them to use technology effectively in their classrooms (Moursund & Bielefeldt, 1999).

Subject-matter-specific pedagogical content knowledge (PCK) (Shulman, 1986) has an important role in the professional development of STEM teachers. Quite often, teachers' in-service training primarily emphasizes only general pedagogical practices independent of the subject matter and at the expense of content knowledge. Correspondingly, learning generic ICT skills alone does not adequately prepare teachers to integrate ICT into their subject-matter-specific teaching (Lawless & Pellegrino, 2007; Mishra & Koehler, 2006; Mishra, Koehler, & Kereluik, 2009), or in this case, STEM teaching.

The technological pedagogical content knowledge (TPCK or TPACK) framework combines the PCK framework with the use of technology (quite often ICT). High-quality subject matter like STEM teaching requires extensive TPCK, which includes a nuanced understanding of the complex relationships between technology, content, and pedagogy, as well as the skills to use this understanding to develop and use appropriate subject- and context-specific teaching strategies and representations (Angeli & Valanides, 2009; Koehler, Mishra, & Cain, 2013; Mishra & Koehler, 2006).

The framework is based on the pedagogical approach termed "learning technology by design", which places emphasis on learner-centered learning-by-doing in authentic contexts. When this approach is applied to teacher in-service

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.

For these reasons, the LUMA Center organizes many in-service training sessions for teachers to learn how to use ICT skillfully in their STEM lessons; ICT training courses are also components of corresponding educational design research projects. Participating teachers collaborate closely to plan and execute their courses. Engaging in educational design research related to ICT use also provides STEM teachers with opportunities to build their TPCK (Graham et al., 2009; Guzey & Roehrig, 2009; Mishra & Koehler, 2006; Niess et al., 2009).

Example models for two popular ICT in-service training courses are presented in the following sub-sections.

In-service Training Course on Sub-Microscopic Simulations

The course entitled "Getting to know the world of atoms and molecules through simulations" is a part of the educational design research project on modelling in STEM education (Aksela & Lundell, 2008). The main aim of the course is to strengthen chemistry (and physics) teachers' skills with ICT-based dynamic sub-microscopic level visualizations; through the modernization of teaching, students' modelling skills (Gilbert, 2004) and higher-order thinking skills (Aksela, 2005) are also strengthened.

During the course, the participating teachers have an active role in planning and testing ICT-based solutions with real-life chemistry (and physics) education challenges, such as how to visualize the dynamic nature of sub-microscopic level phenomena (Mishra & Koehler, 2006). The course consists of the opening meeting, teaching experiments in a school environment, and a closing meeting.

The program for the opening meeting includes getting acquainted with each other and networking (as participants come from all around the country), turning to the project, its topic (sub-microscopic level modelling and dynamic visualizations using ICT), and the theoretical background in conjunction with the trainer's introduction, discussing earlier experiences, getting to know the wiki-based collaborative project platform, exploring the existing online simulation possibilities with colleagues (trainers are available to help if needed), developing a short plan for a teaching experiment to be carried out at school, and posting this plan on the wiki platform.

Between the meetings, the participating teachers carry out their teaching experiment with sub-microscopic level simulations in their classrooms and reflect on the experience in their learning diaries located within the wiki platform. If needed, they iterate their plan and test it again.

The program for the closing meeting requires teachers to report their teaching experiments and the good practices they have innovated. They also carry out a discussion and a reflection of their experiments and innovations to the theoretical background and survey participants to determine how they like the existing simulations, how the simulations work in teaching, which needs call for the

development of these current simulations, and what types of new simulations are needed and for which topics. The course, the teachers' learning diaries, and the survey become tools for the first phase (the needs assessment phase) in the design-based research project.

During the 2011-2012 school year, 24 teachers participated in the course. They were mostly from Southern Finland, as the meetings were held in Helsinki.

Online In-service Training Course for STEM Teachers on General Content-related ICT Skills

The "Electronic Learning Environments in STEM Education" course covers the opportunities and challenges of electronic learning environments and the aspects of planning, executing, and evaluating education with them. The course begins with the theory of blended learning (Bonk & Graham, 2006), which converges live and online teaching. The practical applications on which the course is structured are based on this theory.

The course is held entirely online so that teachers from all over Finland may attend. The participating teachers can read articles and watch video tutorials on the wiki-based course platform and use social media groups and a weekly online chat to communicate with each other and the trainer.

The school year-length course consists of eight modules. Each module is scheduled to last for two or three weeks.

- Working methods of the course are presented. An overview of the electronic learning environment is provided. The theory of blended learning is introduced.
- The concept of a media-rich learning environment, copyrights, and open-source applications are explored.
- Learning management system (LMS) applications, social media, blogs, and wikis are discussed.
- Shared media, such as online videos, images, and sound services, are introduced and explored.
- Possibilities to integrate different STEM subjects with ICT are studied. Best practices are reviewed and shared.
- The practical opportunities and limits of using ICT to support student evaluation are examined, such as learning diaries and portfolios, as well as electronic examinations across different learning platforms.
- The pilot environment for the Finnish Matriculation Examination is presented and evaluated. The vision and some developmental views of the electronic Matriculation Examination are explored.
- Participants collaboratively plan and carry out a small-scale design research project using open-source tools and report their design experiences on the course platform.

Thus, in this case the teachers are also designing ICT-based solutions to real-life STEM education problems by "learning-by-design" (Mishra & Koehler, 2006) as they conduct a small educational design research project themselves (with the trainer's guidance); their STEM related TPCK is constructed at the same time. ICT

also supports collaboration through the online course. Since the theme of the course is STEM education, there is no lack of content knowledge, which is typical for many other ICT training courses (Lawless & Pellegrino, 2007; Mishra, Koehler, & Kereluik, 2009).

CONCLUSIONS

As has been presented in this chapter, the LUMA Center is an award-winning collaborative ecosystem in which universities, schools, teachers, students, guardians, and industry participants actively collaborate using ICT. The motto of the LUMA Center is "Together we are more". Many types of successful and popular collaboration models have been built nationally and internationally during the last ten years.

Various successful LUMA activities have been developed, implemented, and evaluated in Finland since 2003 with the aim to improve the inadequate level of scientific literacy and knowledge of STEM and the insufficient number of skilled experts in STEM fields (Rocard et al., 2007). To increase the interest of children and youth in STEM subjects, various non-formal activities have been offered in which the relevance of STEM is shown (Stuckey et al., 2013) and cooperation is supported with methods such as ICT usage (Passey et al., 2004); teachers' competence in teaching STEM subjects in an inspiring manner and using modern tools, including ICT, is also supported with TPCK (Angeli & Valanides, 2009).

So far, the gathered feedback and studies on the activities have provided promising results. The extensive general demand towards clubs, camps, and webzines, for example, has indicated that there is a need for the LUMA activities. In addition, partly due to this great demand, the LUMA Center Finland has been established to support the live and virtual activities of regional LUMA centers to cover the whole country. There has also been much interest in LUMA activities from abroad, and it seems there is a similar need for this type of collaborative action in other parts of the world. The LUMA Center is keen on international collaboration and promoting STEM activities around the world.

The LUMA Center will continue to develop its functions to reach its goals on all levels in the entire country. It seems that there is a need to engage more teachers and guardians to promote STEM education. A national network of schools could be one possible solution to encourage all teachers who teach STEM subjects to be in touch with LUMA activities.

In the future, LUMA Center Finland will continue to study the operational models that have been identified as effective. For example, long-term research on the lasting effectiveness of LUMA activities like clubs and camps to encourage the interest of children in STEM topics is needed.

NOTES

[1] http://www.helsinki.fi/luma/english
[2] http://www.luma.fi/centre

[3] http://www.luma.fi/isse
[4] http://www.luma.fi/kemma-en/chemistrylab-gadolin
[5] http://www.ejippo.fi
[6] http://www.eluova.fi
[7] http://www.myscience.fi
[8] http://www.luma.fi/
[9] http://www.luma.fi/news
[10] http://www.luma.fi/lumat-en
[11] http://www.myscience.fi/ejyse

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12. THE INTERNATIONAL MILLENNIUM YOUTH CAMP AS AN ACTIVE LEARNING ECOSYSTEM FOR FUTURE SCIENTISTS

ABSTRACT

Once a year, the LUMA (STEM) Education Center of the University of Helsinki, Technology Academy Finland and Aalto University, organizes a popular international STEM education camp in Helsinki in collaboration with some organizations and global industrial companies. The camp is aimed at gifted youth – possible future scientists – and more than a thousand 16- to 19-year-old students apply from over a hundred countries. The camp has ten theme groups that are all related to sustainable development. These theme groups include applied mathematics, ICT, and various fields of natural science (e.g. climate change, energy, water). The groups are guided by scientists from Finnish universities and companies. The camp provides an opportunity to network with like-minded peers, university students, and the scientific community. Participants also receive expert guidance while working on a science project. This chapter presents how the Millennium Youth Camp works as an active learning ecosystem by summarizing some previous research done on the camp.

Keywords: *non-formal education, gifted education, science education millennium youth camp*

INTRODUCTION

Having a shortage of talented scientists is a problem that many countries will face in the future. For example, environmental problems, such as climate change and over consumption of resources, bring forth many challenges for future scientists to tackle. However, especially in the western world, not enough students want to pursue a career in science (Hofstein, Eilks, & Bybee, 2011; Osborne, Simon, & Collins, 2003). Researchers have pointed out that one of the major causes is that students do not see science education as relevant and therefore are not motivated to study it (Gilbert, 2006). Therefore, it is vitally important to build a supportive learning ecosystem, especially one where youth – our future researchers and engineers – recognize the relevance of science and technology and work together to make the world a better place.

H. Niemi et al. (eds.), Finnish Innovations & Technologies in Schools, 145–153.

Supporting the Gifted

The LUMA (STEM) Education Center of the University of Helsinki has a long history of supporting kids and youth through different activities, such as clubs, camps, and web magazines (see the chapter written by Vihma and Aksela for more details). At the LUMA Center, non-formal education is also seen as an effective means to give gifted youth extra support, as is done through the Millennium Youth Camp. This support is important, as gifted youth tend to perceive their giftedness as either a positive or a negative thing, depending on how the people around them react (Tannenbaum, 1983). In this chapter, the word "gifted" is used to describe students who are motivated to study STEM subjects and are also high-achieving.

The best way to support gifted youth is by providing a holistic learning environment (Tirri, 2011, 2012), a so-called learning ecosystem where interactions between a community of people and the nonliving environment takes place. This ecosystem should acknowledge the students' academic, social and emotional needs and support their personal growth (Tirri & Kuusisto, 2013), as well as provide them with opportunities to benefit from the nonliving environment around them, such as university facilities. Their academic needs can be met by providing a curriculum that reflects the students' interests (Subotnik, Olszewski-Kubilius, & Worrell, 2011) and includes advanced content, allowing students to move forward at a faster pace (Colangelo, Assouline, & Gross, 2004). Furthermore, as gifted youth are typically more inclined to moral reasoning than their non-gifted peers (Narváez, 1993), the curriculum should contain morally inclined topics, such as themes related to sustainable development. A supportive community that consists of teachers and peers is important for meeting social needs (Tannenbaum, 1983; Tolppanen & Aksela, 2013). This social network can provide the youth with an environment where they are able to interact with likeminded peers (Tolppanen & Aksela, 2013) and discuss ethical elements of their discipline (Tirri, 2011).

A learning ecosystem should also be one that is relevant to the student on an individual, societal, and vocational level (Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013) so that the students will recognize the importance of their studies. Though there are several ways to achieve such an ecosystem for gifted youth, in Finland this need has been filled mainly by non-formal education, such as enrichment programs. These programs give the students the opportunity to be actively involved in their own learning.

An Active Learning Ecosystem

Education needs the ability to adapt to meet the future needs of students. However, the world is changing at a fast pace, and it is difficult for any individual teacher to keep up. Therefore, the learning ecosystem should be changed so that students actively participate in their own learning by co-creating, co-designing, and co-producing their own education (McCulloch, 2009). In fact, researchers have argued that active engagement is critical in order for learning to be meaningful and encourage students to take responsibility (Bovill & Bulley, 2011). Increasingly,

education policies have also called for students to become active learners and be engaged in their learning through discussions, critical questioning (Entwistle, 2012), and even curriculum planning (Bovill & Bulley, 2011). This trend is particularly prominent in universities, as they are starting to more aggressively pursue active global citizenship as a desirable attribute of graduates (Furlong & Cartmel, 2009).

Non-formal Education as a Learning Ecosystem

Though each non-formal education program is different, enrichment programs for gifted youth typically have an accelerated curriculum, an encouraging environment with dedicated organizers, and peer interactions with students of similar ability in common (Olszewski-Kubilius, 2003). In addition to academic advancement, these programs also offer an opportunity for social growth and peer acceptance (Lenz & Burruss, 1994). Non-formal education also provides a great possibility for students to actively participate in their learning. For example, 4-H programs implement a learning-by-doing method, giving youth an excellent opportunity to gain an understanding of the nature and context of science (Williamson & Smoak, 1999). At the same time, collaborative learning, where students interact with peers, volunteers, and experts in an environment of mutual learning, has been used effectively in non-formal education (Smith, Meehan, Enfield, George, & Young, 2004).

Therefore, non-formal education provides a great learning ecosystem for gifted youth. Earlier research has shown that non-formal education can increase students' self-confidence, motivation, basic thinking skills and autonomous learning (Moon, Feldhusen, & Dillon, 1994; Pedretti, 2002). Longitudinal studies have also reported increases in interest, academic achievement, and ability to get along with peers and adults (Thomas, 1989). As non-formal education allows a learning ecosystem to develop, it is important to consider how such an ecosystem can be created. This chapter will examine how the International Millennium Youth Camp (MYC) has considered learning ecosystems in an innovative way to support scientifically gifted youth.

MILLENNIUM YOUTH CAMP AS A LEARNING ECOSYSTEM

The International Millennium Youth Camp is a unique camp for 16- to 19-year-old gifted youth that is held once a year in Finland (LUMA, 2012). Each year, the camp has over 1000 applicants, and a two-stage selection process accepts 60 youth. In the first stage, applicants fill out an online form detailing their previous accomplishments and their passions. They also present some questions that they would like answered during the camp. In addition, the applicants choose one of the ten theme groups to apply to. These groups are Applied Mathematics, Bioscience, Climate and Climate Change, Energy, Food Science, ICT, Material Science, Renewable Natural Resources, Urban Planning, and Water.

In the second round, 200 applicants (20 from each theme group) are selected to advance. The students are asked to complete a project related to the theme group they chose. The projects are designed by experts from each theme group and measure creativity, motivation, and knowledge. The applicants have one month to finish and submit their projects, which are then assessed by the experts. These experts select their top six candidates from each theme group for interviews. The purpose of the interviews is to ensure that the students have done the projects independently, as well as to ensure a proficient level of spoken English. If no problems occur during the interview, the candidate is admitted to the camp.

Under the guidance of scientists from universities and companies, the campers start working on a group project two months before camp begins. MYC lasts for one week, and participants are involved in different kinds of academic activities, including tours of universities and companies, visits from start-up companies, and lectures by experts, such as the winners of the Millennium Technology Prize. In addition, the campers put the finishing touches on their projects in these different environments, such as companies and universities. In order to help the youth network with each other and build international connections, the camp also has many social activities, such as an international evening, where the campers all share something from their home country, welcome and farewell parties, evening activities, such as a sauna, a bonfire, and games, as well as an Amazing Race of Science (Tolppanen & Aksela, 2013). The travel and living expenses for the selected 60 youth are covered by the organizers of the Millennium Youth Camp.

The Curriculum of the Camp

The camp has a general curriculum that is met by the numerous academic and social activities that take place during the camp. The curriculum contains goals to encourage students to study science, technology, engineering, and mathematics (STEM) subjects, introduce them to academic and professional opportunities, and network with each other and experts. All of these tasks have been developed in a fun way so that the youth will also enjoy the experience.

In addition to the general curriculum, the group projects have specific goals. They must be related to sustainable development, should have more than one right answer to the problem presented, must encourage creative thinking, and should address an ongoing discussion between science and society (Tolppanen, Vartiainen, Ikävalko, & Aksela, 2014).

Youths' Questions and Expectations When Applying to the Camp

In order to find out what kind of questions and expectations gifted youth have when applying to the Millennium Youth Camp, researchers analyzed 658 first-round applications from Asia and Europe (Tirri, Tolppanen, Aksela, & Kuusisto, 2012). Through content analysis, the researchers divided the students' questions into academic (57%), societal (23%), and moral (20%) categories. The academic

questions were commonly related to wanting to gain more knowledge. The societal questions were typically asked by females, and they were often related to sustainable development. Students also tended to raise moral concerns in their questions. An example of such a concern was presented by an 18-year-old male from Asia:

> The most important and interesting issue for me is saving water. You can't deny that water is the main thing for all living creatures. So, if we don't want our planet to die, we ought to prevent wasting priceless water. It just depends on us. That's why I have a great desire to get acquainted with the water projects of foreign scientists and to share my ideas. (Tirri et al., 2012)

In another study, Tolppanen and Tirri (2014) looked at the primary expectations of youth when applying to the camp. They found that most students had academic expectations (90%), but many also had social (68%) and ethical (38%) expectations.

Stuckey et al. (2013) suggested that for education to be relevant, it should include individual, social, and vocational dimensions. Based on the results of these two studies, all of these three dimensions were present in the youths' expectations.

Camp Meeting Youths' Needs

In order to meet the expectations of the youth, the three dimensions of relevance were also implemented into the curriculum of MYC (Tolppanen et al., 2014). Individual relevance was offered by providing opportunities to network, deal with complex issues, think creatively, and have fun experiences (goals 4a, 5, 7, and 8). As gifted youth are inclined to think about moral issues (Narváez, 1993) and want to change the world to make it a better place (Vesterinen, Tolppanen, & Aksela, 2014), themes related to sustainable development were seen as a way to implement societal relevance (goals 6 and 9). Furthermore, the camp aimed to increase the interest of gifted youth in pursuing a career in science, so vocational relevance was implemented through goals 1 and 3.

In selecting the themes for the project work, experts provided campers with projects that concerned real-life problems that scientists and engineers are currently dealing with (Tolppanen & Tirri, 2014). This aspect made the projects authentic and gave the students the opportunity to participate in meaningful learning (Tirri, Kuusisto, & Aksela, 2013). For example, the material science group was asked to think about ways in which body temperature could be used to produce energy (MyScience, 2013).

Highlights of the Camp

In a study conducted by Tolppanen & Aksela (2013), the participants of the Millennium Youth Camp were asked to describe the highlights of the camp and any areas that needed improvement. This data were collected from all of the 88 campers who participated in the camp during 2010-2012 (before 2013, only 29-30

participants were selected each year). According to the participants, the most important aspects of the camp were the social interactions with peers and experts. These interactions had a high individual relevance and were described by a female camper from Africa with the following words:

> One of the biggest highlights of the camp was meeting the experts and learning firsthand how and what they do. I find it important that I will be able to stay in contact with them, and I learned so much from them.

A female attendee from Europe shared the following statement:

> It was great to see people from all around the world who share similar interests and are having fun.

The academic activity was also highly praised and seen as relevant from a vocational perspective. A male participant from Europe described the project in the following way:

> The project was very interesting. I saw many new things, realized something important about my future studies, and experienced something from the scientific work.

These positive social and academic effects resonate with the goals set in the curriculum of the camp, providing further evidence that the camp was relevant to the youth from an individual, societal, and vocational perspective.

The relevance of the camp is seen even more clearly in the data collected from 30 students a year after the camp had ended (Tolppanen & Aksela, 2013). The findings indicated that the positive effects of MYC persist over time. Even a year afterwards, participants felt that the camp had an impact on their motivation and view of life; many reported the camping experience had encouraged them to aim high in life. Furthermore, participants mentioned that they gained useful insight on international possibilities and made friends with youth from all corners of the world. The camp also helped them clarify their vision for their future and had changed their views on education.

When the experts were asked about the effects of the camp, they realized that the academic and social expectations of the camp had been well received. They especially pointed out that the project task gave the youth the opportunity to use their imaginations and come up with creative solutions (Tolppanen & Tirri, 2014).

CONCLUSIONS

It is important to transform the learning ecosystem to be more student-centered (McCulloch, 2009). This change is especially important for gifted youth, as they tend to be autonomous learners (Hany & Grosch, 2007). As non-formal education is not confined by strict borders, it provides a good opportunity to transform and test different types of learning ecosystems. By presenting the model of the Millennium Youth Camp, this chapter has illustrated how non-formal education is used in Finland to create a student-centered learning ecosystem that aims to be

relevant for the student at an individual, societal, and vocational level. In this way, MYC is building a collaborative community of future scientists who can work together to make the world a better place.

MYC has put much emphasis on social activities because the social context of a learner is important (Tannenbaum, 1983). Camp activities allow participants to network with likeminded peers as well as with renowned scientists. In combination, these activities make the Millennium Youth Camp a platform where students from all corners of the world can meet and shape a common vision on how to improve the world through science and technology. As gifted youth are inclined to consider moral issues (Narváez, 1993), MYC has implemented topics related to sustainable development into its curriculum. Furthermore, to support academic development, the curriculum for the project is developed to reflect student interest. Implementing these areas of a holistic learning ecosystem may support students' personal growth (Tirri & Kuusisto, 2013) and increase their motivation (Pedretti, 2002). This can lead to an increase in the number of gifted students who choose to pursue a career in science and a subsequent decrease in the deficit of scientists that the western world is facing (Hofstein et al., 2011; Osborne et al., 2003).

Formal curricula could learn from the innovative way that a holistic learning ecosystem is integrated into the camp; more emphasis should be placed not only on academic traits but also on social, socioethical, and moral aspects as well. Furthermore, formal curricula should aim to provide opportunities to explore science in different non-living environments, including laboratories, universities, and the urban environment.

Though the motivational aspect of the camp is promising, long-term studies will be needed to determine how many of the campers go on to pursue a career in science. However, it is important to note that the students who attend the camp are already interested in science, so the camp itself may have little influence on their career choices. Regardless, research shows that the camp helps the youth build a strong network of peers and experts. More research will be required to identify the extent to which students use and benefit from these networks in the years that follow their stay at the camp.

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13. SCHOOLS AND COMPANIES IN A CO-CONFIGURATIVE COLLABORATION

Agile Product Development Applied in a School's Ecosystem

ABSTRACT

Implementing educational technology into a school's ecosystem is not a simple process. Challenges arise due to the different ways that schools and companies have for interacting and working. In order to build mutual understanding and productive interaction between schools and companies, collaboration should be seen as a two-way learning process where both parties discover new ways of interacting and doing things. When schools and companies reach a level of reflective communication and co-configuration, a new and flexible learning ecosystem can exist. This chapter offers opportunities for new partnerships and innovation.

Keywords: *School-company collaboration, reflective communication, co-configuration, agile product development, ecosystem*

INTRODUCTION

The history of educational technology has demonstrated that putting technology successfully into operation in schools is not an easy process. The successful implementation and use of technology requires intensive collaboration between different parties, especially amongst the companies that develop the technology and the schools. This kind of partnership between companies (software companies, publishers that focus on digital learning material, and game companies) and schools is rather new both in the field of education as well as in companies. Collaboration between schools and companies has traditionally been tied to short internship periods, projects, and student field trips to companies or a visit from a company to the schools. In recent years, however, the collaboration between schools and companies has been seen from a wider perspective. Companies now provide products for schools and also offer complete services, infrastructures, and networks to support teaching and learning processes and implement technology (Smeds, Huhta, Pajunen, & Väänänen, 2010). In many cases there can even be a joint development project in which new products are created together; schools and company partners can produce new educational services. As the center of the learning community, educational institutions can integrate multiple resources to

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produce and develop learner-centered educational services (Huhta, Väänänen, & Smeds, 2011).

It is not an easy endeavor for many companies to successfully enter schools. In order to develop their products and support their use, companies need to figure out how to best grasp a complete picture of school life and identify its key details. For companies, it is essential to understand the local-level and the school curriculum, the teacher's pedagogical thinking, and the overall school context. On the other hand, schools are not very experienced in working with partners who have a very strong business orientation. When these interests differ, it is essential to take ethical questions into account, such as with marketing issues (Niemi & Sarras 2012). A school's duty is to protect students from direct marketing and help them understand the commercial side of advertising and marketing. When companies enter a school, it is important to consider the teachers' roles and responsibilities in educating students to be aware of certain marketing issues. The National Board of Education (NBE) and the Finnish Competition and Consumer Authority (2007) have set up guidelines regarding how to make the collaboration between schools and companies more explicit. The Ethical Council for the Teaching Profession has also worked to promote ethical awareness among teachers (Niemi, 2012). Still there remains a need for discussions and instructions regarding how public-private partnerships should be organized and controlled. As Huhta et al. (2011) suggests, it is necessary to develop the know-how and skills of decision-makers, educators, principals, and teachers. We also need to create common rules and procurement guidelines for company collaboration, as well as create concrete information packets about the public-private collaboration and disseminate these to schools.

After all this, the collaboration between schools and companies can at its best be seen as a partnership defined as an agreement that provides mutual benefits to both parties (Levin, 1999). There are at least two crucial and intertwined dimensions that need to be considered to understand the partnership between schools and technology companies: the actual act of collaboration between the parties and the process of creating technology and services for schools. First, we will examine the process of collaboration.

WORKING TOWARDS PARTNERSHIP

Smooth and productive collaboration is not self-evident. The ability to work productively together requires a high level competence and should be viewed as an achievement of a genuine learning process in which all parties need to learn new ways of talking and accomplishing things. To plan the collaboration between schools and companies, we refer to Fichtner's (1984) and Engeström's (2008; Rantavuori, Engeström, & Lipponen, 2014) ideas.

On the basis of Fichtner's (1984) suggestions, Engeström (2008; Rantavuori et al., 2014) proposed a three-level notion of developmental forms of interaction:

- coordination
- cooperation
- reflective communication

The level of coordination of each participant (individual or collective) focuses on and carries out its own role and actions, which are scripted or predetermined. Thus, there is not yet much mutual or shared understanding of the aims and objects of the interaction. In cooperative interactions, participants concentrate on a shared problem, trying to find mutually acceptable ways to understand, conceptualize, and solve it. The third form of interaction elaborated by Engeström (2008) is reflective communication in which the participants focus on reconceptualizing their own interaction system in relation to their shared objects of activity. As a result, both the objects and the scripts are reconceptualized. This process of recognizing and making the disturbances and breakdowns of shared work visible offers a path to the zone of proximal development of the particular parties. Solving anomalies and disturbances always requires the creation new methods of working together that come from and are for both parties.

In order to work productively together, companies and schools need to perform successfully on each of the three levels of a learning activity. If they are not able to work in the mode of reflective communication, their collaboration will never be a two-way process: a process that leads to productive collaboration between schools and companies. Working on the level of reflective communication is not enough, however. While developing technology and services for schools, companies also need to focus on how technology is put into use in schools.

CO-CONFIGURING THE PRODUCTS AND SERVICES

Traditionally, we can say that the process of developing and implementing technology products into schools has been very technology-oriented. It has been, and still is, very common for technology to be implemented as a well-defined plan of action, often accompanied by associated objects, such as teacher guides and student textbooks (Lipponen, Lallimo, & Lakkala, 2006). In this process, schools are seen as passive receivers that adapt and adjust to the given technology. In many cases, this process has resulted in schools ending up with technology they either do not need or do not know how to use to support teaching and learning practices. From a company perspective, a product (application/software; services) is either sold and implemented in the same form for each school as a mass product or designed for each individual customer in a process of mass customization (Victor & Boynton, 1998). Mass customization is always based on customer needs and requirements to some degree, while mass production is not.

From the perspective of a partnership between schools and companies, mass production and mass customization mostly represent coordination or cooperation instead of reflective communication. Thus, in the past, there has not been much genuine collaboration between companies and schools. A promising idea to overcome the challenges of collaboration and to work more productively in the process of taking technology products to schools is the idea of co-configuration offered by Victor and Boynton (1998), who identified five developmental phases in the history of work: craft, mass production, process enhancement, mass customization, and co-configuration. Co-configuration is the most recent

developmental phase in the history of work and is closely related to the developing knowledge and technology industry.

According to Victor and Boynton (1998), "The work of co-configuration involves building and sustaining a fully integrated system that can sense, respond, and adapt to the individual experience of the customer. When a company does co-configuration work, it creates a product that can learn and adapt, but it also builds an ongoing relationship between each customer-product pair and the company" (p. 195). Therefore, even if the technological product is the same for each customer (school), the services (putting technology into operation in schools, maintaining the technology, and so on) require co-configuration work.

Co-configuration is by nature a transformative and reflective form of work. Engeström (2004) states that co-configuration refers to a dialogue in which the parties rely on real-time feedback information regarding their activity. The interpretation, negotiation, and synthesis of such information between the parties requires new dialogical and reflective knowledge tools as well as collaboratively constructed functional rules and infrastructures. In an educational context, teachers and students should be co-designers of the technical infrastructure of the school at the very least. According to Victor and Boynton (1998), co-configuration is a continuous process that never results in a finished product.

If companies want to move beyond pure mass production or mass customization (and we argue that they should) and achieve a level of reflective communication in their interactions with schools, they need to follow the principles of co-configuration work. Companies must understand school life, the context of learning, and the needs of the schools more deeply than they currently do. Co-configuration involves not only building a customer intelligent product (or service) but also constructing a productive relationship between companies and schools.

Co-configuration is a challenging form of work. It requires that learners learn to create and master something that does not yet exist. Co-configuration cannot rely on "learning the given new", the transfer of culturally given knowledge. Instead, the parties must "learn the societal new", the mastery of culturally new practices and knowledge. This form of work requires sustained periods of time and cannot be described with traditional narratives of heroic individuals making ingenious discoveries through sudden moments of insight. Instead, success is achieved through the collaborative efforts of every party and participant.

CO-CONFIGURATION PRODUCES NEW ECOSYSTEMS

The aim of co-configuration according to Victor and Boynton (1998) is to understand and adjust to the customer's needs and create customer-intelligent products or services as part of the process. Adjusting to customer needs calls for a continuous interaction between the company, the school, and the product. Whilst thinking about the co-configuration, we can hypothesize that co-configuration work creates a new ecosystem of learning.

An ecosystem is an open system that constantly changes and in which everything is connected. When a new organism or component enters the

ecosystem, it interacts with the ones that already exist (Zhao, Lei, & Frank, 2006). An ecosystem consists of living organisms and nonliving components that have an effect on each other on multiple levels (Zhao & Frank, 2003). Ecosystems can be seen as relationships between different organisms and components as well as a network of self-organized and reflexive processes that follow each other in a circular causality (Keiny, 2002).

Schools can be seen as ecosystems or ecological networks where interests and relationships are interdependent, interrelated, and interwoven (Keiny, 2002; Thomson, 2010). From an ecosystemic perspective, non-living components include infrastructure, technology, blackboards and books (Zhao & Frank, 2003), and versatile formal and informal learning environments and contexts (Barron, 2004). Teachers, students and parents are important living organisms in a school that interact within the system and are responsible for their actions and knowledge building (Keiny, 2002). Transformations and changes in one part of the ecosystem exert effects on the other parts. For example, a teacher's way of teaching affects the students' methods for studying and working.

Traditional collaboration between schools and companies has viewed the school as a non-living component, and the school's ecosystem has been quite closed and resistant to change. Companies have delivered their products to the school and then simply left, which was a separate and independent process from the school's ecosystem. In this type of an approach, the technology provided by a company is seen as neutral and therefore not an active agent in an ecosystem (Zhao et al., 2006). In contrast, when schools and companies are in a co-configurative relationship, the learning ecosystem is open, flexible, and communal and enables innovative ways of working. It is easy for a company to enter an open ecosystem. After arriving, there is a need to create shared rules in a dialogic and reflective process for both actions and interactions. With this approach, a company and its products can be an active agent in a school's ecosystem.

AGILE PRODUCT DEVELOPMENT IN FINNISH SCHOOLS AS AN EXAMPLE OF THE CO-CONFIGURATION PROCESS

The authors have recently participated in joint research and development (R&D) projects on a national level. In these R&D projects, agile product development has been proven to be a successful example of a co-configurative process where companies' products are given to users (in our case, teachers and students) at a very early stage of development. A developing process is called agile when users play a key role in the iterations of developing and testing the customer-intelligent products or services and giving developers real-time feedback from the beginning (Humayoun, Dubinsky, Carmel, Nazarov, & Israel, 2011; Silva da Silva, Silveira, & Maurer, 2011). This kind of co-configuration process proceeds through small, concrete steps that are taken at a somewhat rapid pace.

As an example of an agile development process, we present the case of a math learning game's (10 Monkeys) development in collaboration with developers, researchers, teachers, and students. The game itself is a cloud-based, single-player

math learning game for children aged 6-10 where monkey characters lead students through basic math challenges, such as understanding numbers, addition, subtraction, division, multiplication, and verbal and money-related calculations.

Before classroom piloting, an expert evaluation of the game was carried out via developer-researcher collaboration. This stage involved matching and connecting schools, teachers, and groups with the developers. Researchers discussed meaningful ways of pedagogical use for the game data stored on the server. This exchange was used as the basis for reshaping the functionalities and layout of the teacher UI of the game. From this point on, the data used in making developmental decisions were gathered in an expansive series of user testing sessions. Technical and pedagogical usability as well as the user experience were addressed during the process from both teachers' and students' perspectives. At the start of the series, detailed observational data on areas such as functional requirements, learning solution group management features, and student motivation factors in the classroom environment were gathered. The participating researcher both observed and guided teachers and students. In the next phase, data were gathered in the form of survey responses and automatically stored game data from the servers. To emphasize the perspective of co-configuration, at the center of this iterative process is a continuous feedback loop between the developer and the actors of the pedagogical context. The invaluable activity of reflective communication takes place within the feedback loop and is grounded in the pedagogical reality by the data created and communicated first immediately during the testing sessions and second, post facto, in case of the aggregated survey and server data.

Teachers and students participating in the agile product development could be identified as "experts of their experience" (Sanders & Stappers, 2008). Their engagement in the process should be supported by the developers of the company, allowing users to test the first, beta versions of the product or simple prototypes before the actual launch (Hosseini-Khayat, Hellman, & Maurer, 2010). Continuous interaction between the company, the school, and the product are required to adjust to customers' needs and develop the product to better fit into the schools' ecosystem. The awareness of teachers and students of the opportunity to have an impact on how the product will work and appear in the future should also be promoted.

This type of agile product development has produced a mutual benefit for both schools and companies in four key areas. First, even without a large effort, collaboration can be beneficial for both parties. Teaching will be adjusted and reshaped to a degree when adopting new technologies. Companies will become aware of missing or poorly designed features, inconsistencies, and bugs immediately once the school's user testing reports are transmitted. Second, to reach a deeper level of collaboration and interaction and create conditions for co-configuration, it is essential to acknowledge that the users of a technological product are also able to point out deeper ideas for development. When asked to do so, users give feedback about the original product concept and the underlying conceptualization of learning. This kind of future-oriented user feedback and participation in the development process creates learning activities that are

currently lacking in both technological and pedagogical contexts. The third aspect of co-configurative collaboration is when the teachers and students become more aware of the nature of a technological development process and also better equipped to provide meaningful feedback to the company by being exposed to "product in process" thinking. This aspect helps to overcome the mismatch between the rapid and constant pace of technological development and the slower evolution of a school's ecosystem. Fourth, the uniqueness of each educational context is recognized when companies take the time to build an individual relationship with the school. This recognition can be seen as a part of the general trend of seeking ways to break free from educational one-size-fits-all approaches (Tödtling & Trippl, 2005; Pratt, 2002; Westheimer, 2005; Robinson, 2010).

REFLECTIONS AND CONCLUSIONS

In order to develop new ways of interacting and working together, schools and companies will need to engage in a multi-level process where interaction and action are reconceptualized, reorganized, and rebuilt. In practice, this means that both parties need to offer openness, confidence, and opportunities to actively give feedback and change ideas. In order to reach the zone of proximal development (Vygotsky, 1978), unpleasant development ideas must also be shared and said. It should be remembered that teachers and other practitioners at a school are aware of the needs of the school and how it can be improved, while companies can offer the best tools and technological solutions to meet the school's needs and solve these problems. To encourage collaboration and co-configuration building can be encouraged when schools are seen as holistic ecosystems where one change affects other areas.

Networks and networking have become increasingly important for schools. The prerequisites for school-company collaboration include common goals and rules for collaboration, shared values and visions, which are beneficial and understandable to both parties, and understanding of each other's processes and practices (see Huhta et al., 2011; National Plan, 2010; Lim, Wong, & Quah, 2007). Developing co-configurative collaboration between companies and schools therefore requires a long-term partnership.

Networking with companies provides schools with opportunities for joint development and peer support and sets a diverse perception, allowing for the acquisition of new ideas. For companies to be successful in a school's ecosystem, services and products should be planned in collaboration with schools and from the school's perspective (Smeds et al., 2010). Companies also have an important role in supporting teachers as they use the product. If the teacher is left alone with a new product or tool, lesson-planning time increases, and the intention to use the tool is reduced. Developing and adopting technologies in the current teaching and learning settings require a wide comprehension of the schools' ecosystem and needs. Therefore, multilevel collaboration between schools and companies and agile product development are vital.

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EPILOGUE

What Are Innovations in the Finnish Educational Ecosystem?

The Finnish educational system has matured during the past 40 years into an ecosystem. Its guiding principles have been equity in education and life-long learning. What have we learned from the processes that have taken place as the educational system has grown and developed? Which ones can be said to be innovations? Innovations can be products, processes, services, ideas, or emerging technologies. They are often defined as a new way to think and work. An innovation can also be a new product that is useful to users and solves earlier problems. The innovation is not necessarily something absolutely new. It can also be something that redefines and revisions that connect elements and pieces in a new way. We will use the experiences described in this book to summarize what we see as innovations in the Finnish educational system.

High Quality Education for All in Society

The Finnish society has had to face several problems that resulted from the parallel school system. The educational structure was very selective, and students had to decide about their future when they were 10 years old. The system tracked students at an early phase either on an academic or a vocational route, which divided the nation into two categories (Niemi, 2012). It was very difficult to switch paths later on. The whole system was reformed 40 years ago to focus on delivering high-quality education to all people throughout their lives. This objective has required decision makers to see the system as a whole. They also demand that educational policy seek ways to support different learners who need to exercise their right for learning and development. No educational system can provide equal opportunities without structural and functional support systems. The Finnish solution has been to offer special needs support at an early a stage as possible to all learners in order to avoid dropouts. Another important decision was also to provide all teachers, including primary school teachers, with a high-quality five-year university education (MA). All Finnish teacher education programs prepare teachers for an autonomous professional role in local schools.

H. Niemi et al. (eds.), Finnish Innovations & Technologies in Schools, 165–169.

Invite Partners to Work Together for a Joint Vision of Education

Another real challenge is for different parts of the educational system to continue to work together. In a democratic nation and in a decentralized administration, the Ministry of Education and Culture cannot dictate what municipalities or higher education institutions must do in education. However, these institutions can be monitored through guidelines and national strategies. Negotiations and agreements are typical instruments of policy making. There are even some national resource allocations, but most decisions regarding resources are made at local level. In this kind of governance system, commitment to quality of education at the local level and also the quality of institutions' policy-making tools become important. This commitment requires transparency in political decision making at all levels of the system and joint preparation of reforms. The reform of the national core curriculum process (Vahtivuori-Hänninen et al., 2014, in this book) is one example of this. Different partners should understand the main goal of the system and its reform. Inviting different partners to offer their contributions as early as possible is an important way to get people to work together toward joint aims and to disseminate reforms.

The parts of the system must have common aims in order to achieve long-lasting goals. In Finland, the vision of equal opportunities and support for life-long learning for everyone has provided an important umbrella for different levels and sectors of the educational system. There are also many tensions regarding how to implement these values. Competition for resources, territorial thinking, maintaining boundaries between institutions, and power disturbances are typical in each system; they are also threats in Finland. Therefore, public debates and improvement-led evaluations (Niemi, 2014, in this book) are always needed. The educational ecosystem has many layers and levels. It is not enough that the decision makers are discussing these issues (Korhonen et al., 2014, in this book). The voices of teachers, students, and parents are important for ensuring the wellbeing of learners, as well as the involvement of other partners locally, such as representatives of the health and social sectors.

An Active Concept of Knowledge and Learning

The Finnish educational system started to stress an active concept of knowledge in 1990's curriculum reforms. Schools were asked to design their local curriculums and implement active learning methods. The process has been slow, but we can see a gradual transfer. The change cannot happen without the teachers' own concept of active learning. In most cases, teachers must also learn to work collaboratively. The models of innovative school (Korhonen et al., 2014, in this book) indicated that active learning is a cultural change in schools. It is not only a selection of new teaching methods but also includes more ways of creating and sharing knowledge in the entire school community. These models are also concerned with how technology can be used as a tool for active learning. This book introduces many examples, such as how students created active knowledge with digital storytelling

both in and outside of the school setting (Harju et al., 2014, in this book) or were game designers (Kiili et al., 2014; Ketamo, 2014, in this book). The methods regarding how to make STEM subjects inspiring were very student driven. Students are researchers; they seek knowledge and work together to make decisions and draw conclusions (Penttilä et al., 2014 and Vihma & Aksela, 2014, in this book). Typical of these methods is crossing the boundaries of formal and informal learning environments.

Focus on Learning, Not Testing

Andreas Schleicher (2012, p. 34; 2013, p. 9) writes "The skills that are easiest to teach and easiest to test, are also the skills that are easiest to digitise, automate and outsource" and continues "where jobs are changing rapidly, education systems need to enable people to become lifelong learners, to manage complex ways of thinking and complex ways of working that computers can't take over easily" (Schleicher, 2013, p. 12). He also sees that increasingly diverse and interconnected populations, and rapid technological change in the workplace and in everyday life demand educational systems to enable people to live in a multi-faceted world as active and responsible citizens.

The Finnish educational system does not include standardized testing (Niemi, 2014, in this book). Instead, one focus is to get different learners to learn skills and to provide students with other skills they will need to continue their education. When teachers are not consumed with the pressure of standardized testing, they have the freedom to take care of student learning, and they can use various teaching and assessment methods depending on the students' needs.

The research group at the Institute for the Future (Davies, Fidler, & Gorbis, 2011) analyzed how workplaces will change in the coming years and which skills will be the most important ones for workers to have in the future. The working life will be connected with technology, but it requires far more than technological skills. In addition to identifying those abilities needed to use new devices and technological applications, the research group summarized the following skills as being the most important: sense-making, social intelligence, novel and adaptive thinking, cross-cultural competency, computational thinking, new-media literacy, transdisciplinarity, design mindset ability, cognitive-load management, and virtual collaboration. Skills and abilities will be related to higher-level thinking. Social relationships that cannot be easily transferred to machines and that will enable us to create unique insights will be critical for decision making. Workers will require social skills that enable them to collaborate and build relationships of trust locally, as well as globally, with larger groups of people in a variety of settings. The Finnish solution has been the curriculum system that allows teachers and students the freedom to apply methods that promote 21st century skills. Preparation to these kinds of competences demands a flexible system that focuses on skills that are not so easy to test but will be urgently important in the future (Vahtivuori-Hänninen et al., 2014, in this book).

Technology as a Tool in Teaching and Learning Through School-Based Cooperation

Finland has investing in educational technology since the 1990s. The first wave of information and communication technologies raised many expectations regarding how technology would bring an additional value to teaching and learning. Finland launched several Information Society programs. During the 2010s we could see that Internet technology as itself does not bring real changes to schools or solve problems in teaching and learning. What is needed is its pedagogical use. The recent trend has been to establish school-based projects in which researchers, teachers and students have worked together from the first beginning (Kankaanranta & Vahtivuori-Hänninen, 2014, in this book). In these activities also policy makers and companies have been partners (Aarnio et al., 2014, in this book) as was described. This kind of cooperation has ensured that schools have developed practices that fit with their own every day life.

A Value of Networking

Knowledge is expanding at an accelerating pace and needs to be updated continuously. In these areas, networking brings a big additional value to schools, teachers, and the entire educational system. Even though Finland does not have high-stakes testing and other heavily controlled mechanisms, there are a lot of formal and informal networks and working groups that plan educational practices together. Through discussions and sharing, they are also benchmarking their own work.

Education is not a separate domain in society. The value of networking is important especially with issues related to special needs in education and the well-being of students. The Finnish solutions have been to add a student care group at each school, in which a principal, teachers, nurse, and social workers participate in multi-professional groups (Niemi, 2014 in this book). The important lesson from these networks is that crossing boundaries between different sectors in not always easy and effective; school and social care networks need a long-lasting cooperation and mutual trust.

Teachers' professional associations are also important networks, and virtual groups in which teachers can share their experiences and learn from each other are also valuable. The new form of networks is hosted in cooperation with companies when developing learning materials and new technological solutions for teaching and learning (Aarnio et al., 2014, in this book). Finnish teachers have an advanced university education, and partnering with universities is a natural part of in-service training. This type of networking provides excellent joint learning opportunities but also requires respect from both partners. These networks can be extended to different stakeholders in society, as has happened at the LUMA (STEM) Center (Vihma & Aksela and Tolppanen & Aksela, 2014, in this book). Networking provides a rich environment to learn school subjects in a new way and allows

learning to provide a source of inspiration to different learners, including gifted students.

Technology offers many forums for networking and ways to invite partners who are experts in their own fields in society. Environmental issues, health, arts, and sports are areas where their representatives can contribute to schools when students are working with their inquiry-based projects.

Based on the studies described in this book, we found that it is highly valuable to get students networked both nationally and internationally. Networking and sharing are skills they will need in their future. They also add to the students' cultural knowledge and understanding. When promoting students' networking digital literacies, collaborative skills, and active knowledge creation can be connected simultaneously with networking. All in all, we could find that networking is an essential element when promoting 21st century skills both locally and globally (Griffin, McGaw, & Care, 2012; Niemi & Multisila, 2014, in this book).

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