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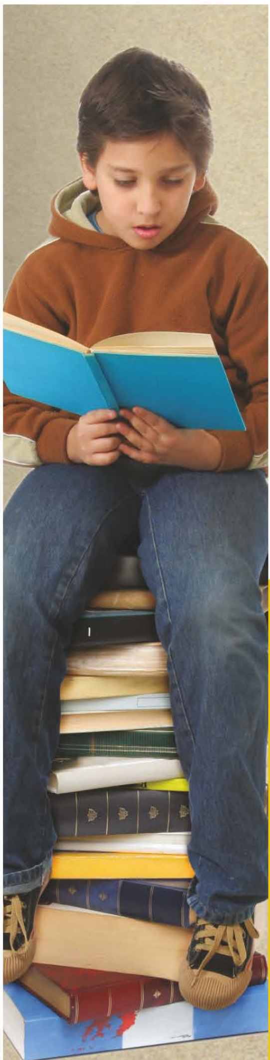

Agriculture and Rural Development

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INNOVATIVE SCHOOLS: TEACHING & LEARNING IN THE DIGITAL ERA

WORKSHOP DOCUMENTATION

EN

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CULTURE AND EDUCATION

INNOVATIVE SCHOOLS: TEACHING & LEARNING IN THE DIGITAL ERA

WORKSHOP DOCUMENTATION

Abstract

The digital revolution is transforming our work, our organisations and our routines. It is transforming the way children and young people play, access information, communicate with each other and learn. But, so far, this revolution has not transformed most schools or most teaching and learning process in classrooms.

There is no doubt that education has an important role to play in increasing the European competitiveness and reducing unemployment, but what can policy makers do to take full advantage of emerging technologies in education while avoiding their downsides?

With the objective of shedding some light on how Europe is performing (within the education field) in the "digital revolution" and to how strongly it is embedded both in school curricula and in teachers' education, the CULT Committee requested PolDep B to organise a workshop on "Innovative Schools - teaching & learning in the digital era".

The present document is the compilation of the background papers and power point presentations prepared for the workshop.

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AUTHORS

Department of Teacher Education, University of Helsinki, Finland: Kirsti Lonka, and Mind the Gap Research Group: Lauri Hietajärvi, Mona Moisala, Heta Tuominen-Soini, Lauri. J. Vaara
Institute of Behavioural Sciences, University of Helsinki, Finland: Kai Hakkarainen, Katariina Salmela-Aro

RESPONSIBLE ADMINISTRATOR

Ana Maria Nogueira / Markus J. Prutsch
Policy Department B: Structural and Cohesion Policies
European Parliament
B-1047 Brussels
E-mail: poldep-cohesion@europarl.europa.eu

EDITORIAL ASSISTANCE

Lyna Pärt

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DISCLAIMER

CONTENTS

LIST OF ABBREVIATIONS

1:1	The principle that each pupil/student possesses a personal device
BYOD	Bring Your Own Device: pupils/students use their own devices in educational institutions
CPS	Collaborative Problem Solving
CSCL	Computer Supported Collaborative Learning
CULT	Culture and Education Committee
cMOOC	Connectivist Massive Open Online Course
ELE	Engaging Learning Environment
F2F	Face to Face Learning
IA	Internet Addiction
KBE	Knowledge Building Environments
MOOC	Massive Open Online Courses
MTSD	Mobile Touch Screen Digital (Devices)
NCLB	No Child Left Behind
PBL	Problem-Based or Project-Based Learning
P2P	Peer-to-Peer learning
PLE	Playful Learning Environments
SDP	Socio-Digital Participation
SEL	Social and Emotional Learning
STEAM	Science, Technology, Engineering, Arts, and Mathematics

EXECUTIVE SUMMARY

Background

There is a worldwide concern that our educational systems are outdated and failing to promote the necessary skills that will adequately prepare our children for the future. The previous generations' motivation to study was strongly based on sense of duty. Younger generations have different motivational profiles: in their lives interest, emotions, and engagement matter much more.[1] The emerging social practices of the new generation are always evolving as is the state of digital communication. There is no reason to assume that the development of ICT will be any slower in the future. In contrast, new innovations will emerge at an increasingly faster pace – and we can only hope that they are going to be developed by Europeans. We need to take care of our future by designing innovative and engaging learning environments for our youth.

Aim

The aim of this paper is to provide a review on how we currently understand the role of schools and education in the digital era. This topic is not easy to tackle and there is no current research that can objectively tell us what would be the most beneficial way to move forwards. The problem goes far beyond technology. Current research literature indicates that we are moving from an individualistic knowledge acquisition culture towards a collaborative knowledge creation culture of learning.

As stated in the NMC Horizon Report Europe: 2014 Schools Edition,[2] European schools are facing key challenges linked to the impact and use of new technologies. Today's young Europeans are the first generation to have come of age in a digital society. Computers, smartphones, and global communications have shaped and educated this generation of students. They are active and often enthusiastic participants in the creation of online communities since early childhood. The problem is that such activities generally take place outside schools. In many cases, informal learning is much more engaging and effective than formal learning. Furthermore, most pupils do not learn how to systematically make use of technology in academic activities.

The other worrying trend is disengagement at school. Our own research indicates that the students with the best skills in technology are also the ones who are most bored and disengaged at school. Important 21st Century skills involve, for instance, new forms of (digital) literacies, creative problem solving skills, collaboration and communication skills, cultural and ethical awareness as well as entrepreneurship. In order to maintain well-being at school, Social and Emotional Learning (SEL) is important for teachers, pupils and parents.[3] SEL includes the skills that are needed to regulate oneself and interact with others in constructive ways.

Europeans who were born after 1980 can be labelled as "digital natives" since they do not normally remember a world without digital technologies.[4] The term itself is debated[5] and it cannot be claimed that being a digital native necessarily indicates effective or sophisticated use of technology in educational settings. In order to

2 https://ec.europa.eu/jrc/sites/default/files/2014-nmc-horizon-report-eu-en_online.pdf.
3 www.casel.org.
4 Prensky, 2001; Hakkarainen et al. 2015, in press.
5 Kirschner & van Merriënboer, 2013.

cultivate complex personal and social competencies, adolescents need systematic support from parents and teachers. It is important to investigate how digital technologies affect our everyday life inside and outside the educational environment. Our recent inquiries indicate that these so-called digital natives are far from being a unified group. There is a huge variation in ICT use among adolescents, even among fairly homogenous populations, such as one city area.[6] It is also quite likely that there is a gap between the informal knowledge and media practices of digital natives and the practices of educational institutions.[7] Young people need to discover meaningful ways of using technology for learning purposes and collaborative knowledge creation.

For personalized and flexible learning, the use of technologies should be embedded in sophisticated pedagogical practice. There is no evidence that students' learning styles are the key to designing personalized learning. Meaningful learning matters more. Students should be guided towards innovative practices of knowledge creation. The time of e-learning as it was originally defined appears to be over. MOOCs do not necessarily change anything since they are often based on knowledge transmission rather than knowledge creation. Rather, hybrid forms of learning are advisable, where mobile, digital, virtual, social and physical learning spaces merge.[8] Mobile devices and MTSD play a role when virtual and face-to-face merge in new and seamless ways. It is also important to design physical learning spaces in accordance with current knowledge practices and new forms of socio-digital participation.

Assessment is the tail that wags the dog: It guides student learning in many ways.[9] ICT-based assessment is often recommended, but it is rarely indicated how it should be applied. It is possible that our assessment practices are the major obstacles to educational transformations. In some countries there are indicators that the efforts to improve school and PISA scores have resulted in increasingly obsessive individualized assessments. This trend hinders meaningful learning.

There is great disparity in our schools and education systems. Research[10] shows that disparities persist in the availability of ICT-based educational tools and content. There is not only variation among adolescents, but also among schools and teachers in how they use ICT in schools. The lack of equal access to technology and knowledge puts entire communities and populations of students at a disadvantage, especially minorities and students in sparsely populated or geographically remote areas. In Finland and many other countries the availability of technology is adequate, but the primary challenge to overcome is the readiness deficiency for pedagogically meaningful use of ICT. It is imperative to develop innovative pedagogies that simultaneously support the acquisition of a deep knowledge base, understanding, and 21st Century skills. Such instructional procedures do exist, such as problem-based and project-based learning as well as inquiry-based science education. Art, music, sports, and handicraft are also important for the balanced development of individuals. Such activities foster not only well-being, but also

[6] Hietajärvi et al., 2015.
[7] Hakkarainen et al. 2015, in press.
[8] Lonka, 2012.
[9] Darling-Hammond, 2012; Tillema, Leenknecht & Segers, 2011.
[10] http://eacea.ec.europa.eu/education/eurydice/documents/key_data_series/129EN.pdf.

cognitive development.[11] Playful learning is recommended for all age groups, but playing is especially important for children.

When it comes to economic equity, there are currently several conversations being had regarding how parents and families should contribute to buying technologies for schools. BYOD discussion (Bring Your Own Device) is one example of this, indicating that each pupil could use their own devices at school. However, in many countries it is forbidden to use one's own mobile devices at school. Instead of being denied technological tools, the pupils should learn how to use them in socially and pedagogically acceptable ways. They need to learn how to regulate their own use of mobile devices inside and outside school. The opposite approach is 1:1, favored by the manufacturers and companies, where each pupil is provided her own device by the school. Many pedagogues think that 1:1 is not necessary if the goal is to promote collaborative knowledge creation and meaningful P2P interaction.

Action is needed to promote innovation in the classroom and to take advantage of increased use of social media, open educational resources, and the rise of data-driven learning and assessment. Consequently, this requires a new set of competences for teachers[12], teacher educators, and education leaders. According to the Key Competence Framework,[13] digital competence involves the confident and critical use of Information Society Technology (IST) and thus basic skills in Information and Communication Technology (ICT). In this paper, we are conceptualizing this issue in a novel way. Instead of discussing the technologies themselves, we will be discussing new ways of socio-digital participation (SDP).[14] Teacher education and educational leadership need to be in constant development.

[11] Hillman, Erickson & Kramer, 2008; Schlaug, G., Norton, A., Overy, K., & Winner, E., 2005; Sevdalis & Keller, 2011.

[12] Most teachers use computers mainly for administrative tasks - schedules, tests...

[13] http://europa.eu/legislation_summaries/education_training_youth/lifelong_learning/ c11090_en.htm.

[14] Hakkarainen, 2009; Hietajärvi et al., 2015.

GENERAL INFORMATION

KEY FINDINGS

- It is important to base our conclusions on perceiving learning as knowledge creation, rather than emphasizing mere knowledge acquisition. 21st century skills are integral parts of learning.
- Learning takes place between people and their cultural surroundings. It is therefore important to develop collective cultural practices, physical learning environments, and institutional routines (e.g. assessment) to support engagement, innovation, and knowledge creation at school. Paradoxically, this can be done by supporting local agency and participation.
- The knowledge practices of digital natives are different from previous generations, even though there is no reason to assume that their cognitive system is profoundly different from ours. They have just extended their minds differently with new kinds of tools.
- Well-being and Social and Emotional Learning (SEL) are at least as important as other 21st century skills (such as media literacy, cultural awareness, and complex problem solving). Arts, music, sports, and handicraft are also important for balanced emotional and cognitive development.
- Instead of computer-supported learning, it would be advisable to talk about new forms of Socio-Digital Participation (SDP). This includes media literacy, such as using social media and search engines.
- There is <u>no</u> evidence that learning styles or types would be informative in designing learning environments. Alternatively, it would be advisable to observe users' motivational profiles or study orientations. Meaningful and engaging learning methods are advisable, which support collaboration and self-regulation.
- Pedagogical innovations are needed – technological innovations are often pedagogically weak. Fragmented projects start and end, but fundamental structures remain the same. Systematic development of flipped and inquiry-based learning programs with meaningful use of technologies would be advisable.
- We need constant reforms in schools and teacher education. The schools are not following the important developments of society. We have perhaps spent too much time looking at test results, such as PISA.

1. INTRODUCTION

This paper addresses the question of how schools can update their practices in the digital era. Research in this field is developing fast, since the development of technologies is exponential. Grasping the essence of this ever-changing digital landscape is like taking a picture of a rapidly moving target. The present paper looks at these problems from a global perspective, but focuses on Finland as its primary example.

The methodology used is based on the collection and processing of secondary data available from the abundant amount of literature available on cognition, learning, schools, learning technologies, motivation, and teacher education. Our own original empirical research is also used.[15] This analysis is inevitably hypothetical, since predicting the future is always difficult. It is possible, however, to tackle some major issues in the literature.

We are facing numerous severe problems and risks related to climate change, sustainability of the Earth, and radical inequality. Such problems are so complex that they exceed the capacity of individual cognition. Many researchers are concerned that there is an increasingly deep ingenuity gap[16] between such huge practical challenges and the limited problem-solving capabilities that are promoted by the prevailing educational practices.[17] Productive participation is essential in the emerging innovation-driven knowledge-creation society.[18] A society that is oriented toward building a sustainable future will require the cultivation of sophisticated innovative competencies by all citizens who need better capabilities of seeing things in fresh perspectives, enhanced self-efficacy, and associated identities as potential creators of knowledge. Therefore, it is critical to cultivate pedagogic practices that nurture such capabilities from an early age.

In a time of rapid technological development and economic uncertainty, these competences are fundamental for personal and professional development as they enhance citizens' well-being and provide career opportunities. The abovementioned key competences were defined by EU in 2006 and many countries have modified these to fit their own cultural and societal needs. For instance, the new national core curriculum in Finland[19] defines seven core skills that are central in Finnish 21st century skills:[20]

1) Thinking skills and learning to learn.
2) Cultural competencies, communications skills and self-expression.
3) Taking care of oneself and everyday skills.
4) Multiple literacies.
5) ICT competencies.
6) Work life skills and entrepreneurship.
7) Participation, agency, and the readiness to build sustainable future.

15 Rym.fi, wiredminds.fi Mind the Gap – between digital natives and educational practices. A project funded by Academy of Finland Mind Program. 2013-2016.

16 Homer-Dixon, 2001; Facer, 2011.

17 Scardamalia et al., 2012.

18 Bereiter 2002; Hakkarainen, Palonen, Paavola, & Lehtinen, 2004.

19 http://www.oph.fi/download/163777_perusopetuksen_opetussuunnitelman_perusteet_2014.pdf; http://www.oph.fi/ops2016 (in Finnish).

20 http://www.oph.fi/download/163777_perusopetuksen_opetussuunnitelman_perusteet_2014.pdf (in Finnish).

The new national core curriculum in Finland is the basis of locally accustomed and tailored curricula in each school.[21]

The European Commission Communication 'Rethinking Education'[22] states that technology offers unprecedented opportunities to improve quality, access, and equity in education and training. It is a key lever for more effective learning and reducing barriers to education. In particular, social barriers play a large role. Individuals can learn anywhere, at any time, following flexible and individualized pathways. The Europe 2020 strategy[23] provides the supporting framework for this flexibility, and the 2013 Country Specific Recommendations[24] highlight the importance of the Digital Agenda. More recently, in its Council Conclusions from March 2015[25], the European Council declared supporting efforts to encourage relevant education and training in digital skills.

There are no simple solutions in the field of education, but fortunately there is a vast research base on learning and instruction. For instance, the members of the European Association for Learning and Instruction (EARLI) are currently conducting excellent research in addition to learning from the global research community. We already understand a great deal about human memory, the brain, and learning. Evidence is swiftly accumulating regarding how people learn[26] in addition to methods of promoting high-quality education.

[21] http://okm.fi/export/sites/default/OPM/Julkaisut/2015/liitteet/tomorrows_comprehensive_school.pdf?lang=en.
[22] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0669&from=EN.
[23] http://ec.europa.eu/europe2020/index_en.htm.
[24] http://ec.europa.eu/europe2020/making-it-happen/country-specific-recommendations/index_en.htm.
[25] http://www.consilium.europa.eu/en/meetings/compet/2015/03/02-03/.
[26] Bransford et al., 2000.

2. THEORETICAL BACKGROUND

2.1. A cognitive approach to learning

In order to understand how to educate people, it is very important to understand some main principles of our cognitive system. Human memory does not work like a scanner or videotape. Rather, we constantly construct mental models of our environment. Additionally, biases in human reasoning are well known.[27] On the basis of what we know about human cognition, it is quite unlikely that people could ever be able to integrate all possible knowledge into an objective truth. Rather, we are likely to construct personal understanding on the basis of facts that are presented. Each reader, for instance, reads this same document on the basis of their own expertise and the interpretation depends on their mental models. Modern theories of learning see the learner as the central component in the creation of meaning. It is not possible for the teacher to transmit knowledge into an empty container[28]. In general, learning is viewed as an active, constructive process, rather than a passive, reproductive process.[29]

The term "working memory" refers to a multilevel system of the human mind that provides temporary storage and enables the manipulation of information necessary for the achievement of complex cognitive tasks, such as reasoning and conceptual learning.[30] Working memory has a limited capacity, making it very difficult, if not impossible, to consciously process more than 3-7 items of knowledge at the same time.[31] It is therefore impossible to be capable of true multitasking (i.e. carrying out two or more tasks simultaneously that require cognition or active information processing). The human cognitive system and brain functions only allow for switching between different tasks (i.e., perform different tasks in quick succession) even though the performance seems to subjectively occur simultaneously.[32] In this sense, the idea of "digital natives" being good at multitasking is an urban legend.

Anther urban legend can be observed in regards to learning styles. There is no evidence that learning styles or types exist in the sense that people could be divided, for instance, into "auditive", "visual" or "kinesthetic" learners.[33] Professor Jan Vermunt uses the term "learning styles", but means something entirely different: there are different orientations, depending how willing students are to process meaning instead of applying rote learning. Such orientations to learning are not traits of people, but rather, develop through interactions with students and the learning environment.[34]

It therefore does not make sense to design learning environments according to different "types" or "styles" of students, but instead, to help people develop increasingly functional and productive approaches to learning and studying. The stereotypical view of innate abilities and traits is harmful to this approach and reflects a

27 Gilovich, Griffin & Kahneman, 2012.
28 Biggs, 1996; Bransford et al., 2000.
29 e.g. Bruner, 1996; Lonka, Joram & Bryson, 1996; Loyens, & Gijbels, 2008.
30 Baddeley, 1992.
31 Dijksterhuis, Bos, Nordgren & van Baaren, 2006.
32 Kirschner & van Merriënboer, 2013.
33 Pashler, McDaniel, Rohrer, & Bjork, 2008.
34 Lonka, Olkinuora & Mäkinen, 2004.

fixed mindset.[35] Such a mindset, in contrast to the growth mindset, reduces resilience and willingness to spend time working on the upper limits of our cognitive capacity.

When solving complex problems, decisions are often based on abstracted mental models (or scripts).[36] Long-term experience with a certain domain causes mental models in memory to be better organized, thus enabling the learners to base their decisions on their past experiences rather than needing to fit each piece of data into a complete model. Mental models also guide the search for new information. All humans need to learn a sufficient knowledge base in order to form functional mental models.[37] It is not possible to learn thinking skills separately from knowledge. Therefore, there must be some knowledge base in biological memory as all information processing cannot be outsourced to search engines (such as Google).

The majority of research literature in psychology is based on the assumption that cognition takes place within the minds of individuals. Such an approach to defining expertise relies on the acquisition metaphor of learning,[38] which treats learning as an accumulation or change of an individual's knowledge, but says nothing about the community around the learner. A cognitive view highlights the role of mental models, which, of course, is very important. However, decision-making is not only about mental models because human cognition is always embedded in a historical continuum of social community, culture, and its tools.

2.2. New approaches to learning and technologies

Socio-constructivist or socio-cultural theories of learning have become increasingly important in learning sciences.[39] There are numerous tools that may help to reduce the load on human memory. Books, notes, calendars, and calculators were used in the past to help people to outsource parts of their cognitive functions and, consequently, expand their intellectual resources. In an information society, we use increasingly more intelligent technologies (computers, search engines, artificial intelligence) to expand our biological memory. These external conceptual artefacts support human cognition in many ways. It is important that such external tools capitalize on the strengths of human cognition or help to overcome its weaknesses. Individuals need to rely on external supports to help them focus on crucial features of the problem rather than forcing them to try and track more information than they are able to process.[40] In many ways, we are still just beginning to understand how to use technology more to support our thinking rather than distract it.

Learning is an interactive process of participating in cultural practices and shared activities that structure and shape cognitive activity in many ways. Learning always takes place in a context. This context is not only situational, but it relies on culturally and historically developed structures. Human beings have evolved in such a way that their normal cognitive development depends on a certain kind of cultural environment for its realization.[41]

[35] Dweck, 2006.
[36] Schmidt & Rikers, 2007.
[37] Bereiter, 2002.
[38] Paavola, Lonka & Hakkarainen, 2004.
[39] Kumpulainen & Lipponen, 2010; Säljö, 2012; http://www.oppimisensillat.fi/index_eng.php.
[40] Lonka, 2009.
[41] Lave & Wenger, 1991; Sfard, 1998; Vygotsky, 1978; Tomasello, 1999.

Schools are institutions with highly structured methods of interaction. The classroom or lecture hall has its own roles, norms, rules, and tools. Students and teachers have developed certain types of identities, and they have become accustomed to certain ways of thinking and behaving. The majority of these collective ways of thinking and social practices may be beneficial, but some may be harmful. Recently it has become clear that it is imperative to change physical learning environments and technologies in order to alter the ways in which people behave and think.[42]

The acquisition metaphor is not sufficient to explain learning in the digital era. The new metaphor of learning is the knowledge-creation metaphor of learning.[43] Its emphasis is not only on individuals or on the social community as such, but on the way people transform their practices by collaboratively developing artefacts and tools to mediate their current activity. It emphasizes the importance of deliberately engaging in generating, sharing, and jointly developing new conceptions, models, and other artefacts and instruments. Complex decisions, such as how to manage mobile devices in the classroom call for constant creation of new knowledge practices.[44]

Such collectively cultivated knowledge practices determine the nature of learning. Knowledge practices are social procedures related to working with knowledge, i.e., personal, collaborative, and institutional routines. Personal knowledge practices of young people may be quite advanced outside schools and their informal methods of socio-digital participation (SDP) may be innovative and advanced. However, institutional routines in schools and educational institutes are crucial in determining whether school learning is reduced into mere knowledge acquisition and rote learning. Institutional routines include repeated procedures for carrying out learning tasks, solving problems, completing assignments, and creating epistemic artefacts, such as essays, exam papers, blogs, videos, or research reports.[45]

The knowledge-creation metaphor is necessary to better understand the dynamics of pursuing novelty and innovation that appear to characterize modern knowledge-intensive work, including activities in schools. Rather than being a privilege of some selected population, knowledge creation is expected to be part of all citizens' everyday activity in terms of tackling complex and ill-defined problems, adapting tools to novel purposes, and contributing to developing new professional standards. While an individual person may play a crucial role in endeavors of professional knowledge creation, this activity is always embedded in collaborative activity.

Knowledge acquisition and knowledge creation are not mutually exclusive. They are both needed in order to adequately understand complex learning processes. For instance, in PBL tutorials students learn the facts and simultaneously develop high-level knowledge-creation skills. Greater emphasis on knowledge creation is likely to generate further innovations in education and technology. Technological tools may help to mediate the relation between human decision-making and its target, by providing cognitive support that is consistent with human cognition. In the future, artificial intelligence, robotics, and the Internet will likely fuse into hybrid networks consisting of people and complex tools.

[42] Lonka, 2012; Kuuskorpi, 2012; www.rym.fi.
[43] Paavola, Lipponen & Hakkarainen, 2004; Paavola & Hakkarainen, 2014.
[44] Hakkarainen, 2009.
[45] Muukkonen, 2011.

2.3. New approaches to instruction

The traditional concept of schooling, based on a re-production model (knowledge acquisition) where there is one classroom, one teacher, one class, and one subject at a time, is being increasingly questioned.[46] Rethinking the relationship between education and practices that scaffold knowledge creation is vital. Currently, the comparison of mere knowledge acquisition versus the added value of knowledge creation is made increasingly often.[47] Researchers refer to the former by using terms such as "knowledge transmission/telling" or "pedagogy in an industrial society". The opposite would be "knowledge building/creation/transforming" or "pedagogy in the information society". Also terms "socio-constructivist learning" or "deep learning" are used for the latter type of learning.[48] These two opposites form a continuum where one end is rote learning and the other end is collaborative knowledge construction.[49] Doing so might help us see important roles for different artefacts, technologies, and conceptual tools than are currently employed. Perhaps it is time to focus on developing further external tools to aid decision-making and thinking more explicitly about how they should be used in education. We cannot develop our cognitive system without re-organizing our social practices and inventing tools that help us use our cognitive limitations to our advantage. In the following sections, examples of how technologies are used will be presented.

Technology co-evolves rapidly with novel learning practices. Learning becomes increasingly blended[50] or hybrid[51] which means that Face-To-Face (F2F) and Peer-To-Peer (P2P) instruction is often combined with virtual learning environments. Recently, new forms of socio-digital participation and tools, such as social media and Mobile Touch Screen Digital Devices[52] (MTSD) are part of such systems. Instead of exploring "learning environments" or "technological tools", it may be possible to develop Knowledge Building environments (KBE) in general that enhance collaborative efforts to create and continually improve ideas.[53] In this context, our research group uses the term new forms of Socio-Digital Participation (SDP).

Engaging Learning Environment (ELE) is a holistic model of designing new learning environments. It was created to design a new learning space for the Helsinki World Design Capital in 2012. It is a synthetic model of innovative learning and instruction that depicts learning as an iterative and cyclic knowledge advancement process.[54] It involves an iterative process of: 1) diagnosing current knowledge and activating a meaningful context to guide and direct learning, 2) going through and facilitating various inquiries in which new knowledge and understanding is produced, and 3) assessing learning gains and knowledge produced so as to engage the participants in an expanding learning and inquiry cycle. Assessment is therefore an integral part of learning. Such activities characterize the activities of teachers, students, professionals and researchers equally. With this kind of general model, it is possible to cover different kinds of process-oriented instructional procedures. These include: PBL, inquiry (or enquiry)-based learning, project or case-based learning, phenomenon-based learning, student-activating lectures,

[46] Kumpulainen, Mikkola & Jaatinen, 2013.
[47] Scardamalia & Bereiter, 2003; McFarlane, 2015.
[48] Lonka, Olkinuora & Mäkinen, 2004; Loyens & Gijbels, 2008.
[49] Lonka et al., 2008.
[50] Bonk & Graham, 2006.
[51] Vernadakis, Antoniou, Giannousi, Zetou, & Kioumourtzoglou, 2011; Wang, Fong, Kwan, 2010.
[52] Joanne O'Mara et al., 2015.
[53] Scardamalia & Bereiter, 2003.
[54] Lonka, 2012¸ Lonka & Ahola, 1995: Lonka, Hakkarainen & Sintonen, 2000; Lonka & Ketonen, 2012.

MOOCs, simulations, flipped learning, and so on. These principles are common with all student-centered forms of learning.

In Finland, the national RYM Indoor Environment[55] project (2011-2015) is aimed at creatively transforming the prevailing built learning environments by relying on a shared set of principles that could be customized to fit the need of the whole community. The idea was to transform spaces of learning by relying on the combined strength of innovative pedagogical methods and novel ICT-based instruments of learning that created dynamic spaces for facilitating learning. In order to facilitate knowledge-creating activity it was essential to integrate the physical space of learning with novel technology-mediated learning tools (virtual space) that elicit the participants' personal learning activity (mental space) as well as their collaborative learning activity (social space).[56] An integrated approach on developing the spaces of learning and knowledge creation separated the present project from several other studies.

[55] www.rym.fi. www.indoorenvironment.fi, wiredminds.fi http://rym.fi/the-smart-space-is-reality/. Vimeo.com/hufbs ; http://rym.fi/rym-award-2014-goes-to-professor-kirsti-lonka/.
[56] Compare Nonaka, Konno, & Toyama, 2001.

3. THE KNOWLEDGE PRACTICES OF DIGITAL NATIVES

3.1. Who are digital natives?

The generation of young people, who were born around 1990s, may be called ”digital natives”, since they were born together with Internet and mobile technologies.[57] Typical knowledge practices for this generation are claimed to be multi-tasking, that is, carrying out several activities side-by-side.[58] They are also reading comfortably from screens, are fond of computer games, and are using social media extensively. Young people outsource many cognitive functions to different technological tools.

The concept of “digital native” is, however, a controversial idea.[59] Our own research shows that even the Millennium -generation (who were born in 2000) are heterogeneous in terms of their knowledge practices and technology use.[60] Regardless, we can claim that the knowledge practices of young people have drastically changed during the last decade although the educational practices have largely remained the same. Marc Prensky (2012) pointed out that “today’s students are no longer the people our educational system was designed to teach” (p. 68).

Further, there is no reason to assume that new technologies would automatically have a beneficial impact on learning and development. Carr (2010) pointed out that constant interruptions associated with the Internet, shallow surfing from one website to another, and a tendency to work with relatively short fragments of text might produce ‘grass-hopper minds’, unable to undertake coherent and disciplined thought; minds for whom knowledge is a matter of ‘cut and paste.’ Without support of parents and teachers some groups of students may not achieve the advanced skills and practices of using new technological tools. Although social media provides a strong sense of belonging to a community, it may also elicit self-presentation, virtual bullying, and exclusion of those without socially desirable characteristics.[61] Little is known, however, about what truly happens in developing minds of youth. Therefore longitudinal and careful studies are required.

Our own project (funded by The Academy of Finland) “Mind the Gap – between digital natives and educational practices”[62] integrates educational, developmental, socio-emotional, and neuroscientific approaches to examine the development of the minds of so called “digital natives”. We examine 1) patterns and trajectories of ICT use in different populations of young digital natives (disengaged vs. engaged ICT user; restricted vs. creative use of ICTs). Experiences of early, middle and late adolescents are followed across four years regarding 2) intellectual, emotional, and social engagement and wellbeing; 3) contextual daily variation of engagement of those having diverging ICT experience, and 4) social networks. Further, we analyze 5) how the intensity of using ICTs structurally and functionally shapes the minds and brains of digital youth. The data collected is nested (adolescents, classes, peers, teachers, schools, parents), longitudinal and process-oriented in nature.

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57 Prensky, 2005; 2012.
58 It is not possible to do such things simultaneosly that load the same functions of working memory.
59 Bennet, Maton & Kervin, 2008; Kirschner & van Merriënboer, 2013.
60 Hietajärvi et al., 2014.
61 Nadkarni & Hoffman, 2012.
62 wiredminds.fi

HOW IS TECHNOLOGY AFFECTING THE BRAINS OF OUR CHILDREN?

Concerns have been raised about how the ever growing pervasiveness of modern information technology in young people's everyday lives affects their developing brains. A lively public debate has given rise to claims that extensive technology use might lead to a decline in mental ability, seen as an inability to focus or think deeply.[63] Although polarized opinions are voiced in the public sphere with great conviction, very little actual scientific evidence exists to substantiate these claims. Only a handful of experimental studies have examined the relationship between technology use and cognitive functioning, and these studies have produced conflicting results. For example, a study which is often cited in popular media showed an association between chronic media multitasking and increased distractibility in adults,[64] but a follow-up study by a different research group failed to replicate these results.[65]

Even fewer studies have focused on children and adolescents, but some researchers suggest that media multitasking might in fact train the developing brain in a way that enhances attentional capabilities.[66] In an effort to shed more light on these issues and to provide much needed experimental evidence, a brain research study is currently being conducted as a part of our Mind the Gap project. In this study, brain activity of adolescents belonging to different ICT user groups is recorded with functional magnetic resonance imaging (fMRI) during selective and divided attention to spoken and written sentences, alsoand during an audio-visual working memory task. The groups are then compared on their level of task performance speed and accuracy, brain activity, and brain structure in order to determine whether ICT use has any effect on these variables. These longitudinal follow-up studies are still in progress.

Source: PhD candidate Mona Moisala, University of Helsinki, Finland.
Supervisor: Professor Kimmo Alho.

3.2. School engagement and motivation

3.2.1. Academic emotions and interest

German professor Reinhard Pekrun[67] is a pioneer in the research on academic emotions, pointing out that far more literature on test-related anxiety than on positive academic emotions exists. Pekrun and his colleagues defined academic emotion as "an emotion experienced in academic settings and related to studying, learning or instruction". Such emotions are, for example, enjoyment of learning, pride of success, or test-related anxiety.

Academic emotions are social in nature and emotional experiences are always situated in the immediate and broader social context. Teachers can influence their students' emotions, although it may be difficult to make teachers change their instructional behavior in such a way that functional student emotions are fostered.[68] Research on the

[63] e.g., Carr, 2010.
[64] Ophir et al., 2009.
[65] Minear et al., 2013.
[66] Foehr, 2006.
[67] Pekrun et al., 2002; Hidi & Renninger, 2006.
[68] Opt't Eynde & Turner, 2006; Pekrun, 2005.

impact of classroom instruction, learning environments, and social contexts on the development of academic emotions is still scarce.

Interest is characterized by an affective component of positive emotion and a cognitive component of concentration.[69] Interest is an academic emotion that develops in the interaction between a person and the surrounding context. As such, instructions that activated prior knowledge, supported autonomy and a sense of control, and where the goals were transparent, were reported to promote interest.[70]

While it seems clear that students' emotions develop in social contexts, we do not yet know how this process can be fostered so that the enjoyment of learning is enhanced, and that negative emotions hindering learning are prevented or put to productive use. Future research on academic emotions should include more intervention studies and provide information on how instruction and social interaction with students can be modified in such a way that students' emotional development is fostered.

We investigated the role of academic emotions in studying and learning processes in teacher education and showed that situational academic emotions were related to study success. Anxiety was negatively related to the grade awarded for the course. Interested students invested more study time and also gained better course grades than the others[71].

3.2.2. School engagement

Emotional engagement in school is thought to play a central role in adolescents' academic achievement and adjustment. Positive and negative emotional engagement has been shown to have significant concurrent and prospective associations with multiple indicators of academic and psychological functioning.[72] Many policymakers and educators focus on enhancing youth's emotional engagement in school as a way to address issues of underachievement, truancy, and school dropout.[73]

The 2012 PISA results reveal that 15-year-old Finnish students ranked 60th out of 65 countries for how much they like school (OECD, 2013). The research shows that many Finnish secondary school students reported feeling inadequate to be successful in school, exhausted by school, and cynical about school value, a phenomenon which Finnish scholars call school burnout.[74] Studies of Finnish adolescents have also rarely examined emotional engagement and school burnout simultaneously,[75] even though research suggests that positive and negative emotional processes are distinct and may have differential effects on adolescents' academic and emotional wellbeing.[76]

Salmela-Aro et al. (submitted) recently identified five groups of elementary school students in terms of engagement and burnout: Engaged (50%) students, who formed the majority; Stressed (4%) students, who reported high exhaustion and high inadequacy as a student; Cynical (15%) students, whose cynicism was directed in particular towards studying and school; Burnout risk (5%) students, who scored very high in all the

69 Hidi & Renninger, 2006.
70 Tsai et al., 2008.
71 Lonka & Ketonen, 2012.
72 Wang, Chow & Salmela-Aro, 2015.
73 National Research Council, 2003.
74 Salmela-Aro, Kiuru, Pietikainen, & Jokela, 2008.
75 See Tuominen-Soini & Salmela-Aro, 2014 for exception.
76 Janosz, Archambault, Morizot, & Pagani, 2007.

components of school burnout, particularly in cynicism but also in exhaustion and inadequacy as a student; and, finally, those at risk for cynicism (26%), whose feelings of cynicism were elevated. These results revealed that almost half (46%) of the elementary students felt cynicism towards school, thereby supporting the gap hypothesis between the school practices and digital natives. These groups of cynical students reported that they would be more engaged if new forms socio-digital participation (SDP) would be applied at school.

In conclusion, our results demonstrate that students in elementary school display diverse patterns of school engagement and burnout (see also Tuominen-Soini & Salmela-Aro, 2014). The results indicate that early adolescence is not consistently a time of either school engagement and well-being or disengagement and distress. Some students both value school and thrive at school, some students are exhausted despite their school engagement, some students are disengaged but still get along quite well, while a small minority of students display both low engagement and school adjustment problems. However, their engagement might be enhanced by employing new forms of socio-digital participation also in schools to support personal and shared interests, positive emotions, and implement innovative pedagogies that could make education a more engaging experience. Experiential and authentic learning, playfulness, and reorganizing the physical and social environment would be worth trying.[77]

3.2.3. Social and emotional learning

SEL (Social and Emotional Learning) is defined as a comprehensive approach to reduce the risk factors associated with and to foster the protective mechanisms for positive life development.[78] SEL includes the skills that are needed to regulate oneself and one's human relationships. The applications to education of emotional intelligence theory and developmental psychological models of social and emotional competence support this SEL theory.[79] Educational psychology theories, especially self-determination theory,[80] emphasize the own efforts and autonomy of children and youth. SEL training helps teachers deal with challenging situations and to promote their pupils' autonomy.[81] This has consequences on the pupils' well-being and their academic achievement.[82] It is also important to integrate SEL with SDP.

[77] McFarlane, 2015.
[78] Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011, www.casel.org.
[79] Humphrey, 2013.
[80] Ryan & Deci, 2000.
[81] Talvio, 2014.
[82] www.casel.org.

4. PROMOTING PRACTICES OF KNOWLEDGE CREATION IN EDUCATION

4.1. Activities that promote knowledge creation

Sophisticated instruments and practices of knowledge creation given to young students may extend their minds[83]. Technologies already exist that involve artificial intelligence, such as Siri and Skype Translator. New technologies may help our students augment their personal and collaborative intellectual resources in a way that makes knowledge creation feasible. This does not happen without scaffolding of the surrounding learning environment and more experienced peers, parents, and teachers.

Investigations of Professor Kai Hakkarainen and his colleagues[84] revealed that primary and lower secondary school students who were supported by proper instruction and collaborative technologies were able to pursue challenging inquiries in biology and physics. Further, investigations of supportive technology-enhanced learning provided clear evidence that technology-enhanced processes of Investigative Learning (or "progressive inquiry",[85]) or Inquiry-Based Science Teaching (IBST[86]) or Learning by Collaborative Designing (LCD[87]) do, in fact, foster students' learning engagement at various levels of education. This helps build core literate and mathematical-scientific competencies.

Measures of process skills, inquiry methods, and practices relevant to Science, Technology, Engineering, Arts, and Mathematics (STEAM) education have been developed. Such approaches include not only using innovative technologies, but also, handicraft and art. It is essential that collaborative knowledge construction is involved. Students could be introduced to fabrication technologies such as CAD and 3D printing, constructing and programming robots, designing and constructing circuits, wearable computing (e-textiles) by which one may create multi-faceted complex artefacts.[88] Such technologies enable even young children to construct complex controllable artefacts with hybrid material, digital, and virtual features. Besides fun and practical activities, it is crucial to facilitate deep learning through guided engagement in scientific inquiry, expert-like designing; in short, students' deliberate efforts to build, create, and synthesize knowledge.

Such approaches highlight the importance of active personal and collaborative engagement of students in their learning processes. They are able to share objectives, produce artefacts in teams, and apply both self-reflection and peer review. Such processes are central to knowledge creation as it is understood in this context. Activities that promote knowledge creation provide guidance and socialize participants into authentic inquiry-based practices, such as posing questions, designing experiments, analyzing and interpreting results, and, thereby, cultivating scientific skills and acquiring a core understanding of the "nature of science".[89] When students take part in design projects,

[83] Clark, 2001; Donald, 1991; Ritella & Hakkarainen, 2012.
[84] Hakkarainen 2003; 2004; 2009; Hakkarainen et al., 2013.
[85] Hakkarainen, Lonka, Lipponen, 2004 This book was first published in Finnish in 1999 and it has sold more than 20 000 copies nationally until 2011. It has had an impact on national core curricula and teacher education in Finland.
[86] Juuti, Loukomies, & Lavonen, 2013.
[87] Seitamaa-Hakkarainen et al., 2010.
[88] Blikstein, 2013 ; Buechley, Peppler, Eisenberg, & Kafai, 2013; Gershenfeld, 2007; Kangas, Seitamaa-Hakkarainen, & Hakkarainen, 2013.
[89] Anderson, 2007; Linn & Eylon, 2006; Karpin, Juuti, & Lavonen, in press.

they are able to develop capabilities to see possibilities, to try out new ideas by sketching and prototyping, and to make leaps of imagination.

4.2. Socially shared metacognition

When introducing new technologies, schools have two choices. The first is to say that BYOD is forbidden and all private mobile devices should be turned off. This may not be such a good idea, if we want children to learn how to regulate their own learning and use their digital devices for learning. Professor Sanna Järvelä suggested that a better option would be to train our youth on how to regulate one's own behavior and how to develop metacognitive skills that help them co-regulate their work in teams.

Socially shared metacognition is one of the crucial components in collaborative problem solving.[90] Socially shared metacognition emerges when group members make their thinking visible and ask questions requiring an explanation or a rationale. Based on these explanations and rationales, the group discusses whether or not they select a new approach or a new strategy for proceeding in problem solving.

For example, in a Finnish secondary school, an inquiry-based project supported by an asynchronous learning environment was conducted in a Geometry course with a mathematics teacher and 13-year-old students.[91] The students worked in pairs and they were instructed to make an inquiry about a polygon in a discussion forum. The inquiry with an invented problem was submitted to the learning environment as a computer note. Also a figure of a polygon was attached to the computer note. The student pairs were also instructed to read other pair's inquiry notes, make comments and ask questions, and solve the invented problems. The student pair communicated in face-to-face situations as well as in computer-based learning environments. The computer notes in a discussion forum can be seen as a result of collaborative negotiations with a peer. The discussion in general reached a high level. The students evaluated other pair's work and provided alternative strategies to be used. The students asked for rationale or explanations if they did not understand. The students' messages were either metacognitive in nature or they were important for interaction among the pairs. The mathematics teacher shared her expertise by providing metacognitive knowledge into the discussions. For example, she asked a pair of students to draw a triangle by using the suggested values to see whether it works or not.

Mathematical problem solving in collaborative groups is also a challenge for pre-service teachers, especially if the interaction takes place solely in a computerized learning environment. In a group where the solution was constructed together and ideas were presented and developed further, socially shared metacognition emerged. In this group, the group member's feelings of difficulty decreased during collaborative problem solving.[92]

90 Hurme, Järvelä, Merenluoto & Salonen, 2015.
91 Hurme, Palonen & Järvelä, 2006.
92 Hurme, Merenluoto & Järvelä, 2009.

5. HOW OPEN ARE SCHOOLS TO USING NEW TECHNOLOGIES?

5.1. Challenges in using new technologies

In order to prepare for the emerging innovation-driven knowledge society, students and teachers should be engaged in functioning as a knowledge-creating community, oriented toward advancements of collective knowledge. Such an undertaking entails both cultivating shared innovative practices and constructing gradually refined artefacts. After 20 years' research experience in the field, we are well aware of the challenges involved.

In 2009, 94% of Finnish 10- to 14-year-olds children and youth already used computers in their spare time on a weekly basis.[93] The most frequent activities being searches for information on the internet, studying, playing games, reading e-mail, and downloading and listening to music. More than half of these internet users (55%) reported online chatting, and 32% were registered for at least one online discussion forum. However, the use of educational technologies in Finnish schools is, on average, far from adequate in terms of quality and frequency.[94]

During previous decades, due to poor infrastructure, lacking human capital (teacher competencies), and institutional inertia, initial efforts of using educational technologies for transforming educational practices of Finland or elsewhere in Europe have not been successful.[95] Although a new generation of teachers and socio-digital participation has altered the landscape, many teachers' still rely on traditional teacher-centered instructional practices; hence in-depth pedagogic transformations are needed.[96]

It appears that educators or researchers have not sufficiently addressed the challenge of developing knowledge practices that trigger meaningful pedagogical uses of technology. In many cases, students and teachers have been expected to directly appropriate digital technologies to find meaningful practices for using them, without questioning prevailing educational practices and institutional routines or reflecting on the role that technology plays in transforming the context of education. To move further, we need to take a fundamentally different approach in terms of starting with new pedagogies and opportunistically appropriating diverse (more or less ubiquitous) technologies for assisting various aspects of learning and instruction. Some pilot projects regarding implementing technologies in schools through transforming social practices have already revealed promising results.[97]

With the changes regarding the socio-digital revolution[98] bubbling under surface as well as the upcoming policy updates (the revised National Core Curriculum), many schools (for instance all the schools in the city of Kaarina)[99] have now taken a stance to open up their prevailing practices to critical evaluation and the development of novel approaches that utilize new technologies, such as investing in technological tools, participating in

93 Statistics Finland, Helsinki 2009.
94 Kumpulainen, Mikkola & Jaatinen, 2013.
95 Niemi, Kynäslahti, & Vahtivuori-Hänninen, 2013; Ritella & Hakkarainen, 2012.
96 McFarlane, 2015.
97 Niemi et al., 2013.
98 Hakkarainen, Hietajärvi, Alho, Lonka, Salmela-Aro, 2015.
99 In Finnish: http://www.kaarina.fi/tiedotteet_media/etusivun_tiedotteet/fi_FI/tabletit_kayttoon/; Kuuskorpi et al., 2015.

developmental pilot projects, and teacher training. There are also some highly advanced schools in terms of architecture, interior design, technology, and pedagogy. One of the best examples is the award-winning UBIKO school (University training school of University of Oulu).[100]

Informally, Finnish teachers have created vast networks of sharing pedagogical expertise on technology-mediated learning over social media. For instance, a Facebook group on the general topic of "ICT in education" has now at the time of this report over 13 700 participants and the number is growing. Of course, there is also resistance regarding changes. Some schools and teachers are trying to hold on to more traditional practices, but overall, the general trend appears positive and open towards developing new technology-mediated practices of teaching and learning.

5.2. Assessment – the tail that wags the dog?

Assessment practices guide and direct student learning in many ways.[101] One example is the criticism targeted towards the “No child left behind” program in the USA.[102] Another example comes from Portugal, where assessment practices have been increasingly tightened and there is a risk that this hinders meaningful learning.[103] We should educate our children for better learning, not for passing tests. There are already indicators in the USA that the labor market is not interested in young people who are good in the examination game, but lack initiative and important 21st Century skills.

In Finland, there is only one national high stake educational test, i.e., the matriculation examination at the end of high school. It is a compulsory test aimed at examining whether students have acquired skills and competencies determined by the upper-secondary education curriculum and have reached an adequate “level of academic maturity”. Only after completing the test are high school students eligible to continue their studies at university. The examination is performance-based in nature[104] in terms of relying mostly on students’ knowledge production (e.g. writing essays) across a six-hour examination sessions in each subject examined. The examinations are assessed by the high school teachers and then by academic experts of the National Matriculation Examination Board.

Because of pressures related to this test, high schools have not been too eager to implement pedagogical changes in general or technology-mediated learning in particular. The situation is, however, changing. The Finnish National Matriculation Examination Board has decided (due to a decision of Finnish Government) to digitalize the matriculation examination. The digitalization project, DigiAbi, involves the digitalization of the whole test (from paper to electronic test (2016-2019)).

The digitalization of the Matriculation examination is a major effort as there are yearly 35.000 candidates taking 200.000 exams. The DigiAbi will provide a student with a local environment that involves the most common office applications for responding to the tasks that may be multimodal in nature (including text, pictures, audio- and video material). The digital examination will allow embedding of examination tasks of various authentic materials, such as YouTube videos or webpages. In accordance with phenomenon-based emphasis (to be explained below), the examination tasks are not only going to measure remembering content,[105] but also call for application of

[100] www.ubiko.eu
[101] Darling-Hammond, 2012; Tillema, Leenknecht & Segers, 2011.
[102] Darling-Hammond, 2007.
[103] UP=Universidade do Porto, 2011.
[104] Darling-Hammond & Adamson, 2010; Torrance, 2007.
[105] This would be the lowest level of learning as defined by Anderson & Krathwohl, 2001.

knowledge for analyzing complex problems with authentic materials (beyond textbooks) and evaluating, synthesizing, and creating knowledge. The students' examination responses will go to a secure cloud environment for scoring by teachers and censors (i.e., academic experts). Due to this reform, digital competencies are likely to be prioritized by teachers and schools to the utmost extent. An electronic examination system[106] has also been created that allows teachers to create electronic examination questions in their classrooms.

[106] www.abitti.fi.

6. HAVE THERE BEEN ANY REVOLUTIONS IN THE EDUCATION SYSTEM?

Current Finnish education innovation efforts aim at producing new insights concerning productive integration of school subjects. This process is carried out to address complex real world phenomena and for facilitating the effective use of investigative methods for socializing students to the productive and creative use of knowledge emphasized by the new National Core Curriculum in Finland. In early childhood education, playful learning is something new. In elementary schools and upward, phenomenon and inquiry-based technology-mediated approaches are increasingly popular.

One revolution is to better integrate informal and formal instruction. Traditionally, the most common way of learning in Finland is free play (voluntary, unstructured activities) until the age of 7, when the children go to school. Before that, in daycare and kindergarten, most of the time is spent playing and playing games, often outdoors. There are formal systems of early childhood education, but they are not at all focused on classroom learning. Recently, computer gaming has become increasingly popular. Therefore there have been attempts to integrate playing and technology as well as formal and informal structures of learning.

Play is important for children in several different ways. It has been shown that play develops abstract thinking, i.e. the ability to make generalizations and to develop awareness of self and others.[107] Further, playing develops children's sense of agency: that is, through play a child develops a disposition to dream, to improvise and to imagine alternative ways and worlds which all are crucial for the sense of agency. Alternative ways of thinking are important in all creative activity. It is necessary to be able to escape the given culture and society binding us through imaginative play.[108] Brought into school, "playworlds" that adults and children create together offer a shared space which can transform traditional power relations, as it shapes and changes the relationships between educators and students.

In early childhood education Playful Learning Environments (PLE) are innovative spaces for learning, where gaming, playing, informal learning, and technologies emerge. Kangas and Ruokamo (2012) defined the term PLE as "an innovative, technology-enriched play and learning environment whose components are located indoors as well as outdoors [of the classroom]. Learning in such an environment takes the form of content creation and engagement in physical gaming and play" (p. 2653). The SmartUs playground is a technology-enriched playground that was developed to integrate curriculum-based learning with outdoor games. The first SmartUs playgrounds opened in Finland in 2006 and have been gaining popularity in other parts of the world: Sweden, Norway, Denmark, and The Netherlands, Great Britain, Germany, France, Italy, Romania, Spain, Portugal, and Hong Kong. SmartUs integrates outdoor playgrounds and computers into the classroom learning experience. Technology-enriched playgrounds can foster new avenues of playing and gaming, and research has revealed that they can also foster new avenues for learning.[109] It is worth reflecting on whether learning environments for older students could offer such engaging and playful elements.

Phenomenon-based pedagogy is built on the foundation of engaging in collaborative examination of complex real world phenomena with support from various fields of research, tools, and experts. Empowering students to design the curriculum, providing avenues for utilizing students' personal and shared interests[110] and/or supporting the

[107] Marjanovic-Shane & Beljanski-Ristic, 2008; Lindqvist, 2003.
[108] Rainio, 2009; Rainio, 2010.
[109] Kangas, 2010.
[110] Hidi & Renninger, 2006.

development of the students' epistemic agency[111] are also key aspects of phenomenon-based studies. The students' collaborative activities are mediated by digitally sharing inquiries and knowledge artefacts. Such phenomenon-based studies have already been piloted in many high schools in the metropolitan area[112] and as encouraged by the new national curriculum also in lower and upper comprehensive education. A good example of the development efforts regarding phenomenon-based studies is the eKampus project of the Helsinki City Department of Education. There has been an intensive process of teachers being involved in designing the nature of phenomena to be studied through integrative study projects aimed at improving synthesizing and integrating knowledge across disciplines.[113]

Many Finnish schools capitalize on practices of co-teaching[114] so there will be several teachers together with researchers and other experts managing experiments and guiding and facilitating student learning. Further, as a form of revolutionizing the learning tools provided in schools, as well as striving to bridge the gap between informal and formal learning settings towards a culture of connected learning,[115] the bring your own device (BYOD) approach has been adopted by many Finnish high schools. Open wireless networks allow students to take any device to school to be capitalized on learning situations. Schools and principals put a lot of effort to guide students in using their own devices at their schoolwork; the main emphasis is on new forms of thinking and processes rather than in devices as such. Already in some schools such development efforts have paid off in terms of revising the school culture.

Niemi et al. (2013) identified the following six main characteristics of successful technology integration in schools: (1) digital technologies were included in strategic planning, as part of school culture, (2) teaching and learning methods facilitated participation and were leading to empowerment, (3) the schools had flexible curricula, (4) high investments in communication were made, (5) the leadership and management were optimum, and (6) the teaching staff's had a strong capacity and commitment.

Moreover, the data of the Mind the Gap project indicates that many students either spontaneously or with school support utilize social media to share co-constructed information regarding their school tasks, for instance, by creating Facebook or WhatsApp groups to support schoolwork. It appears that although students mostly use socio-digital participation for hanging out with their friends and entertaining themselves, there appears to be a new trend of engaging in social learning for academic purposes, or by interest-driven activities in the fields of, for example, media composing and sharing.[116]

[111] Edwards, 2011.
[112] See http://martsarinilmio.blogspot.fi/.
[113] There is also a national project www.enorssi.fi for university training schools and departments of teacher education.
[114] Roth, 2002.
[115] See Kumpulainen & Sefton-Green, 2012.
[116] See e.g. Hietajärvi et al., 2015.

7. WHAT PEDAGOGIC INNOVATIONS REQUIRE FROM TEACHERS

Guiding extended pursuits of inquiry in schools requires that teachers learn to orchestrate knowledge-creation projects, as distinguished from the conventional focus on merely here-and-now situational interaction learning.[117] An elementary teacher's long-term orchestration of inquiry learning was analyzed in Viilo's and her colleagues' study. Grade 5 and 6 students took part in an 18 months inquiry-based project focused on studying, analyzing, and examining artefacts. Their activities were mediated by the Knowledge Forum environment. By analyzing videotaped classroom practices and teacher's structured project diaries it was possible to relate planned and enacted activities to one another. In many cases, planned activities could not be carried out and the teacher had to improvise and redirect activities after negotiating with students. Although student agency and initiative is important in technology-mediated inquiry learning, the teacher's strategic guidance also plays a crucial role because only she can have a clear understanding of long-terms objectives of an inquiry project. Creative efforts produce valuable results only through deliberate but flexible structuring and systematic guiding. Such an example shows how demanding it is to develop new practices in schools. Intensive efforts in teacher education are needed.

Technological innovations are not necessarily pedagogical innovations. If the teachers' goals are mainly directed towards contents and knowledge acquisition, new technologies do not change very much. For instance, in many cases MOOC environments are mainly used for structuring and organizing learning materials. There is not very much space for knowledge creation. Originally, Connectivist cMOOCs were started in Canada. They were heavily integrated around social media. Commercial MOOC approaches are more often integrated in very traditional ways.

Flipped classroom is more likely to flip the logic of learning than MOOCs.[118] This approach is quite new, and the best sources to learn about it may be found in Twitter. #flipped #flippedlearning compensate for the lack of literature. Flipped classroom means that instead of using contact time for knowledge transmission, the students or pupils acquire the needed information before the session. The F2F time is then used for such expert-like ("mind-teaching"[119]) activities as solving collaboratively complex problems, getting repeated feedback from teachers and tutors, investing deliberate efforts for recovering failures and improving performance, and engaging in joint elaboration, discussion and creation of knowledge. Such approaches call for transforming teacher education.

7.1. Recent developments in Finnish teacher education

Finnish teacher education has been described by Dr. Pasi Sahlberg and many others in detail:[120] In Finland, the teacher's profession has been surprisingly popular. Getting accepted to the 5-year class teacher education program (BA+MA) is about as difficult as getting into medical or law school. Teacher education programs are research-based

[117] Viilo et al., 2011; 2012.
[118] Bergmann & Sams 2012.
[119] Schank, 2011.
[120] FNBE 2012; Sahlberg, P., 2015; Westbury, I., Hansén, E., Kansanen, P., & Björkvist, O., 2005.

and emphasize integration of theory and practice. There have been some challenges, however, in the transition from university to working life.[121]

As society is ever-changing, the profession of a teacher also meets new challenges. The perceptions of knowledge and learning of the industrial age, which can still be found in the culture and practices of pedagogical training, are not sufficient.[122] The practice of teacher training has historically been based on a school-type environment. Silos between school subjects have been emphasized, especially in subject-matter teacher training. The fragmented nature of teacher studies and a superficial type of learning have been typical observations.

Even if the strongly autonomous nature of a teacher's profession may be considered a strength in Finland, it has also led to the perception of a culture of isolated performing. Research-based focus has not always been emphasized during in-service training. For a long while, it was typical for the development of pedagogical training to have a very narrow viewpoint, which lacked an overarching holistic element.[123] During the digital era, increasingly networked society only increases the complexity of the phenomena at hand.

Since 1998, there has been an alternative teacher education program at the Department of Teacher Education, University of Helsinki. Each year, 12-20 freshmen who have educational psychology as their major, start a 5-year BA + MA study program in order to become elementary school teachers. The students study intensively in small groups, applying progressive inquiry and phenomenon-based learning as their main approaches. Research on these processes, which emerge in this intensive group process, have been reported by the academic teachers of the program.[124]

The new study plan of the pedagogical training program recently implemented at the University of Jyväskylä, Finland, is based on five essential phenomena of the educational profession.[125] The aim of the study plan is to help the understanding of the multilayered educational phenomena at hand. Here, future teachers need a comprehension of multiple viewpoints, which consists of numerous conflicts of interest, real-life challenges, cultural differences, and the differences between scientific disciplines.

The phenomenon-based study plan also challenges us to change the functional culture of pedagogical training. A key concept is breaking the culture of isolated performing, while forming an intellectual learning community to replace it. The pedagogical mentors who guide the students to work in teams emphasize the sharing of expertise and learning from each other. The students are treated as younger colleagues. Having a group instead of an individual as the studying unit enables the sharing of the multiple viewpoints that phenomena-based studying requires. Students gain experiences by working as a community and see the importance of group activities.

The basis of teacher education in Jyväskylä is examining real world phenomena according to the principles of a research-based learning process conducted in its authentic environment. The studies concentrate on the essentials and attempt to form a deeper understanding of the phenomena. The students have increased possibilities to focus their

[121] Tynjälä, P., & Heikkinen, A. P. H. L., 2011.
[122] Hökkä & Eteläpelto 2013; McFarlane, 2015.
[123] Rantala & Rautiainen 2013.
[124] Eteläpelto et al. 2005; Lipponen and Kumpulainen 2011; Litmanen et al., 2012 ; Rauste von Wright 2001.
[125] Päivi Häkkinen and Tiina Silander from University of Jyväskylä kindly provided this information.

studies according to their personal interests. Their responsibility for their own and group's learning process increases.

One of their groups is the so called Teacher in the Clouds – group that defines being a teacher through communal experience and new learning environments. The training aims to achieve inspiring experiences. All work processes employ modern technology and new learning environments. Typical features of this group are phenomenon- and inquiry-based as well as collaborative and technology-enhanced learning approaches. The learning environments are hybrid entities, in which they use multiple tools and technologies (e.g. MTSD, social media, games) for individual access, communication, sharing, and joint knowledge construction with peers.

The University of Jyväskylä (Department of Teacher Education and Finnish Institute for Educational Research) is also involved in research on pre-service teacher education, and particularly on its capability of preparing pre-service teachers with the 21st century skills. The aim of the National PREP21 project[126] (Universities of Oulu, Jyväskylä and Eastern Finland) is to investigate and outline factors that affect the development of students' strategic and collaborative problem-solving skills in addition to their competencies and attitudes towards the use of ICT in teaching and learning. The particular research focus of University of Jyväskylä in this project is related to Computer-Supported Collaborative Learning (CSCL), and particularly to assessment of Collaborative Problem Solving (CPS). Previous research has indicated several challenges related to productive collaborative learning and the necessity of providing adequate support for collaboration.[127] There is also a growing awareness of the need to support the development and assessment of collaboration skills.

One of the most powerful ways to change teacher education is to influence assessment. Still, it can be argued that many assessment practices are still not very effective at measuring how students solve complex, cross-curricular problems and use technology as a cognitive tool in helping this.

Mentoring programs of teachers are increasingly typical.[128] Lifelong learning and continuing professional development of teachers is essential if we want to carry out reforms that are now in progress.

7.2. A new kind of educational leadership is called for to change schools

Developing new learning environments and positioning them successfully into operation requires a corresponding supportive atmosphere and culture. Contemporary ICT-based solutions can improve learning results only if the surrounding social practices are updated and revised accordingly. However, the pedagogical shift is not the only factor that is challenging the operative working culture in school context: also the amount of administration and responsibilities has increased and thus reduced the time available for pedagogical development work.

How to react to these contemporary demands is, eventually, always a matter of leadership. Therefore at least in Finland many innovative schools have already developed various practices of shared leadership to ease the situation, and mainly purely out of practical reasons. Shared leadership means the distribution of different organizational

[126] Preparing teacher students for the 21st century learning practices https://prep21.wordpress.com/about/.
[127] Arvaja et al., 2007; Häkkinen, 2013; Häkkinen et al., 2010; Häkkinen & Hämäläinen, 2012.
[128] www.opesaaoppia.fi.

responsibilities between the employees.[129] This spares time and liberates the school's principle to promote the pedagogical development work at school, for instance by participating, encouraging and leading by example, which should be the main role of a modern principal.[130]

Shared leadership also demands collective guidelines to ensure convergence of decision making. This highlights the importance of one's own vision and strategy.[131] Furthermore, teachers' ownership of their own work and commitment increases and the shared responsibilities encourage them to implement new practices of collaboration, such as various teams that focus on different responsibilities of their school. Such practices of collaboration, directly and indirectly, also increase the amount of activities that happen somewhere between the classrooms and official administration.[132] This kind of cultural transformation led by visionary leadership can be seen as a crucial adaptation for future needs and should influence also the design of new learning environments.

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[129] Wang et al, 2014.
[130] Risku & Kanervio, 2011.
[131] Mielonen, 2011.
[132] Vaara. & Lonka, 2014.

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AUTHORS

Vincent Cho, Ph.D. and Adam Steiner, M.Ed. - Boston College, United States

RESPONSIBLE ADMINISTRATORS

Ana Maria Nogueira / Markus J. Prutsch
Policy Department B: Structural and Cohesion Policies
European Parliament
B-1047 Brussels
E-mail: poldep-cohesion@europarl.europa.eu

EDITORIAL ASSISTANCE

Lyna Pärt

LINGUISTIC VERSIONS

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ABOUT THE PUBLISHER

To contact the Policy Department or to subscribe to its monthly newsletter please write to: poldep-cohesion@europarl.europa.eu

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CONTENTS

LIST OF ABBREVIATIONS

1 :1	One to one computing environments
BYOD	Bring Your Own Device
MOOC	Massive Open Online Course
OER	Open Educational Resources
PLN	Personal Learning Network

EXECUTIVE SUMMARY

Background

Technology has produced fundamental changes in the routines of daily life, but the educational world has remained largely unchanged. Adding complication to this dilemma, different technologies may promise different forms of contribution to education. Accordingly, this brief takes stock of three sets of focus technologies, each carrying potential to improve teaching and learning in Europe: Open Educational Resources (OERs), digital devices and 1:1 computing, and computer data systems.

Open Educational Resources

Internet and satellite-based connections have led to significant changes in how people access and use information. Open educational resources (OERs) attempt to capitalize on these changes by offering up free, openly licensed educational materials. This category of resources includes Massive Open Online Courses (MOOCs), which offer online coursework and instruction to many participants at once. An alternative conceptualization of OER involves the use of Web 2.0 technologies (e.g., wikis, blogs, social networking sites), which have become especially popular in every lives. Using these technologies, educators and students may freely share questions, insights, and resources. Both approaches represent a trend toward “anytime, anywhere” learning. Important considerations for the use of OERs include: promoting their value to potential users; advancing supports for special students; and investigating best practices in online instruction.

Digital Devices and 1:1 Computing

One-to-one (1:1) computing initiatives aim to bring about changes in schooling by attempting to leverage the unprecedented power of today’s computers and mobile devices. Such initiatives have become increasingly popular in the EU. There is some research to suggest that the uses of such technologies in classroom may improve student learning outcomes. These initiatives are often premised on the assumption that students have Internet access and that teachers encourage dynamic learning activities. Important considerations regarding 1:1 computing initiatives include: attention to child development; promoting digital citizenship; and various structural and logistical decisions relating to implementation.

Computer Data Systems

Today’s computer data systems provide educators with a range of sophisticated analyses about their students. With this information, educators are better able to address individual student learning needs or to plan activities for groups of students. However, the uses of data systems vary among EU Member States. This not surprising, since policies and practices relating to data vary from place to place. Important considerations relating to computer data systems include: promoting local dialogue about the future of data use; restructuring local education authorities to support data use; and supporting efforts to improve the flow of data among schools.

Discussion and Recommendations

Although each technology focus area was associated with unique considerations, some trends that emerge across the technologies as an ensemble. First, it is inappropriate to assume that technologies simply and directly determine human behavior. Rather, norms, expectations, and personal experiences all influence how and why technologies are used. Accordingly, future investments in technology should also attend to the social processes around use. Second, recent technological innovations have become increasingly reliant on multiple forms of media to deliver information. However, it is important to note that not all media communicate information with equivalent degrees of richness. Accordingly, there is still much opportunity to design and refine what users experience when attempting to learn using computers. Third, the focus technologies in this brief have all been reliant on the availability of networked communications. It is important to recall, however, that some communities and some socioeconomically disadvantaged students may not have easy access to the Internet. Similarly, the use of computer data systems is premised on local privacy policies and system interoperability. Fourth, it may be valuable to also consider what about education should not change. Life in the digital era is different than in previous decades, and now is the time to reflect about what should not happen with technology. Rather than blindly adopt technologies, research can help uncover productive and counterproductive approaches to technology use.

1. INTRODUCTION

In thinking about the future of technology and education, it is helpful to look back at a bygone era. Imagine an electronics store from only a couple decades ago. The aisles would have been lined with corded phones, video and audio cassette recorders, handheld calculators, and desktop computers able to store a few megabytes of information. In other words, young Europeans today have little or no memory of such devices. They would seem to be foreign, senseless objects. After all, today Europeans come of age in a time when all of those innovations have been combined into a single device—one that fits into one's pocket and is capable of outperforming any of its predecessors.

New technologies have been associated with fundamental changes in the routines of daily life. These changes span communication, socialization, and entertainment. Nonetheless, education stands out as an area that has been slow to change (Cuban, 2001). After all, one could transport today's young European to a classroom from a few decades ago, and rather than feel lost, that young person might feel immersed in business as usual. Many of the routines, curricular content, and perhaps even lesson plans might be the same. Thus, a key dilemma facing educators and policymakers involves when and how will education catch up with today's technological innovations.

Adding complication to this dilemma, not all technologies are the same. Although it might be convenient to speak about technology in monolithic terms, such generalities mask the unique technological and social processes at the heart of change (Orlikowski & Iacono, 2001). Different technology initiatives might be aimed at different kinds of changes in schooling. For example, some technologies might be aimed at changing education by providing online alternatives to traditional brick-and-mortar schools. Others might maintain traditional classrooms, but focus on enhancing teaching and learning by placing more technology in the hands of students. Yet others might focus on the student-teacher relationship, providing teachers with insights into individual students' academic and non-academic needs.

Accordingly, this brief aims to encourage reflection about the future roles of technology in education. It does so by taking stock of three sets of focus technologies, each of which are gaining prevalence in Europe and around the world. Each of these technologies promises its own unique contribution toward a "digital revolution," thus making it attractive to educators and education policymakers alike. The first set of technologies attempts to reshape teaching and learning by leveraging the power of the Internet and satellite-based communications. This set includes Open Educational Resources (OERs), such as Massive Online Open Courses (MOOCs) and other forms of online learning. The second set of technologies attempts to change teaching and learning by changing the materials of schooling. In particular, this brief focuses on the move toward one-to-one (1:1) computer environments, which aim to ensure that every student has individual-level access to a personal device (e.g., laptop, tablet, smartphone). The third set of focus technologies attempts to improve education by changing improving educators' knowledge about individual- and classroom-level performance. The remainder of this brief reviews some of the considerations associated to each of these sets of technologies in Europe. Subsequently, this brief synthesizes trends among these focus technologies and provides discussion about the future of technology adoption in Europe.

2. FOCUS TECHNOLOGIES

This chapter describes issues relating to three sets of initiatives that promise to change education in Europe: Open Educational Resources; one-to-one computing programs; and computer data systems.

2.1. Open Educational Resources

Internet and satellite-based communication technologies have led to astonishing changes in how people see themselves, interact with one another, and go about their daily lives (Gardner & Davis, 2013; Turkle, 2011). For some, the Internet is the first place that one turns when making a dining decision, maintaining a friendship, or even to find love. Yet, precise answers regarding how and when the Internet might be leveraged for educational purposes have been difficult to come by. One potential answer lies in open educational resources (OERs). OERs are free, openly licensed educational materials available to individuals and institutions including textbooks, lesson plans, videos, and assessment tools. By attempting to capitalize on the power of today's communication technologies, OERs provide an alternative framework for thinking about the business of education.

Massive Open Online Courses (MOOCs) are one form of OER. The use of MOOCs in Europe has expanded dramatically in recent years (Gaebel, 2014), and may be already familiar to many. MOOC platforms range from those catering specifically to particular Member States (e.g., Spain's Miridia X or the United Kingdom's Futurelearn) to those that are offered to users throughout Europe. A key example is EU's Opening Up Education initiative, which serves as a directory of MOOCs and related resources. Adding to the many options available, some European educational institutions offer courses via OpenupEd, another MOOC platform. Indeed, one third of MOOCs worldwide include a European university partner (Gaebel, 2014).

MOOCs are open, but relatively structured. They offer online coursework and instruction to large numbers of participants at once (at times upwards of 100,000). Courses may be free, while others might cost up to 200€ per course. Some may offer university course credit or some other form of certificate demonstrating mastery and completion. MOOCs attempt to leverage multimedia platforms by providing students with reading texts online, instructional videos, text- and video-based discussions, and complete various forms of assessments about course material. By giving students choices in how they demonstrate mastery, some MOOCs may also encourage students to reflect about their own learning processes during the course. Students may be asked to complete certain class activities within a particular window of time, but in general students have flexibility as to exactly when or how. This kind of flexibility represents one of the most attractive dimensions to OERs.

An alternative conceptualization of OER involves the use of Web 2.0 (e.g., wikis, blogs, social networking sites). This is exemplified by the movement toward "connected learners" (Ito et al., 2013) and "connected educators" (Nussbaum-Beach & Hall, 2012). Compared to MOOCs, this approach is even more open and flexible, if also less structured. However, it is notable because it highlights the ways in which it is now possible to learn and exchange ideas about issues of interest in instantaneous, public, and open ways. The image that emerges is of people freely sharing questions, insights, and resources about matters relevant to education (Burden, 2010; Greenhow, Robelia, & Hughes, 2009). For example, students might learn curricular content and connect to other students or experts in the field. Further, teachers have even begun to use social media as a form of professional development, publically sharing educational resources and engaging in dialogue around teaching (Carpenter & Krutka, 2014; Cho, Ro, & Littenberg-Tobias, 2013). In this way, the knowledge shared might contribute directly to classroom learning what might contribute to the quality of education in schools.

Together, MOOCs and Web 2.0 technologies highlight the trend toward “anytime, anywhere” learning. On one hand, MOOCs provide a formal strategy for supporting this kind of learning. The assumption is that making coursework easily available online will help mitigate issues facing many students, such as family or career obligations and distance to a traditional university. On the other hand, Web 2.0 technologies provide an informal, self-organized approach to learning. This approach would seem to be engaging, personalize, and highly collaborative. Thus, these two sides to the OER phenomenon shed light on the importance of “openness,” as well as on the personal and social needs of users.

If Europe is to make the most out of OER approaches to learning, several priorities are worthy of additional consideration.

- Encourage quality resources. Without support, it may be difficult for users to determine beforehand whether an online course or other resources will be of value. However, platforms such as Open Education Europa can help ensure the quality of resources, providing students and educators with descriptive and critical reviews about what might be in store. Thus, this may help to address problems of rigor among some online courses (Verstelle, Schreuder, & Jelgerhuis, 2014).
- Promote the value of OERs. Educational resources are a waste of effort if people do not know about them. Thus, it may be necessary to market OERs to target users. Although such activities could include the use of advertisements, it could also include other forms of outreach about the uses and potential value of OERs. For example, students might be asked to take a miniature online course as a part of their traditional studies. Teachers might be asked to engage in similar courses as a part of their professional development. Additionally, another set of strategies would involve making OER platforms more gratifying. If the value of Web 2.0 involves the ability to connect and learn from “real people,” then OER platforms might benefit from hosting webinars, online discussions, or other socially and personally engaging activities.
- Advance supports for special students. Educational resources are not truly open if there are barriers to their use. For example, some students may have difficult financial circumstances, learning disabilities, or lack other supports at home. Simply offering coursework at low cost, or simply including the use of some multimedia, might not be sufficient to ensure that these students will successfully benefit from OERs. Thus, there is still opportunity to consider how to shape MOOCs or other learning platforms toward supporting students. For example, some students with reading disabilities might benefit from the ability to convert text to audio. Other benefits might benefit from translations into other languages, perhaps even including sign language. Further, students may benefit from online social interactions with other students, instructors, or mentors. For example, OERs can be a valuable source of job retraining for adults (Yuan & Powell, 2013), but some students might have difficulty conceptualizing a career and educational plan. Online social interactions could motivate students and help them visualize next steps.
- Investigate best practices in online instruction. Expanded use of OERs will benefit from further research on best practices in education. Generally, it is hard to translate knowledge about traditional classrooms to an online environment (Sabadie et al., 2014). For example, text and video communications are not as rich as face-to-face interactions (Ferran & Watts, 2008; Watson-Manheim & Bélanger, 2007). The benefits of classroom discussions may be difficult to replicate online, especially among hundreds or thousands of students. In addition, a particular challenge facing MOOCs is the issue of high drop-out rates (Halawa, Greene, & Mitchell, 2014). Some schools have found success with a blended

model in which a cohort of students follow a MOOC as a group, and supplement the online platform with face-to-face meetings (Witthaus et al., 2015).

2.2. Digital Devices and 1:1 Computing

One-to-one (1:1) computing initiatives[133] aim to bring about changes in schooling by attempting to leverage the unprecedented power of today's computers and mobile devices. In such initiatives, each student is afforded individual-level access to a digital device (e.g., laptop computer, tablet, netbook). In a subset of such cases, access to a digital device could be as simple as students using their personal smartphones for the purposes of classroom learning. In another subset of cases, students might have individual-level access to more than one device, perhaps choosing different devices for different classes or tasks.
Although scholarship around such initiatives is still emerging, 1:1 computing would seem to hold some promise. For example, some studies have found academic benefits for students, especially around reading and writing skills (Bebell & O'Dwyer, 2010; Sauers & McLeod, 2012). In addition, some studies have reported that 1:1 computing initiatives may enhance educators' attitudes about work and sense of professionalization (Bebell & Kay, 2010). One should note, however, that the body of research assessing the academic and non-academic effects of 1:1 computing is still relatively nascent. Many of these studies predate today's mobile devices, focusing instead on the use of traditional laptops in particular classes or situations where students did not bring computers home.

One-to-one initiatives are premised on the hope that changing the material features of classrooms might lead to changes in the instructional processes in classrooms. In other words, 1:1 proponents imagine that changes to teaching and learning might be brought about by changing the kinds of tools that teachers and students might have on hand. For example, Shuler (2009) argues that mobile handheld devices may especially benefit socioeconomically disadvantaged groups and students in rural areas. The reasoning in this argument is that such devices offer a cost-effective, and perhaps even more engaging, way to deliver educational content to students. Foundational to such beliefs are observations about how the Internet has changed. Today, students are able not only to access new information, but also able to engage that information in more creative, more collaborative, and more dynamic ways (Greenhow, Robelia, & Hughes, 2009; Ito et al., 2013). Take, for example, a science classroom learning about the environment. One group of students might choose to create a video documentary capturing the perspectives of local experts or community members about the impact of climate change. Another group of students might measure levels of air or water pollutants in various spots in their communities, geotagging results to an online map. Both groups might create written reports or other products to be shared, debated, and explored online. As next steps, students might leverage the Internet to connect with scientists, policymakers, or other students attempting to promote a healthy environment.

In general, European schools would seem to be well-positioned to take advantage of 1:1 devices. For example, a comparison of 1:1 computing adoption worldwide ranks Europe second in terms of number of devices deployed in schools (Richardson et al., 2013). In fact, Europe was second to South America, due in part to Intel's initiatives in Argentina. Another estimate suggests that 8% of grade 4 EU students and 21% of grade 8 EU students were in 1:1 classrooms (European Schoolnet, 2013). Existing European 1:1 programs include Portugal's "escolinha" program and Spain's "Escuela 2.0," which provide laptops to more than one million students in primary and lower secondary grades (Bocconi, Kampylis, & Punie, 2013). However, caveats should be made regarding Europe's position. For example, having large number of devices in schools does not

[133] For the purposes of this brief, the term 1:1 is meant to highlight the ratio of students' access to technology. It should be noted, however, that some distinguish between centrally organized 1:1 approaches, and "Bring-Your-Own-Device" (BYOD) approaches. The latter describes approaches students and their families have discretion over device selection, sometimes purchasing devices out of pocket.

necessarily indicate evidence of real changes to teaching and learning (Bebell & Kay, 2010). Further, it is yet unknown how best to manage classrooms in the presence of these technologies. For example, some teachers might encourage students to use devices for note-taking, despite research finding that students learn better when they hand write their notes (Mueller & Oppenheimer, 2014). What's more, recent research suggests that the simple presence of a mobile device could have negative effects on the quality and sense of connection during face-to-face interactions (Przybylski & Weinstein, 2013).

Thus, if Europe is to make the most out of students' increased access to computers and other Internet-connected mobile devices, several priorities are worthy of additional consideration.

- Support research about 1:1. In order to make informed decisions about increase computerization, more information is needed. For example, although Europe is poised to incorporate digital devices into student learning, future research should uncover the extent to which computerization has led to changes in instruction and benefits to student learning. Are students simply retrieving rote facts, or are they learning in more collaborative and engaging ways? What pedagogical practices involving 1:1 devices lead to noticeable improves to student learning?

- Consider child development. Although there is much optimism about the potential value of digital devices to schooling, it may be important to consider the science about child development when making decisions about 1:1 adoption. For example, excessive screen time may be detrimental to youngsters' academic, cognitive, and social development (Gentile, 2009; Pagani, Fitzpatrick, Barnett, & Dubow, 2010; Uhls et al., 2014). Thus, as schools become increasingly computerized, they may also need to ensure that technology use does not come at the expense of other forms of interaction. At the same time schools may need to be sensitive to how students' needs may differ depending upon their ages and stages of development.

- Promote digital citizenship. Although today's youth have been born into a digital world, they are not necessarily born knowing how to make responsible, ethical decisions when using technology. Challenges range from those involving distractedness from technology, to self-protection, to copyright, to respectful communication and etiquette. In this regard, efforts to incorporate digital citizenship into the International Baccalaureate Learner Profile are especially laudable. Looking ahead, schools may need to adopt policies (i.e., Acceptable Use Policies) and materials promoting digital citizenship, and parents may need to be educated about these issues.

- Rethink the structure of schooling. If increased computerization is to make a difference in schools, schools may themselves need to be reshaped. At one level are issues of basic infrastructure, such as Internet capabilities, increased numbers of power outlets, and processes for repairs. Similarly, lost or missing equipment might need to be replaced, and many devices begin to show their age after three years. At another level are issues involving what school ought to look like. Collaborative spaces and libraries might need to be redesigned in order to support students' increased use of devices. This includes not only resources, but also seating arrangements, and the ability to project information among students working in small groups. What's more, increased technology may also necessitate increased technical support. Staff may need to be added before deployment in order to support progress over time.

- Navigate logistical decisions. Logistical decisions involving 1:1 initiatives are many. There is no one-size-fits-all when it comes to digital devices. This may be problematic for more centralized educational systems. For example, in socioeconomically disadvantaged areas, the only computers to which students might have access might be the ones introduced by 1:1. Assuming that students are permitted to bring devices home and can afford Internet access, a laptop computer might offer the most power for the investment. In other cases, tablets or other devices might suffice. In less centralized systems, funding and implementation decisions might also be complicated. If students must purchase or lease their own devices, what shall become of students who cannot afford to pay? What becomes of students who cannot afford Internet access at home? If students are allowed to determine for themselves what kind of device they might use (a "Bring Your Own" approach), then how will issues involving interoperability and technical support be handled?

2.3. Computer Data Systems

Teachers make countless decisions about how best to teach and to serve their students every day. Computerization can play an important role in these processes by providing teachers with a range sophisticated analyses about their students (Wayman, Cho, & Richards, 2010). For example, teachers might leverage data to address individual student learning needs, to plan instruction or supports for particular sets of students, and to celebrate school accomplishments (Lachat & Smith, 2005; Supovitz & Klein, 2003). In this way, data and computer data systems serve as an integral dimension to school reform initiatives (Stringfield, Reynolds, & Schaffer, 2008).

Today's computer data systems integrate, analyze, and distribute information about students in manners that were not feasible only a few decades ago (Wayman et al., 2010). Take, for example, a traditional and ubiquitous technology in schools: the locked filing cabinet. Such a cabinet might contain folders for individual students. In the folders might be a range of data (e.g., contact information, attendance, test scores, or notes from teachers and staff), but a teacher's ability to access and analyze that data for insights about individual students or group-level trends is limited. In contrast, data systems are able to mitigate many of the technical challenges associated with data use (Brunner et al., 2005; Chen, Heritage, & Lee, 2005). Moreover, the most advanced systems are beginning to offer teachers sophisticated insights that might not be immediately evident otherwise. For example, some systems offer specific recommendations about curricular or instructional practices (e.g., lessons or how to group students), predictions about future performance, and even assessments of students' non-cognitive or socioemotional needs.

To some extent, the degree and nature of computer data systems use in Europe has differed by EU Member State. This is not surprising, since policies, expectations, and practices data use differ among Member States. For example, accountability policies may influence the kinds of assessments, analyses, and graphical representations offered from place to place (Verhaeghe, Schildkamp, Luyten, & Valcke, 2015). Comparing conditions around data use in five Member States, Schildkamp, Karbautzki, and Vanhoof (2014) found that teachers in the UK had access to the most robust computer data systems and were also the most refined in their data use practices. Other factors that may influence successful data system implementation may include time, leadership, professional development, opportunities to collaborate, and access to data experts (Wayman & Cho, 2008).

Thus, if Europe is to leverage computer data systems, several priorities are worthy of additional consideration.

- Promote local dialogue about data. Within Member States, dialogue would seek to address local policies, norms, and expectations around what data are to be prioritized and how they might inform teacher practices. These kinds of understandings are at the heart of teachers' decisions to accept or to reject computer data systems (Cho & Wayman, 2014). Further, such dialogue would seek to air concerns about the unintended consequences of accountability policies and their influence on data use (Booher-Jennings, 2005; Ehren & Swanborn, 2012). In these regards, dialogue should be seen as an opportunity to develop local understandings about the nature of schooling, what data might be important, and what designs might need to be incorporated into computer data systems. For example, some places might decide to prioritize holistic or socioemotional data. Thus, policies and data systems might need to be aligned toward the uses of such data for school improvement.

- Share innovations across Member States. Across Member States, the emphasis would be on sharing innovative ideas and approaches to data use. Points of comparison might include: local education authorities' approaches to supporting data use; comparisons of the kinds of data are prioritized; and practices that might benefit students.[134] In this way, promising approaches and effective computer data systems might be introduced elsewhere.

- Restructure local education authorities and schools. Efforts should be made to ensure that teachers are supported in learning to use data. However, among Member States there is great variance in terms of teachers' access to time, to effective leadership, and to data experts or support staff (Schildkamp et al., 2014). This variability might be addressed by ensuring that teachers receive effective training, regular opportunities to collaborate around data, and practice using computer data systems in their everyday work (Wayman, Jimerson, & Cho, 2012). Thus, it might benefit local education authorities and/or schools to create job positions with formal responsibilities over supporting the use of data and computer data systems. Such positions would demand political acumen, as well as the ability to synthesize knowledge about curriculum, assessment, instruction, and technology.

- Support the flow of data. Students move from teacher to teacher, grade level to grade level, and school to school. When data systems are centrally supported, student data flows with the student. In this way, teachers are better able to pick up where others have left off (Wayman, Conoly, Gasko, & Stringfield, 2008), and teachers who share students are better able to collaborate around their needs. In contrast, if different teachers use different systems, then interoperability issues stifle the ability to share and analyze data effectively.

[134] At the academic level, the International Congress for School Effectiveness and Improvement's (ICSEI) Data Use Network may provide another model for exchanging knowledge about data use.

3. DISCUSSION AND RECOMMENDATIONS

This brief took stock of issues relating to three sets of focus technologies: Open Educational Resources, 1:1 computing environments, and computer data systems. Each of these focus technologies promises a different type of contribution toward a “digital revolution” in Europe. However, each also comes with its own unique limitations and challenges. For example, although OERs promise widespread, instantaneous access to knowledge, it is yet unclear how to ensure that learners regularly access and benefit from those resources. Similarly, although 1:1 computing environments promise to support changes in classroom instruction, they also face questions regarding their best and most appropriate uses. Finally, computer data systems promise to improve what educators see and understand about students. Even so, the success of these systems is influenced by issues including access, interoperability, and questions about which data are most appropriate.

The disparities in these various challenges point toward the need for tailored approaches to supporting the uses of particular technologies. However, some trends do emerge when considering these focus technologies as an ensemble. The following discussion describes commonalities among the focus technologies, as well as recommendations that might serve technology implementation generally.

3.1. Change is Driven by People, Not by Technology

Although it seems as if everyday lives are different “because” of certain technologies, the reality is that everyday lives are different because people have chosen to use those technologies. Technologies do not, of their own accord, predetermine social or organizational change (Markus & Robey, 1998; Orlikowski & Barley, 2001). Rather, technologies provide occasions for people to experiment and attempt to reconcile present conditions with understandings about the past. In the context of schooling, successful technology use is thus influenced by the norms, expectations, and personal experiences of the users (i.e., educators and students) (Cho & Wayman, 2014; Ertmer, 2005).

Viewed through this lens, it becomes evident that many “technology problems” might actually be “people problems.” For example, the problem of successful engagement in OERs might involve issues of motivation, sense of investment, and the ability to self-regulate one’s learning. Similarly, a successful 1:1 program might depend also upon issues of having enough staff to support technology use, teacher’s understandings about how to integrate technology into instruction, and student’s choices about when (and when not) to use a particular device. The effective use of computer data systems might also depend upon issues involving teachers’ knowledge about assessment and instruction, confidence in the data at hand, and local cues from leaders about how and why data ought to be used.

Altogether, these “people problems” highlight the importance of conversation, talk, and training to technology adoption (Ertmer, 2005; Leonardi, 2009). Rather than expect OERs to produce learning in and of themselves, people might need to be trained and supported in getting the most out of their online experiences. Similarly, teachers might need increased time to explore and opportunities to collaborate around new technologies. Engaging in such activities helps teachers to innovate new teaching and apply new knowledge (Bredeson, 2002; Putnam & Borko, 2000). Unfortunately, teachers in Europe may vary greatly when it comes to time and opportunities to connect with colleagues (OECD, 2014). Accordingly, future investments in technology might benefit from similar investments in helping people to understand and envision how to get the most out of the tools at hand.

3.2. The Importance of Media and Multimedia Resources

The value of the focus technologies described in this brief is premised on the capacity for technologies to deliver information to learners or to teachers. For example, OERs and 1:1 initiatives assume that users will find value in text, audio, and video materials. Similarly, computer data systems do not simply provide educators with raw data about students. Rather, data is analyzed and displayed via some form of visualization, such as a color-coded graph, matrix, or map of learning objectives. It is important to realize, however, that not all media or presentations of information carry the same value for recipients. Different forms of media may communicate with varying degrees of richness (Carlson & Zmud, 1999; Daft & Lengel, 1986).

Thus, it might be important to question whether particular media are suited to the challenge. For example, people who attempt to learn via video might pay more attention to the likability of the presenters, rather than to the content of the knowledge presented (Ferran & Watts, 2008). Similarly, the design and aesthetics of graphs or other visualizations influence how well people comprehend the information presented (Purchase, 2002). In other words, people are not simply passive recipients of media. Instead, people must work to interpret and to make sense of the information before them.

Consequently, one next step may involve designing and refining what users experience when attempting to learn using computers. Some content might be best shared using one form of media (e.g., text, audio, video), while at the knowledge might best be shared using several at once. Further, the experience of these media should be personalized and interactive. These measures could include the use of quizzes, simulations, online discussion, or face-to-face conversations. For example, a student in a traditional classroom attempting to learn via technology might be asked to reproduce knowledge, apply it, or reflect about it with other learners. Similarly, a non-traditional student, such as an early school leaver attempting to regain credits, might have similar experiences through an online environment. A teacher attempting to learn about students' performance might be asked to summarize, make predictions, or converse with other educators about the data.

3.3. The Assumption of Networked Communications

The value of the technologies in this brief is also premised on the availability of satellite-based or Internet communications. The promise of OERs is to connect people to the information they need, whenever they need it. Digital devices provide students with points of access to information. Computer data systems can ensure that student data flows from school to school, grade to grade, and teacher to teacher.

Although it might seem obvious that geographically remote areas might benefit from increased communications infrastructure, it is also important to bear in mind that many students living in poverty face a similar digital divide. These students may see their peers interacting with digital worlds, but themselves have neither devices nor plans for accessing such worlds themselves. Thus, addressing inequities in education is a matter both of geography and of socioeconomics. The potential of OERs is limited if learners must hunt, beg, or borrow for Internet access. Similarly, 1:1 computing might contribute to a few classroom lessons, but the potential value of devices drops when students cannot bring them home or cannot communicate with outside worlds. Further, the observation of trends in student data and the ability of teachers to pick up where others have left off is predicated on local privacy policies and interoperability of data systems. Actions to address these challenges are unique to each technology in question. They range from creating publically available Internet access, to increasing the centralization of data systems, to addressing concerns about privacy and security.

3.4. What Might Stay the Same?

This report addresses questions about the role of technology in supporting educational change. In considering such issues, it is easy to become wrapped up in exuberance around the promises of technology. This exuberance, however, leads to blind spots regarding whether technologies are actually effective at helping students learn (Brooks, 2011; Cho & Wayman, 2015). As much as the digital era might seem inescapable today, it is still a relatively new and fresh even in the arc of human progress (Turkle, 2011).

Now is the time for careful reflection about the place of technology in schools. On one hand, some technological innovations might be misused or used to the detriment of student learning. Email provides an example from our everyday lives. Despite promises that email would free up our time, it has actually become a source of increased stress and lost time (Barley, Meyerson, & Grodal, 2010). Similarly, schools in the United States wrestle with narrow definitions of student learning that in turn lead to shallow and questionable uses of computer data systems (Booher-Jennings, 2005; Cho & Wayman, 2014). On the same note, the increased use of Internet-capable digital devices raises questions about student distraction (Mathias Hatakka, Annika Andersson, & Åke Grönlund, 2013), teacher and student privacy (Peck & Mullen, 2008), and the adverse effects of screen time (Pagani, Fitzpatrick, Barnett, & Dubow, 2010; Uhls et al., 2014).

Future research will be important in determining productive and counterproductive approaches to technology use. Evaluations are needed, not only to examine the most effective designs for OERs, 1:1 initiatives, and computer data systems, but also regarding how they might compare to more traditional educational methods. Under what conditions do such technologies make a difference? Under what conditions are conventional methods still best? Finally, there are some conversations that research might support, but ultimately be unable to answer. For example, what is the definition of a successful student? Do conventional methods promote any social values, qualities, or skills worth preserving? How is responsible, ethical technology use to be promoted outside of the school walls?

4. CONCLUSION

In the end, the transformative power of any technology in schools depends on human choices and circumstances. As digital technologies become increasingly ubiquitous in daily life, it becomes ever more important to consider not only how they might contribute to learning, but also why. In other words, some of the work of ensuring a "digital revolution" in education is about logistics, investment, and policy. However, some of the work is also about good storytelling. Learners will not engage in online learning if they do not subscribe to a vision about its potential benefits. Digital devices will go little used if students and teachers do not envision a new mode of schooling. Computer data systems are poor investments if communities and educators do not agree about the end goals of schooling and which data conform to those goals. Thus, the challenge of the digital era is as much about making well-informed decisions, as it is a matter of developing insight into what convinces people to make the most of their technologies in the first place.

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