

Journal of Computer Assisted Learning

Challenges to learning and schooling in the digital networked world of the 21st century

J. Voogt,* O. Erstad,† C. Dede‡ & P. Mishra§

*University of Twente, The Netherlands

†University of Oslo, Norway

‡Harvard University, USA

§Michigan State University, USA

Abstract

This article elaborates on the competencies, often referred to as 21st century competencies, that are needed to be able to live in and contribute to our current (and future) society. We begin by describing, analysing and reflecting on international frameworks describing 21st century competencies, giving special attention to digital literacy as one of the core competencies for the 21st century. This is followed by an analysis of the learning approaches that are considered appropriate for acquiring 21st century competencies, and the specific role of technology in these learning processes. Despite some consensus about what 21st century competencies are and how they can be acquired, results from international studies indicate that teaching strategies for 21st century competencies are often not well implemented in actual educational practice. The reasons for this include a lack of integration of 21st century competencies in curriculum and assessment, insufficient preparation of teachers and the absence of any systematic attention for strategies to adopt at scale innovative teaching and learning practices. The article concludes with a range of specific recommendations for the implementation of 21st century competencies.

Keywords

21st century competencies, 21st century learning, digital literacy, implementation, research synthesis.

Introduction

Several attempts have been made, during the first decade of the 21st century, to formulate key challenges for learning and schooling due to social and cultural changes happening across the world [e.g., European Union (EU), 2007; Organisation for Economic Co-operation and Development (OECD), 2005]. The globalization and internationalization of national economies, along with the rapid development of information and communication technologies (ICT), are

continuously transforming the way in which we live, work and learn (e.g., Anderson, 2008). While demand for routine production workers has decreased, the need for service and knowledge workers has grown (Reich, 1992). Studies increasingly indicate for a shortage of creative and innovative workers (Levy & Murnane, 2004, 2006). Advances in ICT have created jobs that did not exist a decade ago, and young people need to be educated for careers that do not yet exist (Dede, 2011; Voogt & Odenthal, 1997). All these developments impose new challenges to us as educators and require fundamental changes in both *what* has to be learned and *how* this learning is to happen.

The discourse on how digital technology is seen as transforming education has moved from prophecies of

Accepted: 3 June 2013

Correspondence: Joke Voogt, University of Twente, 7500AE Enschede, The Netherlands. Email: j.m.voogt@utwente.nl

the end of schooling as we know it (Papert, 1994) and cyber-learning manifestos (Perlman, 1992) to scenarios of e-learning and mobile learning that question the formal, institutionalized ways of learning. These issues are elaborated in two other articles of this special issue: Davis, Eickelmann, and Zaka (2013) and Lai, Khaddage, and Knezek (2013).

Research, however, has shown a significant gap between such visions and how technologies are actually instantiated in educational practice (e.g., Law, Pelgrum, & Plomp, 2008; Voogt, 2008). In contrast to past over-optimistic scenarios within policy and research about the impact of ICT on our education system at large, scholars are now exploring how to use different technological tools in specific circumstances and for certain purposes (e.g., Dede, 2008; Hinojosa, Labbé, López, & Iost, 2008; Rutten, van Joolingen, & van der Veen, 2012), as well as attempting to understand how technology is shaping competencies necessary for life today and in the future (e.g., Anderson, 2008).

The new competencies are often referred to as '21st century skills', a term more familiar in North America, or '21st century competencies', a term more common in Europe. In the remainder of this article we will use the term '21st century competencies', drawing on our research experiences from a broad international context, to address the knowledge skills and attitudes that are needed for living and working in the 21st century. The main purpose of this article is to discuss (a) what competencies are agreed to be necessary for living in the 21st century, in particular competencies associated with digital technologies, including the implications for learning; and (b) issues related to the implementation of 21st century competencies in educational practice.

Frameworks for 21st century competencies

During the last decade, oppositional discourses have evolved around both (a) the specific competencies that are needed in our current and future societies: such as hard (e.g., a focus on Science Technology Engineering and Mathematics) versus soft skills (e.g., emphasizing collaboration and creativity), basic competencies (e.g., knowledge of standard school subjects, literacy, math and so on) versus key competencies (e.g., adaptability, ability to think laterally), and (b) approaches to acquiring these competencies, such as individual (e.g., adaptive online or computer-mediated learning) versus

collective (e.g., Computer Supported Collaborative Learning) approaches to learning. International organizations such as the OECD and the International Association of Educational Evaluation and Achievement (IEA) are performing international studies [Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS)] related both to familiar skills of reading, writing, science and math and to 21st century competencies for 'new millennium learners'. This illustrates that these two paths could be integrated in their ambitions to pinpoint what learners need to know today and in the future.

Several reviews (Binkley *et al.*, 2012; Dede, 2010b; Mishra & Kereluik, 2011; Voogt & Pareja Roblin, 2012) of different frameworks describing the knowledge, skills and the individual attitudes and attributes of learners needed in the 21st century show consensus about the competencies that are considered critical. Across these frameworks it is generally agreed that *collaboration, communication, digital literacy, citizenship, problem solving, critical thinking, creativity and productivity* are essential for living in and contributing to our present societies.

However, with very few exceptions, the frameworks are contained within overarching statements of goals or educational aims. These are generally brief statements but are supported by justifications for change. For example, there are references to the need to educate for new industry, commerce, technology and economic structures (e.g., EU, 2007; OECD, 2005); the need for new social interaction and communication skills (e.g., Binkley *et al.*, 2012); the need for imagination, creativity and initiative (e.g., Partnership for 21st Century Skills, n.d.); the need to learn and continue to learn throughout employment (e.g., OECD, 2004); the need to maintain national and cultural values (e.g., OECD, 2005); and the need to operate in an increasingly international and global environment (e.g., EU, 2007). Few of the frameworks provide detailed descriptions, or clearly elaborated curriculum standards. Similarly few include descriptions of what the curriculum experienced by learners will actually resemble if the broader aims of these frameworks are to be realized.

Mishra and Kereluik (2011) argue that not all competencies are unique and novel to this century. Cognitive skills such as critical thinking and problem solving have a long empirical history closely connected with

academic achievement. These skills, rather than being novel to the 21st century and necessary for success in the 21st century, are skills that are required for successful learning and achievement in any time, including but not limited to the 21st century. Additionally, interpersonal competencies such as communication, collaboration and responsible behaviour have been integral to successful interpersonal relationships for centuries, although all of these take on new dimensions in 21st century virtual interaction. One must be able to effectively regulate one's needs and goals with that of the larger society to successfully navigate our social world.

Other competencies such as creativity, productivity and digital literacy are less familiar. Creativity especially is an area that has been growing in importance as a key 21st century thinking skill (Wegerif & Dawes, 2004). However, one of the problems with the discussions around creativity has been the often simplified and naive notions and romantic conceptions of the creative individual (Banaji & Burn, 2007), without clear specifications of what this skill area might entail. In a systematic review of the impact of the use of ICT on students and teachers for the assessment of creative and critical thinking skills, Harlen and Deakin Crick (2003) argue that the neglect of creative and critical thinking in assessment methods is a cause for concern, given the importance of these skills in the preparation for life in a rapidly changing society and for lifelong learning. Their review documents a lack of substantial research on these issues and argues for more strategic research (Araya & Peters, 2010).

From a learning perspective, productivity is associated with Papert and Harel's (1991) conception of 'constructionism', which refers to learning-by-making and points to the idea that knowledge is constructed when learners are actively engaged in (physically) constructing an object. Related to 21st century competencies productivity also refers to entrepreneurship and concerns the ability to realize ideas and to plan and manage projects in such a way that goals are achieved. It implies creativity, innovation and risk-taking (e.g., EU, 2007; Partnership for 21st Century Skills, n.d.).

Digital literacy

Due to technological developments, an important change has taken place in the way new digital tools and collaborative environments obtained a place in

our society, and additionally have potential to enhance teaching and learning. The emphasis has shifted from reproducing information and content to content creation and sharing in virtual environments, which some describe as a remixing culture (Lessig, 2008). Because of this change it is necessary to ask what is meant by digital literacy and the implications this has on our construction of the school-aged learner. The background of this terminology goes back to the overall critique of traditional conception of literacy as the ability to read and write (Graff, 1991; Street, 1984). A broader sociocultural understanding of literacy imply our relationship to many different forms of representation (Barton, 2007), all collected under the heading of media literacy and later digital literacy (Buckingham, 2003). Important perspectives on this broader cultural issue can be found in the literature about the changing features of literacy in our culture (Kubey, 1997; Lankshear, 1997; Warschauer, 1999). In her book *Literacy in a Digital World* Kathleen Tyner (1998) studies some of the elements of a modern interpretation of literacy both related to what she terms 'tool literacies', which imply having the necessary skills to be able to use the technology, and 'literacies of representations', which relate to the knowledge of how to take advantage of the possibilities that different forms of representation give the users, especially ICT.

Frameworks describing 21st century competencies argue for a more comprehensive approach to digital literacy. An example of such broader approach is the concept of 'digital bildung' as used in the Nordic European countries: which emphasizes what it means to be literate in contemporary culture. In the Norwegian national curriculum (Kunnskapsdepartementet, 2004) for instance, digital competence is defined as a complex competence that emerges as the sum of simple ICT skills (using software to search, locate, transform and control information) and more advanced skills (to evaluate, interpret and analyse digital genres and media forms to that through the creative and critical use of digital tools and media).

The conceptual framework developed as part of the 'Assessment and Teaching of 21st Century Skills (AT21CS)' initiative distinguishes between ICT literacy and information literacy. Within the AT21CS framework these two skills are seen as basic aspects for developing the other skills under the headings of ways

of thinking, working and living in the world (Binkley *et al.*, 2012). Information literacy covers people's abilities in accessing, evaluating, using, managing and applying information and different sources provided by digital technologies. ICT literacy is related to ways of operating and reflecting on the use of ICT in different contexts and has become important in curriculum development in many countries (Binkley *et al.*, 2012).

Different scholars have described these new literacies somewhat differently. For instance Mioduser, Nachmias and Forkosh-Baruch (2008) describe seven new literacies asked for in the knowledge society. These include everything from multimodal information processing to visual literacy; from interpersonal skills to coping with complexity. Jenkins, Clinton, Puroshotma, Robinson and Weigel (2006), in contrast, offer a broad set of core media skills that partially align with other 21st century competencies. These include capacities such as play, performance, distributed cognition, multitasking and so on. Clearly, digital literacy is a broad concept that has different aspects, which often put the other 21st century competencies in a different perspective.

21st century learning

The importance of competencies for the 21st century has led to fundamental questions about to what extent we provide the necessary knowledge base for children and youth to be competent in contemporary and future societies. The different frameworks express consensus about the pedagogy needed to teach 21st century competencies (Voogt & Pareja Roblin, 2012). The learning sciences as a new field of research (Kalantzis & Cope, 2008; Sawyer, 2006) has been important in looking at how our culture's evolving media create opportunities and affordances for innovative learning practices to develop (Wertsch, 1998). In particular, constructivist approaches to learning is adhered to, such as problem-based learning, cooperative learning, experiential learning and formative assessment (Lai, 2008). Still, today's education systems have as their challenge to relate the sociocultural developments of the knowledge society and its technological innovations to requirements with a refinement of learning and literacy as a process in- and out-of-school (Hull & Schultz, 2002; Lai *et al.*, 2013).

ICT applications such as Web 2.0 tools, multi-user virtual environments and augmented reality can contribute to the development of 21st century competencies (Dede, 2010a). For example, Web 2.0 technology enables users to produce and share content in new ways. User-generated content creation and 'remixing' (Lessig, 2008) become creative practices that challenge the traditional relationships between teachers and students in providing information and content for learning, and the role of the 'school book' (Erstad, 2008). The use of new digital media in education has been linked to assessment of creative thinking as different from analytic thinking (Ridgway, McCusker, & Pead, 2004). Digital camera and different software tools make it easier for students to show their work and reflect on it.

Immersive interfaces, such as multi-user virtual environments and augmented realities, offer two powerful affordances for learning 21st century competencies (Dede, 2010a). First, the ability to access information resources and psychosocial community distributed across distance and time deepens digital literacies. Second, the ability to create activities not possible in the real world, such as interacting with a (simulated) chemical spill in a busy public setting, builds skills such as collaborative inquiry mediated through technology. Design-based research that illustrates these powers of immersion includes the River City curriculum (<http://muve.gse.harvard.edu/rivercityproject/>), which teaches scientific inquiry through simulated time travel; the EcoMUVE curriculum (<http://ecomuve.gse.harvard.edu>), which aids in learning complex causality through classroom-based immersion in simulated ecosystems; and the EcoMobile curriculum (<http://ecomobile.gse.harvard.edu>), which uses the camera in cellphones to enable overlays of information, visualization and simulated experience on real-world settings.

Implementation issues

Agreement about what 21st century competencies are and how they can be learned does not guarantee the uptake of 21st century competencies and learning in schools. In this section of the article, we start with a brief overview of the implementation of 21st century competencies across educational systems as found in the international SITES study, followed by an elaboration of issues related to implementation.

21st century learning in educational practice: Empirical findings

The international Second Information Technology in Education Study (SITES), conducted between 1998 and 2006 by IEA, revealed that, across educational systems on average, the perceived presence of 21st century learning in schools had increased, when findings from 1998 are compared with findings from 2006. However, when inspecting this change more closely it was obvious that in a number of Asian countries (Hong Kong, Japan, Taiwan, Thailand, Singapore) school principals reported an increase of 21st century learning in their school, while school principals in some European countries (Denmark, Norway, Slovenia) reported a decrease (Law, Lee, & Chan, 2010; Law *et al.*, 2008). Bryderup, Larsen, and Trentel (2009) for example, analysed the changes in the pedagogical orientation of school principals in Denmark between 1998 and 2006. They showed that in Denmark, despite an increased availability of technology, the orientation towards some aspects of the lifelong learning paradigm (such as collaboration and independent learning) decreased between 1998 and 2006, at the expense of an increased focus on curriculum-centred instruction, tests and individual student learning. On the other hand, the importance of 21st century competencies in several Asian countries is noticeable. Zhang (2012) describes a number of initiatives in expanding the curriculum with courses in which students develop 21st century competencies: Integrated Practical Activities in China, Life wide learning in Hong Kong, Integrated Studies in Japan and Integrative Activity in Taiwan. These initiatives show that countries that usually score high in the international comparative studies (PISA, TIMSS) probably realize that high achievements on foundational subjects will not be enough to be competitive in the 21st century.

However, regardless the role of educational policy in encouraging or discouraging educational change, the SITES data also showed that, although teachers find 21st century learning important, they do not promote 21st century learning in their instruction (Law, 2009). Eickelmann (2011) found in a follow-up of the German SITES case studies that sustainable implementation of 21st century learning requires a strong connection between pedagogical aims and technology, strong leadership, school-wide adoption of ICT, a focus on the

implementation process, collaboration with external partners and with other schools.

Implementation in curriculum and assessment

It is generally agreed that 21st century competencies demand significant changes in the curriculum (e.g., Dede, 2010b; Voogt & Pelgrum, 2005). These changes are related not only to the need for restructuring the curriculum in order to make room for 21st century competencies (Dede, 2010b) but also to the need for new teaching methods and assessment procedures (Voogt & Pareja Roblin, 2012). The main question is how the discourse of 21st century competencies is addressed in the development of national and school curricula (Trier, 2003). Most of the frameworks (Gordon *et al.*, 2009; Voogt & Pareja Roblin, 2012) that describe 21st century competencies mention different approaches for curricular integration of 21st century competencies: (a) an addition to the existing curriculum, as new subjects or as new content within traditional subjects; (b) integration as cross-curricular competencies that both underpin school subjects and place emphasis on the acquisition of wider key competencies; and (c) included in a new curriculum in which the traditional structure of school subjects is transformed and schools are regarded as learning organizations. Although different approaches are acknowledged, most frameworks recognize the complex and cross-disciplinary nature of 21st century competencies and thus recommend integrating them across the curriculum. Based on their analysis of frameworks describing 21st century competencies Mishra and Kereluik (2011) identified three key areas that need to be addressed in a 21st century curriculum:

- *Foundational knowledge* (or what do we need to know). This includes core content knowledge of the disciplines, information literacy (also sometimes called digital literacy) and cross-disciplinary knowledge or synthetic knowledge.
- *Meta knowledge* (or how do we act on this knowledge). Included in this were processes such as problem solving, critical thinking, communication, collaboration, creativity and innovation
- *Humanistic Knowledge* (what do we value): This form of knowledge offers a vision of the learner's self and its location in a broader social and global

context. These include knowledge of life/job skills, cultural and global competence, and ethical and emotional awareness.

In addition the EDUsummit 2011 contributors to the Thematic Working group on 21st century learning expressed the need for a developmental continuum of pedagogical approaches supported by technologies to address these key areas as learners progress through schools (Voogt, Erstad, Mishra, & Dede, 2011).

Most frameworks describing 21st century competencies acknowledge that, for the assessment of 21st century competencies, new assessment frameworks are needed. Performance assessment strategies are required to be able to understand how students' progress in mastering the 21st century competencies. Few studies focus on the development of immersive, virtual performance assessments for assessing (some) 21st century competencies, (e.g., information and computer literacy skills and scientific inquiry – problem solving, critical thinking and collaboration and communication skills) in multi-user virtual environments. To be able to measure student learning of 21st century competencies, a better understanding of alternative forms of assessment that comply with the demands of valid, reliable and fair testing (Clarke-Midura, Dede, & Norton, 2011). This seems an important prerequisite for the implementation of 21st century competencies at a large scale.

Digital literacy and the curriculum

Several initiatives for digital literacy standards are now being developed around the world (Plomp, Anderson, Law, & Quale, 2008). They are defined as important tools for teachers in the way they use technologies in their educational practices. Linked to the Norwegian experiences mentioned above, research show that there is a gap between the conceptual definitions and elaborations on the importance of digital literacy in our society as expressed in different policy documents and curricula, and what is actually happening in educational practice among teachers and students (Hatlevik, Ottestad, Skaug, Kløvstad, & Berge, 2009). Similar findings are also observed in for instance Belgium (Flanders) (Tondeur, van Braak, & Valcke, 2007). There is a danger that standards can be interpreted too narrowly (restricting themselves to

skills in operating hardware and software), and miss the bigger picture: that of grasping how digital technologies create new conditions for learning and knowledge building (Scardamalia & Bereiter, 2006). It is important that standards do not lead to static tests or assessments, but rather be flexible so as to relate to the rapid rate of technological and cultural change. In addition, it is important to stress that technology literacy and fluency are embedded, that is, the use of technology should be seen within specific real-life contexts (Lankshear & Knobel, 2006). To understand such processes we have to look at different contexts where literacy is practiced and given meaning, and how new technologies are changing the nature and processes of meaning-making. This is especially important when relating it to how children and young adults use digital technologies.

21st century competencies and teacher learning

It is obvious that not only learners, but also teachers need to acquire 21st century competencies as well as become competent in supporting 21st century learning. Teachers need to be prepared for new pedagogical approaches that fit the 21st century, and they need to understand how ICT and pedagogy interact in order to be able to facilitate the development of 21st century competencies in their students. For this reason, incorporating technology in teachers' preparation programs cannot only be an add-on to the existing curriculum. This needs a rethinking of the core curriculum itself to factor in these new advancements and changes. Teachers need to learn how to leverage ICT to help students learn 21st century competencies (Lambert & Cuper, 2009). Tondeur *et al.* (2012) reviewed qualitative studies that focused on strategies to prepare pre-service teachers to integrate technology into their lessons. Based on their synthesis, the results showed 12 key themes for content and delivery methods that prepare pre-service teachers to integrate technology into their future classrooms. The synthesis findings were reported in two parts: (1) key themes explicitly related to the preparation of pre-service teachers (e.g., using teacher educators as role models, learning technology by design, scaffolding authentic technology experiences); and (2) conditions necessary at the institutional level (e.g., technology planning and leadership, cooperation within and between institutions, training staff).

Recently the Technological Pedagogical Content Knowledge (TPACK) framework for teacher knowledge has received a significant level of research and scholarly attention (American Association of Colleges of Teacher Education, 2008; Mishra & Koehler, 2006; Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013). This framework argues that the successful integration of technology into the curriculum requires considering the coming together of technology, pedagogy and content in a creative and integrated manner. Clearly developing 21st century competencies require setting new pedagogical and content goals. Mishra, Koehler, and Henriksen (2011) have argued for extending the TPACK framework into learning in the 21st century through a focus on what they call trans-disciplinary skills – that is, ways of thinking that cut across disciplinary boundaries. They argue that a focus on such skills is important for developing creativity in students within a disciplinary learning context.

Scalability

Beyond making 21st century competencies a part of education, understanding how ICT might shift our educational structures from industrial era schools to new types of 21st century formal educational models is important. Societies can no longer afford a labour-intensive model of education that uses expensive human resources inefficiently. This is not a temporary financial dislocation due to an economic downturn, but a permanent sea change that has already happened in every other service sector of our economy. Many of the innovative pedagogical practices supported by technology of the SITES study (e.g., Kozma, 2003) are based on personal heroism, educators who make sacrifices in every other part of their lives in order to help their students. These are wonderful stories, but such a model for educational improvement is un-scalable to typical teachers. Scaling up involves adapting an innovation successful in a local setting to effective usage in a wide range of contexts (Dede, 2006). Scalable designs for educational transformation must avoid what Wiske and Perkins (2005) term the ‘replica trap’: the erroneous strategy of trying to repeat everywhere what worked locally.

Coburn (2003) describes scale as encompassing four interrelated dimensions: depth, sustainability, spread and shift in ownership. ‘Depth’ refers to deep and consequential change in classroom practice, altering

teachers’ beliefs, norms of social interaction and pedagogical principles as enacted in the curriculum. ‘Sustainability’ involves maintaining these consequential changes over substantial periods of time. ‘Spread’ is based on the diffusion of the innovation to large numbers of classrooms and schools. ‘Shift’ requires districts, schools and teachers to assume ownership of the innovation, deepening, sustaining and spreading its impacts. A fifth possible dimension to extend Coburn’s framework is ‘evolution’, in which the innovation as revised by its adapters is influential in reshaping the thinking of its designers, creating a community of practice that evolves the innovation (Dede, 2006). The U.S. Department of Education’s 2010 National Educational Technology Plan (U.S. Department of Education, 2010) not only presents a transformational vision for 21st century education that builds on insights about modern interactive media gained from other parts of the economy but also depicts new processes and structures that recognize the unique challenges of helping students learn, lifelong and life-wide. Plans like this potentially form a foundation for developing scalable models for 21st century education.

Conclusion and recommendations

Public (e.g., EU, OECD, United Nations Educational, Scientific, and Cultural Organization) and private organizations (e.g., Partnership for 21st Century Skills, Assessment and Teaching of 21st Century Skills) all see the need for new, 21st century competencies to comply with requirements of our present and future societies, and broadly agree what these 21st century competencies are and how they can be learnt (Binkley *et al.*, 2012; Dede, 2010b; Mishra & Kereluik, 2011; Voogt & Pareja Roblin, 2012). Despite this consensus, research (e.g., Law *et al.*, 2008) shows that they are not well implemented in educational practice. A major reason is that the implementation of 21st century competencies requires a restructuring of the curriculum. It is not only a matter of trading 20th century content and goals for those of the 21st century, but a matter of redefining what has to be considered as core in the 21st century curriculum and considering the implications of a 21st century curriculum for the current school system (Dede, 2010b). To further the implementation of 21st century competencies in school system we recommend the following:

- Twenty-first century competencies are often discussed disconnectedly from core school subjects. It seems important to provide models and examples on how 21st century competencies can be related to core subject domains to help policymakers, school leaders and teachers implement 21st century competencies in the school curriculum.
- The need for different types of literacy must be acknowledged. Digital literacy should not be regarded as a separate set of skills but embedded within and across the other 21st century competencies and core subjects. Because of the ubiquitous use of technology in our society, schools and universities often assume that their students are digitally literate, but it is becoming increasingly clear that students differ greatly in their use of technology and therefore in their technology skills (Bennett & Maton, 2010).
- Most frameworks for 21st century competencies seem to assume that 21st century competencies are acquired in formal educational settings, but there is substantial potential to learn 21st century competencies in informal learning settings. Research during the last decade has shown how new social practices evolve due to increased use of new digital technologies, especially among young people (Buckingham & Willett, 2006). Such practices create reconceptions of key skills, not defined from a systems level, but from the everyday lives of people in our societies. Lai *et al.* (2013) in this special issue describe the potential of new technologies in informal settings and the potential for using technology to link learning in formal and informal settings.
- New assessment frameworks need to be developed to assess 21st century competencies. We recommend to closely follow some recent international initiatives that focus on ways of developing assessment tools for 21st century learning because they can also guide national initiatives. For example 'Assessment and Teaching of 21st century competencies', which is now testing out two of the ten key concepts in this framework, that of 'problem solving' and 'ICT Literacy' (Griffin, Care, & McGaw, 2012). Five countries around the world are now piloting how we might assess and teach these two key concepts for future upscaling across the world. Further, the International Computer and Information Literacy Study has focused on developing authentic computer-based literacy assessments that require students to modify

and create information products (Fraillon & Ainley, 2010). This study is currently on its way and will be finalized in 2014.

- Globalization implies that the development of 21st century competencies in young people is important worldwide. It is important to understand how developments of 21st century competencies reproduce or create new knowledge divides within and across countries and cultures. The latter implies a need for cultural understanding of the conception of 21st century competencies.

Acknowledgement

The authors wish to thank all members of TWG6 for their input during the discussions at EDUsummIT2011, Paris.

References

- American Association of Colleges of Teacher Education. (2008). *The handbook of technological pedagogical content knowledge (TPCK) for educators*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Anderson, R. (2008). Implications of the information and knowledge society for education. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 5–22). New York, NY: Springer.
- Araya, D., & Peters, M. A. (Eds.). (2010). *Education in the creative economy: Knowledge and learning in the age of innovation*. New York, NY: Peter Lang Publishers.
- Banaji, S., & Burn, A. (2007). Creativity through a rhetorical lens: Implications for schooling, literacy and media education. *Literacy*, 41(2), 62–70.
- Barton, D. (2007). *Literacy: An introduction to the ecology of written language* (2nd ed.). Malden, MA: Blackwell.
- Bennett, S., & Maton, K. (2010). Beyond the digital natives debate: Towards a more nuanced understanding of students' technology experiences. *Journal of Computer Assisted Learning*, 26, 321–331.
- Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 17–66). Heidelberg: Springer.
- Bryderup, I. M., Larsen, A., & Trentel, M. Q. (2009). ICT-use, educational policy and changes in pedagogical paradigms in compulsory education in Denmark: From a lifelong learning paradigm to a traditional paradigm? *Education and Information Technologies*, 14, 365–379.

- Buckingham, D. (2003). *Media education. Literacy, learning and contemporary culture*. Cambridge, UK: Polity Press.
- Buckingham, D., & Willett, R. (Eds.). (2006). *Digital generations: Children, young people, and new media*. Mahwah, NJ: Lawrence Erlbaum.
- Clarke-Midura, J., Dede, C., & Norton, J. (2011). Next generation assessments for measuring complex learning in science. In D. Plank, J. Norton, C. Arraez, & I. Washington (Eds.), *Policy Analysis for California Education and Rennie Center for Education Research & Policy, The road ahead for state assessments* (pp. 27–40). Cambridge, MA: Rennie Center for Education and Public Policy. Retrieved from <http://renniecenter.issuelab.org/research>
- Coburn, C. E. (2003). Rethinking scale: Moving beyond numbers to deep and lasting change. *Educational Researcher*, 32(6), 3–12.
- Davis, N., Eickelmann, B., & Zaka, P. (2013). Restructuring of educational systems in the digital age from a co-evolutionary perspective. *Journal of Computer Assisted Learning*, 29(5), 438–450.
- Dede, C. (2006). Scaling up: Evolving Innovations beyond ideal settings to challenging contexts of practice. In R. K. Sawyer (Ed.), *Handbook of the learning sciences* (pp. 551–566). Cambridge, UK: University Press.
- Dede, C. (2008). Theoretical perspectives influencing the use of information technology in teaching and learning. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 43–62). New York, NY: Springer.
- Dede, C. (2010a). Technological supports for acquiring 21st century skills. In E. Baker, B. McGaw, & P. Peterson (Eds.), *International encyclopedia of education* (3rd ed., pp. 1–22). Oxford, UK: Elsevier. Retrieved from http://learningcenter.nsta.org/products/symposia_seminars/iste/files/Technological_Support_for_21stCentury_Encyclo_dede.pdf
- Dede, C. (2010b). Comparing frameworks for 21st century skills. In J. Bellanca & R. Brandt (Eds.), *21st century skills* (pp. 51–76). Bloomington, IN: Solution Tree Press.
- Dede, C. (2011). Reconceptualizing technology integration to meet the challenges of educational transformation. *Journal of Curriculum and Instruction*, 5(1), 4–16.
- Eickelmann, B. (2011). Supportive and hindering factors to a sustainable implementation of ICT in schools. *Journal for Educational Research Online/Journal für Bildungsforschung Online*, 3, 75–103.
- Erstad, O. (2008). Trajectories of remixing – digital literacies, media production and schooling. In C. Lankshear & M. Knobel (Eds.), *Digital literacies. Concepts, policies and practices* (pp. 177–202). New York, NY: Peter Lang.
- European Union (EU). (2007). *Key competences for lifelong learning. European reference framework*. Retrieved from http://ec.europa.eu/dgs/education_culture/publ/pdf/ll-learning/keycomp_en.pdf
- Fraillon, J., & Ainley, J. (2010). *The IEA international study of computer and information literacy*. Retrieved from <http://icils2013.acer.edu.au/wp-content/uploads/examples/ICILS-Detailed-Project-Description.pdf>
- Gordon, J., Halasz, G., Krawczyk, M., Leney, T., Michel, A., Pepper, D., . . . Wiśniewsky, J. et al. (2009). *Key competences in Europe. Opening doors for lifelong learners across the school curriculum and teacher education*. Center for Social and Economic Research on behalf of CASE Network: Warsaw. Retrieved from http://ec.europa.eu/education/more-information/doc/keyreport_en.pdf
- Graff, H. (1991). *The literacy myth: Cultural integration and social structure in the nineteenth century*. New Brunswick, NJ: Transaction Publishers, Rutgers University.
- Griffin, P., Care, E., & McGaw, B. (2012). The changing role of education and schools. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 1–15). Heidelberg: Springer.
- Harlen, W., & Deakin Crick, R. (2003). Testing and motivation for learning. *Assessment in Education: Principles, Policy & Practice*, 10, 169–208.
- Hatlevik, O., Ottestad, G., Skaug, J. H., Kløvstad, V., & Berge, O. (2009). *ITU Monitor 2009. Skolens digitale tilstand [The digital condition of schools]*. Oslo: National Centre for ICT. Retrieved from <https://iktsenteret.no/ressurser/itu-monitor-2009>
- Hinostroza, J. E., Labbé, C., López, L., & Iost, H. (2008). Traditional and emerging IT applications for learning. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 81–96). New York, NY: Springer.
- Hull, G., & Schultz, K. (Eds.). (2002). *Schools out! Bridging out-of-school literacies with classroom practice*. New York, NY: Teachers College Press.
- Jenkins, H., Clinton, K., Puroshotma, R., Robinson, A.J., & Weigel, M. (2006). *Confronting the challenges of participatory culture: Media education for the 21st century*. Chicago, IL: MacArthur Foundation. Retrieved from http://digitalllearning.macfound.org/atf/cf/%7B7E45C7E0-A3E0-4B89-AC9C-E807E1B0AE4E%7D/JENKINS_WHITE_PAPER.PDF
- Kalantzis, M., & Cope, B. (2008). *New learning: Elements of a science of education*. Cambridge, UK: Cambridge University Press.
- Kozma, R. B. (Ed.). (2003). *Technology, innovation and educational change: A global perspective*. Eugene, OR: ISTE.

- Kubey, R. (Ed.). (1997). *Media literacy in the information age. Current perspectives*. Information and Behavior (Vol. 6). New Brunswick, NJ: Transaction Publishers.
- Kunnskapsdepartementet. (2004). *St.meld. Nr. 30 (2003–2004) Kultur for Læring [White paper nr 30 (2003–2004) culture for learning]*. Oslo: Ministry of Knowledge.
- Lai, K. W. (2008). ICT supporting the learning process: The premise, reality, and promise. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 215–230). New York, NY: Springer.
- Lai, K. W., Khaddage, F., & Knezek, G. (2013). Blending student technology experiences in formal and informal learning. *Journal of Computer Assisted Learning*, 29(5), 414–425.
- Lambert, J., & Cuper, P. (2009). Multimedia technologies and familiar spaces: 21st-century teaching for 21st century learners. *Contemporary Issues in Technology and Teacher Education*, 8, 264–276.
- Lankshear, C. (1997). *Changing literacies (Changing education)*. Buckingham: Open University Press.
- Lankshear, C., & Knobel, M. (2006). *New Literacies: Everyday practices & classroom learning*. Berkshire: Open University Press.
- Law, N. (2009). Mathematics and science teachers' pedagogical orientations and their use of ICT in teaching. *Education and Information Technologies*, 14, 309–323.
- Law, N., Lee, M. W., & Chan, A. (2010). Policy impacts on pedagogical practice and ICT use: An exploration of the results from SITES 2006. *Journal of Computer Assisted Learning*, 26, 465–477.
- Law, N., Pelgrum, W. J., & Plomp, T. (2008). *Pedagogy and ICT use in schools around the world. Findings from the IEA SITES 2006 study*. CERC Studies in comparative education. Hong Kong/ Dordrecht: Comparative Education Research Centre, University of Hong Kong/Springer.
- Lessig, L. (2008). *Remix: Making art and commerce thrive in the hybrid economy*. New York, NY: Penguin Press.
- Levy, F., & Murnane, R. J. (2004). *The new division of labor: How computers are changing the way we work*. Princeton, NJ: Princeton University Press and the Russell Sage Foundation.
- Levy, F., & Murnane, R. J. (2006). *How computerized work and globalization shape human skill demands*. Cambridge MA: MIT, Department of Urban Studies and Planning & Harvard University, Graduate School of Education.
- Mioduser, D., Nachmias, R., & Forkosh-Baruch, A. (2008). New literacies for the knowledge society. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 23–42). New York, NY: Springer.
- Mishra, P., & Kereluik, K. (2011). What 21st century learning? A review and a synthesis. In C. D. Maddux, M. J. Koehler, P. Mishra, & C. Owens (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2011* (pp. 3301–3312). Chesapeake, VA: AACE.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108, 1017–1054.
- Mishra, P., Koehler, M. J., & Henriksen, D. (2011). The seven trans-disciplinary habits of mind: Extending the TPACK framework towards 21st century learning. *Educational Technology*, 11(2), 22–28.
- Organisation for Economic Co-operation and Development (OECD). (2005). *The definition and selection of key competencies [Executive Summary]*. Retrieved from <http://www.oecd.org/dataoecd/47/61/35070367.pdf>
- Organisation of Economic Co-operation and Development (OECD). (2004). Lifelong learning. *Observer*, February, 1–8. Retrieved from <http://www.oecd.org/dataoecd/17/11/29478789.pdf>
- Papert, S. (1994). *The children's machine: Rethinking school in the age of the computer*. New York, NY: Basic.
- Papert, S., & Harel, I. (1991). *Constructionism*. Norwood, NJ: Ablex Publishing Corporation.
- Partnership for 21st Century Skills. (n.d.). *The intellectual and policy foundations of the 21st century skills framework*. Retrieved from http://route21.p21.org/images/stories/epapers/skills_foundations_final.pdf
- Perlman, L. J. (1992). *School's out: Hyperlearning, the new technology, and the end of education*. New York, NY: William Morrow.
- Plomp, T., Anderson, R., Law, N., & Quale, A. (Eds.). (2008). *Cross-national ICT policies and practices in education* (Rev. ed.). Charlotte, NC: Information Age Publishers.
- Reich, R. (1992). *The work of nations. Preparing ourselves for the 21st -century capitalism*. New York, NY: Vintage Books.
- Ridgway, J., McCusker, S., & Pead, D. (2004). *Literature review of e-assessment (Report 10)*. Bristol: Futurelab.
- Rutten, N., van Joolingen, W., & van der Veen, J. (2012). The learning effects of computer simulations in science education. *Computers & Education*, 58, 136–153.
- Sawyer, K. (Ed.). (2006). *The Cambridge handbook of the learning sciences*. Cambridge, MA: Cambridge University Press.
- Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In R. K. Sawyer (Ed.), *Handbook of the learning sciences* (pp. 97–115). Cambridge, UK: University Press.

- Street, B. V. (1984). *Literacy in theory and practice*. Cambridge, MA: Cambridge University Press.
- Tondeur, J., van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education*, *59*, 134–144.
- Tondeur, J., van Braak, J., & Valcke, M. (2007). Primary school curricula and the use of ICT in education. Two worlds apart? *British Journal of Educational Technology*, *38*, 962–975.
- Trier, U. (2003). Twelve countries contributing to DeSeCo: A summary report. In D. Rychen, L. Salganik, & M. McLaughlin (Eds.), *Definition and selection of key competences. Contributions to the second DeSeCo symposium* (pp. 27–59). Neuchatel: Swiss Federal Statistical Office.
- Tyner, K. (1998). *Literacy in a digital world. Teaching and learning in the age of information*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- U.S. Department of Education. (2010). *Transforming American education: Learning powered by technology (National Educational Technology Plan 2010)*. Washington, DC: Office of Educational Technology, U.S. Department of Education. Retrieved from <http://www.ed.gov/technology/netp-2010>
- Voogt, J. (2008). IT and curriculum processes: Dilemmas and challenges. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 117–132). New York, NY: Springer.
- Voogt, J., Erstad, O., Mishra, P., & Dede, C. (2011). *TWG 6: 21st century learning – expanded brief paper*. Retrieved from <http://www.edsummit.nl>
- Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological pedagogical content knowledge – a review of the literature. *Journal of Computer Assisted Learning*, *29*, 109–121.
- Voogt, J., & Pareja Roblin, N. (2012). Teaching and learning in the 21st century. A comparative analysis of international frameworks. *Journal of Curriculum Studies*, *44*, 299–321.
- Voogt, J., & Pelgrum, H. (2005). ICT and curriculum change. *Human Technology; an Interdisciplinary Journal on Humans in ICT Environments*, *1*, 157–175.
- Voogt, J. M., & Odenthal, L. E. (1997). *Emergent practices geportretteerd. Conceptueel raamwerk [A portrait of emerging practices: A conceptual framework]*. Enschede: University of Twente.
- Warschauer, M. (1999). *Electronic literacies: Language culture and power in online education*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Wegerif, R. B., & Dawes, L. (2004). *Thinking and learning with ICT: Raising achievement in primary classrooms*. London: Routledge.
- Wertsch, J. (1998). *Mind as action*. New York, NY: Oxford University Press.
- Wiske, M. S., & Perkins, D. (2005). Dewey goes digital: Scaling up constructivist pedagogies and the promise of new technologies. In C. Dede, J. Honan, & L. Peters (Eds.), *Scaling up success: Lessons learned from technology-based educational innovation* (pp. 27–47). New York, NY: Jossey-Bass.
- Zhang, Q. (2012). *Supporting teachers to enact integrative practical activities in China*. (Unpublished doctoral dissertation). University of Twente, Enschede.