E-learning in School Education in the Coming 10 Years for Developing 21st Century Skills: Critical Research Issues and Policy Implications

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ABSTRACT

One of the curriculum goals of e-learning in school education is to develop learners for 21st century skills through their daily learning activities. This paper aims to discuss the research issues and policy implications critical for achieving such a curriculum goal. A review of literature in the related fields indicates that K-12 schools should take advantage of e-learning to maximize learning opportunities of learners for the development of 21st century skills. We identify six research issues critical for e-learning in school education, namely the realization of developing 21st century skills of learners; the bridging of the gap between curriculum in school and situations in society; the maximization of learning opportunities in the learning process; the collection of evidence of improvement and building awareness of progress; the assessment of 21st century skills; and the provision of teacher development for enculturating learners to develop 21st century skills. We recommend the relevant stakeholders across different countries/regions to consider policies on the goal-setting of curriculum addressing 21st century skills development and bridging gap between school and society; on the availability of digital technology for school education; on the privacy/legal issues of learning data in e-learning process; and on the teacher development for pre-service and in-service teachers.

Keywords

E-learning, School education, 21st century skills, Research issues, Policy implications

Introduction

The advocacy of learner-centered learning and the emergence of digital classrooms lead to the demand for transformation of pedagogical design that supports the development of 21st century skills through domain knowledge learning. We establish an International Research Network (IRN) "Theory and Practice of Pedagogical Design for Learning in Digital Classrooms" under the World Educational Research Association (WERA) for the collaborative endeavors of practice-driven research for building theories that inform and direct the pedagogical design conducive to effective orchestration of learning in digital classrooms.

We anticipate the growing trend toward a more individualized and collaborative learning in school education; where physical classrooms keep its importance in learners' interaction and socialization, yet learning extending outside classrooms will play a more important role in learners' knowledge construction. Our goal is to advise researchers and governments across different countries/regions to study related research issues and to develop and implement holistic e-learning policies respectively; and then to spread and deepen the impact of digital classrooms for learner-centered learning in K-12 schools.

This paper aims to share our insights into the critical research issues and policy implications for the effective implementation and spreading promotion of e-learning in school education in the coming 10 years. We first share our thoughts of e-learning in school education from a review of related literature; then discuss the research issues in light of our thoughts of e-learning for facilitating K-12 learners to learn effectively in digital classrooms; and finally draw policy implications that we expect from governments at local and global levels for e-learning in school education.

E-learning in school education in the coming 10 years

The popularity of digital technology drives the use of digital resources and communication tools for learning in school education. To benefit from this type of digital learning, learners need inquiry and critical thinking skills to select and process useful and reliable information from varying sources for learning (Padilla, 2010; Trilling & Fadel, 2009). Leaners also need communication and collaboration skills to communicate and collaborate with their peers to complete tasks and share outcomes (Saavedra & Darleen Opfer, 2012; Szewkis et al., 2011). These skills are fundamental components of 21st century skills, which empower learners to successfully acquire knowledge and advance learning in the 21st century (Hoffman, 2010; Rotherham & Willingham, 2009). It is therefore foreseen that the learning goals of school education in the coming 10 years need to address the development of 21st century skills beyond curricular goals of learning domain knowledge.

Both domain knowledge and 21st century skills are the learning outcomes to be concerned in the learning goals for developing 21st century skills. As like domain knowledge, learners' competency in 21st century skills is also needed to be assessed in the process of classroom learning (Claro et al., 2012; Gut, 2011). The assessment of 21st century skills should therefore be linked with the assessment of domain knowledge, so that teachers can better understand the interrelationship between learners' gains in these two types of learning outcomes. The related assessment should target at evidence of improvement and awareness of progress, in order to reveal both positive and negative features of learning process (Hoppe, 2007). The digital platforms/tools used in digital classrooms can track and store extensive information on learners' interaction. Such technological support can facilitate a convenient and systematic record, retrieval and commenting on learners' information on learning process and learning outcomes. Learners in turn can accumulate learner-centered learning experience and create learner-centered learning portfolio. Teachers in turn can provide timely feedback according to learners' learning outcomes (Alvarez, Salavati, Nussbaum, & Milrad, 2013).

It is foreseen that in the coming 10 years, the school education sector over the world has to get ready for the creation of digital classrooms which support learners to effectively develop 21st century skills through the day-to-day learning process. Figure 1 describes our thoughts of learning in school education for developing 21st century skills.
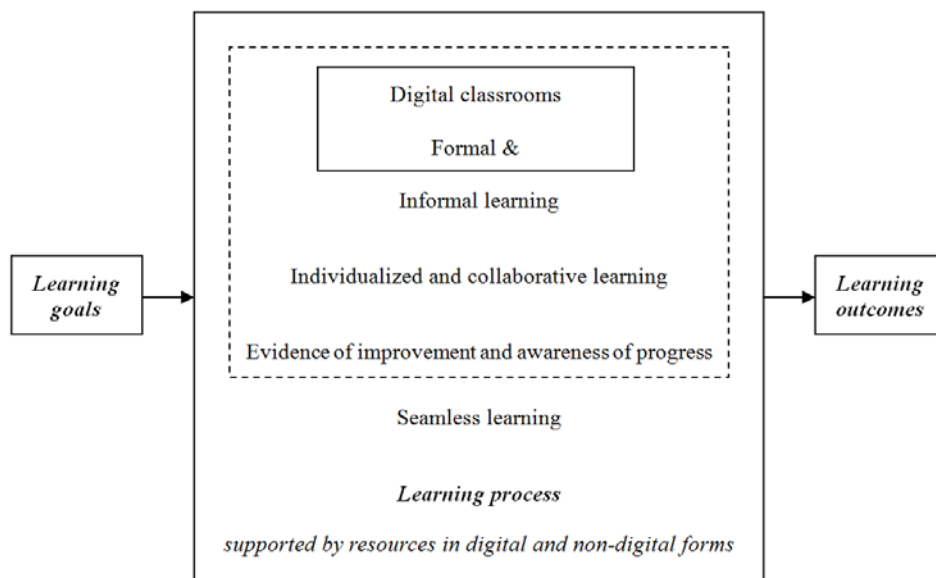

Figure 1. Learning in school education for developing 21st century skills

The introduction of digital resources, digital ways of communication and digital platforms for learning and teaching brings about many opportunities to enhance the learning process in school education in the 21st century. It is foreseen that such learning process is supported by resources in digital and non-digital forms seamlessly inside and outside of digital classrooms (So, 2012), in which learners typically use portable computing devices and social learning networks for the retrieval, selection, and sharing of authentic information from multiple sources (Alvarez et

al., 2013; Chan, 2010; Kong, 2011). The learning process for developing 21st century skills is characterized of three emphases (see Figure 1 and Table 1).

Its first emphasis is skills development in both formal and informal learning contexts (Cox, 2013; Huang, Kinshuk, & Spector, 2013). The learners will be engaged in a seamless learning environment to coherently apply various generic skills for in-school teacher-led learning process initiated in digital classrooms and after-school learner-initiated learning process in social learning platforms/tools according to individual needs (Milrad, Wong, Sharples, Hwang, Looi, & Ogata, 2013; Otero, Milrad, Rogers, Santos, Veríssimo, & Torres, 2011; Wong & Looi, 2011).

Its second emphasis is skills development through both individualized and collaborative learning approaches. On their own or with peers, learners will take responsibilities to apply various generic skills for planning goals, implementing tasks, monitoring progresses and evaluating outcomes in their learning process (Kicken, Brand-Gruwel, Merriënboer, & Slot, 2009; Norris & Soloway, 2009). The feedback for learners will be in a minimal but sufficient amount for identifying individual needs and directions for future improvement (Caballero, van Riesen, Alvarez, Nussbaum, De Jong, 2014; Sims, 2003; Van Merriënboer, & Sluijsmans, 2009).

Its third emphasis is skills development supported by evidence of improvement and awareness of progress. The learning process in the e-learning environments can be designed in a range of activities in authentic learning contexts. Rich evidence of improvement and productive failure could be collected from learners' performance during the learning process of which can be indications on applying 21st century skills for processing real-life information, reflecting on problem-solving ways, articulating tacit knowledge and negotiating multiple analysis perspectives for knowledge construction (Herrington & Kervin, 2007; Niederhauser & Lindstrom, 2006; Zualkernan, 2006). Learners and teachers would then have many opportunities to look into evidence of improvement and reflection on awareness of progress in the e-learning environments which include all and more than those formative assessments in a continuous manner across the learning process and the summative assessments at particular stages.

Technology plays a crucial role in supporting schools on realizing the desirable learning goals, learning process and learning outcomes as described in Figure 1 and as discussed above. Learners in school education nowadays have many channels to access digital resources and use digital ways of communication to connect with peers for e-learning. This exposes learners to many opportunities for applying 21st century skills in the technology-supported learning process. To prompt learners to be benefited from such learning opportunities, there should be convincing research findings and supportive policy initiatives favorable to the integration of e-learning elements in curriculum delivery, in order to motivate K-12 schools to plan for the curriculum goal desirable for the development of 21st century skills among learners through the learning process in e-learning environments.

The learning process in e-learning environments, as discussed, is expected to consider three key elements for maximizing learning opportunities conducive to 21st century skills development. The first element of blending formal and informal learning approaches helps schools to bridge the existing gap between school curriculum and society situations. The second element of balancing individualized and collaborative learning helps learners to increase awareness of learning achievement on individual basis and also increase motivation to make learning progress with peers. The third element of collecting evidence of improvement and building awareness of progress helps teachers and learners to understand levels of learning outcomes on the formative basis and then make informed decisions on next teaching and learning challenge. Providing learners with personal computing devices with wireless connectivity for accessing digital resources, and providing learners and teachers with digital learning platforms/tools for tracking and storing learning data are technological supports favorable to the realization of these three key elements in the learning process for developing 21st century skills inside and outside of digital classrooms. Research inputs and policy planning in relation to the three key elements and the two types of technological supports are genuinely needed for the process of active, constructive and interactive learning in digital classrooms.

Learners will generate learning outcomes in terms of both domain knowledge and 21st century skills in the abovementioned learning process. Research community needs to investigate the effective ways to assess 21st century skills on top of domain knowledge at different stages of such learning process, in order to support K-12 schools on the appropriate and simultaneous measurement of learners' knowledge and skills development.
The successful implementation of the abovementioned learning process requires teachers to realize the vision of promoting 21st century skills among learners; master the skills in facilitating active, constructive and interactive learning process among learners; master the orchestration of digital and non-digital resources; and recognize the

equal importance of academic achievement and 21st century skills as learning outcomes in school education. The current teacher development related to e-learning has to be adjusted to prepare teachers to transform their beliefs and practice in these four aspects (Kong & Song, 2013). The focus of such adjustment will be placed on the impact of the teacher development programs on teachers' motivational change and then practice changes for learner-centered learning, but not only the integration of IT use or technological support in the delivery of teacher development programs. One important focus of future teacher development program, as mentioned, is the orchestration of resources in digital and conventional non-digital form for supporting learning and teaching in digital classrooms (Nussbaum, Dillenbourg, Dimitriadis, & Roschelle, 2013). Orchestration refers to how a teacher manages, in real time, multi-layered activities in a multi-constraints context (Dillenbourg, 2013). Considering that teachers fail to adopt many research-based learning technologies, the orchestration view privileges the process of adoption and adaptation in an effort to bring the dilemmas of practice into focus.

Table 1 highlights the technological supports conducive to learning in school education for developing 21st century skills; and summarizes the research issues and policy implications critical for e-learning in school education in the coming 10 years. The next two sections will discuss the critical research issues and policy implications in detail.

Table 1. E-learning in school education in the coming 10 years: critical issues

E-learning in school education	Technological support	Research issue	Policy implication
Learning goals: 21st century skills	• Digital resources • Digital ways of communication	• Developing 21st century skills	• Policy for setting up curriculum goals for delivering 21st century skills
Learning process: (1) Formal and informal learning (2) Individualized and collaborative learning (3) Evidence of improvement and awareness of progress	• Digital classrooms (personal computing devices and wireless connectivity) • Digital resources • Development/choice of digital learning platforms/tools	• Bridging gap between school and society for linking curriculum content to real life • Learning models for developing 21st century skills • Performing learning analytics for collecting evidence of improvement and building awareness of progress	• Policy for bridging gap between school and society for linking curriculum content to real life • Policy for availability of personally-owned computing devices and free wireless connectivity for developing 21st century skills • Policy for addressing privacy/legal issues in e-learning process in which learning data are being tracked
Learning outcomes: 21st century skills assessment	• Platforms/tools development for assisting assessment of 21st century skills	• Assessing 21st century skills	
Teacher development: (1) Learner-centered learning (2) Active/Constructive/Interactive learning	• With or without platforms/tools development for teacher development	• Providing teacher development for facilitating learners to develop 21st century skills • Scaling up those sustainable teacher development models	• Policy for teacher development for pre-service and in-service teachers

Research issues

Six research issues are considered critical for realizing the changes in the goal, process and outcome of learning in school education in the coming 10 years.
The first research issue relates to the realization of learning goal of developing learners for 21st century skills. The research community can contribute in this regard by conducting evidence-based research which concretely identifies factors that motivate school leaders to change school-based planning priority with regard to the development of 21st

century skills. These research efforts aim to promote school leaders to truly recognize the benefits for K-12 learners who master 21st century skills; and so to take action to give priority to the development of 21st century skills when drawing up school-based plans for e-learning integration into curriculum delivery, as well as solicit campus-wide consensus on this planning direction for a smooth curriculum implementation.

The second research issue relates to the bridging of the gap between schools' curriculum delivery and society's real-life situations. In the knowledge- and competency-oriented society, learners are demanded on applying knowledge across different subject domains for solving day-to-day problems in the home and community environments. The research community can contribute in this regard by promoting K-12 schools to meaningfully link the content of school curriculum delivered to learners and the application of domain knowledge acquired by learners. One of the promising directions is promoting the creation of digital classrooms in K-12 schools to expose learners to the authentic and contextualized learning environments for promoting cognitive engagement, from the perspective of "cognitive realism". "Cognitive realism" in the field of education refers to the process of immersing and engaging students in the use of simulation materials for complex learning tasks for "realistic problem-solving" (Herrington, Reeves, & Oliver, 2006, 2007). The research community could help motivate K-12 schools to value the achievement of "cognitive realism" in subject learning, with an emphasis on learning scenarios with multiple outcomes and learning tasks on higher-order thinking, and thereby motivate teachers to select appropriate digital resources for supporting learners, without teacher mediation, to explore, think, decide and perform the steps that an expert would take to solve complex problems of the subject topics.

The third research issue relates to the realization of learning process of developing learners for 21st century skills. The successful promotion of learners' 21st century skills demands the paradigm shift to learner-centered learning in digital classrooms. It concerns the adequacy and relevance issues of curriculum delivery, in order to allow learners to adequately access resources and scenarios that are related to real-life problem-solving when they develop 21st century skills. Teachers therefore need to change their teaching motivations and pedagogical practice for leading learners in two ways: engaging in active, constructive and interactive learning process for their application and reflection of 21st century skills in school education, and raising their social awareness among the learning processes in school, in community and in home environment. The research community can contribute in this aspect by investigating e-learning models that inform K-12 schools of the promising approach to technological use and pedagogical designs at classroom level for blending formal and informal learning approaches, creating authentic and contextualized learning environments, and balancing individualized feedback provision and self-directed learning process.

The fourth research issue relates to collecting evidence of improvement and building awareness of progress for supporting pedagogical decision-making of teachers and maximizing learning opportunities of learners in developing 21st century skills in the learning process. The advocacy of learners' active learning and the trend of digital classrooms using various learning management systems and social network platforms place new demands on teachers for transforming pedagogical practices in school education. Data mining techniques are designed commonly for collecting large-scale of data, extracting actionable patterns, and obtain insightful knowledge (Long & Siemens, 2011). The integration of data mining techniques into the learning analytics platform allows for a systematic and real-time approach in identifying effective pedagogical changes (West, 2012). However, the information from learning analytics have not yet well used to inform learning and teaching due to various reasons (Ferguson, 2012). One of the reasons is that a good part of the data accessible to learners and teachers may not be able to inform pedagogical decision making because large-scale assessment data are usually not linked to learners' learning processes and outcomes. Another reason is that the technologies used to track learners' learning usually focus on activity tracking instead of knowledge tracking, which do not guide learners and teachers to identify learning problems and make right decision-making to address these issues. Therefore, efforts are needed for researchers to explore ways to provide learning analytics for collecting evidence of improvement and building awareness of progress among learners for appropriate pedagogical decision-making in e-learning environments in school education.

The fifth research issue relates to the assessment of learning outcomes of developing learners for 21st century skills. As both domain knowledge and 21st century skills are the learning outcomes to be concerned in digital classrooms in school education, there should be a coherent and formative mechanism for the assessment of 21st century skills in addition to domain knowledge. The research community can contribute in this regard by studying the ways to support schools to use IT for assessing 21st century skills with a link to domain knowledge.

The sixth research issue relates to the teacher development for facilitating learners to develop 21st century skills. The research community can make corresponding contributions in two ways. First, academics can offer teacher development programs which introduce teachers to the latest development of theoretical frameworks and practical strategies on promoting 21st century skills in e-learning environments, and provide teachers with support ranged from full-scripting scaffolds for less competent teachers to less-scripting scaffolds for more competent teachers. Second, academics can investigate the scalable and sustainable teacher development models that foster teachers' capability to promote learners' 21st century skills. The models are expected to facilitate first the sustainable collaboration between K-12 schools and research community for longitudinal studies that enable teachers to iteratively design, apply, reflect and refine their pedagogical practice for realizing learner-centered learning in digital classrooms; and then the scalable sharing among teachers in K-12 schools within the same school and then across the school community that teachers lead professional development on their own for enhancing competency in orchestrating teaching and learning in digital classrooms.

Policy implications

Building on the above discussions, we recommend four types of governmental policy supports, at local and global levels, for the sustainable and scalable promotion of digital classrooms in school education in the coming years.

The first type of policy supports relates to the set-up of curriculum goals which bridge the gap between school and society for linking curriculum content to real life, for delivering 21st century skills. K-12 learners nowadays are expected to develop both disciplinary knowledge and 21st century skills through day-to-day learning in digital classrooms. Schools are driven to set curriculum goals which emphasize the inculcation of both disciplinary knowledge and 21st century skills. They are also driven to connect school curriculum with society environment; in which schools link learners' formal learning under the curriculum implemented in school and their informal learning echoing community's present situations, and at the same time make campus learning environment transparent to parents and the community. Governments should therefore make policy that officially announces a curriculum emphasis on 21st century skills at national/regional level; and then provide schools with policy incentives to motivate them to prioritize 21st century skills high in e-learning plan and curriculum delivery at school level, re-interpret the school curriculum for a link-up with 21st century skills, identify the possible niches for the integration of 21st century skills into curriculum delivery across different subjects, make curriculum planning with attention paid to its accessibility to sufficient resources and its relevance to real-life situations for skill development, and make long-term school-based plans that indicate their overall directions for curriculum implementation in digital classrooms.

The second type of policy supports relates to the availability of personally-owned computing devices and free wireless connectivity for developing 21st century skills. As discussed, digital classrooms in seamless learning environments enable learners' development of 21st century skills. Learners therefore need infrastructure supports on the engagement in 1:1 learning environments and the acquisition of stable Internet connectivity both on campus and at home. As the current school learning environment is not sufficiently digitalized, governments should provide schools with flexible policy initiatives for collaborative work on realizing the progression from physical classrooms for traditional knowledge transmission to virtual classrooms for authentic and contextualized learning. Examples of the flexible policy initiatives include funding schools to build IT infrastructure and wireless network for the creation of digital classrooms on campus; mobilizing parents to equip learners with personally-owned device for school learning in the 1:1 learning setting in digital classrooms; and subsidizing learners to own personal computing devices and network connectivity at home for seamless learning extended from digital classrooms.

The third type of policy supports relates to the concerns on privacy/legal issues in e-learning process in which learning data are being tracked. The related policy supports can address the trend of evidence-based approach to learning analytics, so as to facilitate the collection of evidence of improvement and the building of awareness of progress among learners. Learners in digital classrooms learn with digital forms of resources and digital ways of communication. This learning process can be facilitated by one-stop digital learning platforms which support learners' convenient connection with learning resources and learning peers, as well as systematic recording and tracking of learning process. Governments should therefore support K-12 schools on the deployment of digital learning platforms which have learning tracking capability and consider data privacy protection in two ways: guiding K-12 school practitioners to select existing platforms of a similar kind for school use, and encouraging the IT-related

industry to tailor-make digital learning platforms for K-12 schools in their own countries/regions. As learners' learning processes are recorded and retrievable on those digital learning platforms over a long period of time on a cross-platform and cross-country basis, this raises a national and even a global concern on protecting the privacy and copyrights of learners' learning information. Governments should make a policy, at national and global levels, on monitoring the storage, retrieval and destroy of information on learners' learning processes in this regard.

The fourth type of policy supports relates to teacher development for pre-service and in-service teachers. In digital classrooms which are conducive to learner-centered learning, teachers are expected to act as facilitators who observe learners' learning processes and provide timely feedback. This role would be relatively new to most teachers who get used to the role as learning authority in traditional teacher-centered paradigm for controlling learners' learning in classrooms. This drives the need to empower teachers with the capability to act as learning facilitators in digital classrooms for creating e-learning environments and design e-learning activities that promote learners' authentic and contextualized learning. Governments should therefore support teacher training institutions and K-12 schools to provide pre-service teachers and in-service teachers, respectively, with sustainable and scalable teacher development for the continuous transformation and implementation of teaching practice desirable for digital classrooms.

Conclusion

E-learning in school education in the coming 10 years has the goal of developing both domain knowledge and 21st century skills among learners in digital classrooms. This paper introduces a vision of learning in school education for developing 21st century skills; and discusses six critical research issues and four policy implications for promoting e-learning in K-12 schools.

The successful achievement of e-learning vision as discussed in this paper needs the joint effort of three related stakeholder groups. First, policy makers should put effort as discussed for charting the way forward for wider and more effective adoption of e-learning in K-12 schools in their schools districts/states/regions/countries. Second, the research community should work for the critical research issues for supporting the development and dissemination of theoretical-based e-learning pedagogies or resources. Third, the practitioners in the field, including school leaders, teachers, parents, learners and business partners, should put effort in realizing the e-learning vision as discussed in this paper — school leaders need to steer goals and directions of e-learning programs; teachers need to develop and implement sound e-learning pedagogical practice; parents need to acquire digital devices and e-learning resources for learners' seamless learning after class; learners need to learn with diverse subject-related digital resources that encourage active engagement in constructive learning and peer interaction for developing domain knowledge and 21st century skills; and business partners (including IT sector and content providers) need to provide schools with supports on technical settings of hardware and software, as well as curriculum-based e-learning resources. These joint inputs altogether help for the progressive realization of learner-centered learning in digital classrooms among K-12 learners in their school education.

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