Using Technologies for Knowledge Creation in Higher Education

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Abstract. Institutes of higher education are investing in information and communication technologies (ICT) with the hope of revolutionizing higher education. Current approaches of using technologies for teaching and learning, however, fall short in terms of preparing students for the 21st century. We present various factors that shape learning in the 21st century: demands of the knowledge-based economy; advances in technologies; and changes in perspectives of learning. Consequently, we argue that learning as knowledge creation is a promising approach to prepare students for the 21st century. It entails engaging students in creating knowledge artifacts and in collaborative discourse that aim at continual improvement of these artifacts. It helps to develop in students the innovative disposition and epistemic agency to explore new perspectives; propose new ideas; and experiment with new ideas. Two case examples are presented to illustrate the knowledge creation approach and to compare it with the current approaches.

Keywords: knowledge creation, technologies for learning, 21st century education

Prevalent technologies for teaching and learning in higher education

The past decade has witnessed a clarion call for the use of technologies to transform and revolutionize teaching and learning in higher education. There have been suggestions on ways through which information and communication technologies (ICT) can be used as a change agent for higher education in the 21st century (Oliver, 2002). Among various technologies, web-based learning management systems (LMS) such as Blackboard and Moodle are prevalent in universities (Chung, Pasquini, & Koh, 2013; Young, 2013). LMS are software systems that facilitate and support a variety of course delivery functions, including repository of course content, course administration, examinations, and tracking learning progress.

Riding on the waves of LMS, an emergence of growth occurred in Massively Open Online Courses (MOOCs). There are two general types of MOOCs: (1) cMOOCs, with small enrollment numbers, that attempt to engage participants in authentic projects and discussion; (2) xMOOCs, with

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massive enrollments, that feature content mastery and scalable assessment as the main objectives (Fasimpaur, 2013). In the 2013 NMC Horizon Report (Johnson *et al*., 2013), MOOC was listed as one of the technologies that would see widespread adoption from 2013 to 2014. In fact, 2012 was referred to as "The Year of the MOOC" in the *New York Times* (Pappano, 2012). The fact that top institutions, including Harvard University and Massachusetts Institute of Technology, are putting their courses online (*e.g*., through edX), and the extremely high sign-up rate for some MOOCs (Pappano, 2012) provide corroborating evidence that MOOCs are in the limelight.

In the face of integrating advanced technologies in higher education, one pertinent question remains: How could these technologies help to advance teaching and learning in higher education?

Problems with the predominant practices of technology-mediated instruction

Despite the huge investment in ICT equipment and infrastructure in higher education, Selwyn (2007) lamented the limited academic use of technologies by faculty and students in many universities. Selwyn proposed four reasons for this dismal outcome. First, for economic reasons, policy makers promote "learning 'about' computer technology rather than 'through' technology" (p.85). Second, the main agenda of commercial ICT vendors is in selling technologies to universities for profit rather than promoting educational applications of ICT. Third, universities are more concerned with administrative and managerial roles of technologies. Fourth, university students are pragmatic and strategic in completing their degrees with good grades that could be achieved without the use of ICT. The 2013 NMC Horizon report (Johnson *et al*., 2013) echoed the same concerns by Selwyn (2007) and listed the low engagement of academics in using technologies for teaching and learning and the resistance to change as two main challenges. The report warns that "[s]imply capitalizing on new technology is not enough; the new models must use these tools and services to engage students on a deeper level." (Johnson *et al*., 2013, p.9). Several reasons were suggested for the apparent inertia toward adopting digital technologies in higher education: competing appraisal system for the faculty; lack of faculty training; and the apprehension towards the use of technologies among academics.

In this paper, we probe the issue further and argue that even if faculty and students are keen in using technologies for teaching and learning purposes, its effectiveness is limited by the pedagogical design and practices of the technology-mediated learning activities.

Let us examine two scenarios of how technologies could be used for academic purposes in the higher education setting. In the first (Scenario A), a university professor puts up course information and course materials in a LMS so that students can access and read the course materials, then answer online examinations. The students' activities are tracked by learning analytics that indicate the time and duration of their logon, and the points gained in the online examinations. To plan and design such online activities effectively is by no means an easy task. It calls for good instructional design skills, which involve performing several analyses and making several critical instructional decisions –

analyze the characteristics of the learners; analyze the content; and break the course contents into smaller chunks to reduce cognitive loads (Paas, Renkel & Sweller, 2004) of the students; decide on the appropriate sequence of the course materials; track the students' participation and provide feedback online or in a face-to-face meeting; incorporate strategies to motivate the learners; and incorporate strategies to enhance the interactivity of the learning activities. Essentially, such an approach entails transmission of knowledge from the expert to the novice, and technologies facilitate this transmission process. This approach, while it could be effective in helping students acquire content knowledge, is highly instructor-directed. The instructor decides what to learn, how to learn, and how to monitor students' learning. Such an approach does not help to develop students' ownership in directing their learning and in leveraging differing perspectives among students for richer discussion to achieve deeper understanding of a topic. Researchers of social constructivist orientation (*e.g.*, Jonassen, 1999) held that the role of the instructor is not to transmit knowledge to the students, but to create an environment for students to construct knowledge collaboratively. Let us consider a scenario of a social collaborative approach to learning supported by MOOC.

In the second (Scenario B), a university professor develops a MOOC. Short video lectures are uploaded into a MOOC platform, where students can access and learn from the video at their own time and pace. During the tutorial sessions, the professor engages the students in deeper discussion of the topic. The discussion is extended to online blogs, where students put up their individual reflection on the topic. This allows the professor and the students to comment on individuals' ideas and issues. Such an approach has elements of a "flipped classroom" (Horn, 2013), which is a form of blended learning that requires students to learn new content at their own pace, often through watching online video lecturers, so that face-to-face instruction time could be used by teachers for guidance or for in-depth discussion. Similarly, such an approach requires extensive preparation effort by the professor in scripting and recording online video lectures; facilitating face-to-face discussions; and providing feedback to the students' blogs. Such an approach does engage the students in achieving deeper understanding of a topic, but it still falls short in terms of preparing the students for the 21st century, in particular, in developing students' capacity to engage in knowledge creation. So, what does learning in the 21st century require?

Learning in the 21st century

Several intertwined factors influence the approaches and outcomes of learning in the 21st century: the demand of the knowledge-based economy that changes the goals of education; the advances in technologies that revolutionize education and provide new affordances for learning; and advances in perspectives of learning that suggest alternative approaches to achieve effective learning.

Demand of the knowledge-based economy

As the 21st century unfolds, it becomes evident that we are living in a knowledge-based society with technology permeating every aspect of our lives. In this economy, knowledge, rather than physical resources, becomes the key asset to generate tangible and intangible values. Technologies play a critical role in a knowledge-based economy in providing the necessary architecture for communication and sharing of information. The advent of a knowledge-based economy creates new demands on education. We are reminded by numerous reports (*e.g.*, Partnership for 21st Century Skills, 2006) that for productive and participatory citizenry in the 21st century, we need to develop in our students new skills and capacity, including knowledge innovation capacity and digital literacy for the survival and growth of individuals and for their future contribution to the new economies (Anderson, 2008). If there is a demand to change in K-12 education, changes in higher education is even more urgent.

Bates (2004), in his address to the Open University of Hong Kong, explicated the needs for universities to change in the face of a knowledge-based economy and the advancement of technologies. Bates listed some necessary skills of knowledge workers: communication skills, computing skills, entrepreneurship, flexibility, and ability to work in teams. In the face of rapid changes, knowledge workers need to be self-directed in learning and develop deep subject expertise. Lifelong learning is not a nice-to-have, but an imperative. Consequently, traditional roles of universities – to conduct research; create and disseminate new knowledge; and to teach students both existing knowledge and the state-of-the-art knowledge – must be expanded. We could help students in higher education shift from acquiring knowledge to managing knowledge, and from learning content to learning how to learn. In other words, we need to develop among learners the disposition to innovate and to be creative, so that when faced with challenges in work and in every aspect of their lives, they are able to see new perspectives, propose new ideas and experiment with their ideas. Bates proposed elearning as one of the means to develop in students self-directed learning skills, and also to support alumni in lifelong learning. While Bates provided compelling reasons for the need to incorporate elearning in higher education, Collins and Halverson (2009) made bolder claims that technologies will revolutionize education.

How technologies revolutionize education

Collins and Halverson (2009) held that technologies are catalyzing the second wave of revolution in education. They argued that while industrialization engendered the first wave of revolution and created universal schooling system, the second wave of revolution is changing the fundamental practices in education. Specifically, technologies enable these changes: (1) from universal learning to customized learning; (2) from teachers as the source of expert knowledge to diverse knowledge sources; (3) from standardized assessment to diverse ways of demonstrating expertise; (4) from

relying on knowledge in the head to leveraging distributed intelligence; (5) from covering a standard curriculum to building capacity to deal with explosion of knowledge, and (6) from learning by absorption to learning by doing. Consequently, these changes challenge some basic assumptions and predominant practices in education: (1) rather than learning specific skills and disciplinary knowledge, we should be focusing on learning generic skills and learning how to learn; (2) learning is no longer confined within schools, but learners learn in multiple venues, traversing formal and informal learning; (3) rather than testing students on their learning outcomes, technologies can be leveraged to provide evidence to demonstrate mastery in skills or knowledge; and (4) rather than using didactic teaching such as lecturing, teaching and learning should emphasize interactions among learners and with instructors, often mediated with technologies. While Collins and Halverson (2009) relate the changes in a broad stroke, we examine one specific shift in technology – from Web 1.0 to Web 2.0 – that brings new affordances[1] for learning, and at the same time, demands new ways of learning.

Changing technologies – new affordances and new ways for learning

The development of the Internet (the network of networks) in the 1980s transformed the ways and speed for communication and sharing of information. The advent of the World Wide Web further enabled the architecture for interlinked hypertext documents to be easily accessed via the Internet. In the new millennium, we witness yet another radical change in the technologies, the advent of the Web 2.0. While there are numerous technological, structural, and social differences between Web 1.0 and Web 2.0 (Cormode & Krishnamurthy, 2008), the key difference lies in the democratization of content creation in Web 2.0. One of the distinct features of Web 2.0 technologies is the facilitative features that allow participants to easily create and share contents. The identity of participant is extended from merely a consumer of content to a producer of content, so much so that the term "prosumer" was created to refer to this new identity.

Lim, So and Tan (2010), however, warned that unless the perspective of learning is changed, the affordances of Web 2.0 technologies may not be leveraged for more effective learning. They reported a case where some tertiary students used a divide-and-conquer strategy when composing a wikis assignment rather than co-constructing a document through productive meaning making. In other words, the students engaged in the old paradigm of elearning using Web 2.0 technologies. Lim, So, and Tan elaborated on the differences between elearning 1.0 and elearning 2.0. From a technological perspective, elearning 2.0 is an open structure where membership is far more open than a closed structure in elearning 1.0 (*e.g.*, a learning management system where membership is pre-determined). Due to this open structure, socially, Web 2.0 allows learners to access resources and interact with others in the social world and subject their ideas to scrutiny by a potentially large audience. Most

[1] A property of an object, or an environment, which allows an individual to perform an action. (see Gibson, 1977)

critically, elearning 2.0 entails an epistemology of learning through participation, rather than learning through possession. A learner adopts the identity of a content creator, learning to talk and engage in social practices of a community, rather than engaging in a uni-directional acquisition of the canonical knowledge "out there". Lim, So and Tan's view echoes the fundamental shift in the perspectives of learning.

Changing perspectives of learning – from knowledge acquisition to knowledge creation

Changes in theories of learning have been associated with how psychologists study the learning phenomenon, which saw the emergence of a few major paradigms of learning: behaviorism, cognitivism, and constructivism (Ertmer & Newby, 1993). In essence, behaviorism focuses on getting a learner to exhibit a specific response to a stimulus (for example, providing a correct answer when asked a question). Cognitivism focuses on information processing, helping a learner to organize and relate new information to existing information. Constructivism emphasizes the active role of learners in meaning making and in constructing their knowledge; it differs from cognitivism in its ontological view that direct mapping of external reality into the minds of learners is not possible. While there is objective reality, constructivism views learning as learner's unique interpretation of their experience.

Changes in perspectives of learning were reframed and extended by Sfard (1998) who differentiated learning paradigms using metaphors. She suggested viewing learning as acquisition versus learning as participation. In essence, the acquisition metaphor has the ontological assumption that knowledge is an entity and learning is gaining this entity. Consequently, this perspective of learning is directed in the individual's enrichment, and it cuts across the behaviorist ways of transfer of knowledge, cognitivist ways of processing information, and constructivist ways of re-construction of knowledge. Participation metaphor, on the other hand, does not regard knowledge as an entity, but emphasizes "knowing" as a way of becoming a member of a community. This processual view of learning highlights social interactions as a necessary part of learning that entail social practices and discourse as ways to become a member of a community. This metaphor echoes the situated learning perspective by Lave and Wenger (1991), who regard learning as participation in socially situated practices and the negotiation of meanings, giving rise to the transformation of participants' identities and practices.

Building on the two metaphors of learning, Paavola and Hakkarainen (2005) suggested a third metaphor: learning as knowledge creation. Recasting this discussion from another perspective, Paavola and Hakkarainen (2005) suggested that the acquisition metaphor is "monological" because learning takes place within the human mind; the participation metaphor is "dialogical" as it entails dialogic interaction with social others. They suggested knowledge creation as the third metaphor of learning, which is "trialogical" in that developing shared objects and artifacts while generating new ideas or innovative practices is a necessary process; these knowledge artifacts mediate the dialogic

interactions among participants. This knowledge-creation metaphor bridges the acquisition and participation metaphors: the creation of knowledge artifacts makes visible the development of conceptual knowledge, yet it takes into account the creation of social structures and collaborative processes that support the advancement of knowledge and innovation.

Making sense of changes – technologies for knowledge creation

Succinctly stated, technologies play a critical role in the genesis of a knowledge-based economy, which creates new demands for education in the 21st century. At the same time, technologies are also changing education, enabling new ways and culture of learning. Concomitantly, there are changing perspectives about what constitutes effective learning, from learning as acquiring knowledge to learning as creation of knowledge. This change in perspectives of learning is also facilitated by new technologies, such as Web 2.0 technologies. The confluence of all these changes suggest that in the 21st century, beyond equipping students with digital literacy and ICT skills, higher education could leverage technologies to engage students in knowledge creation.

This view is mirrored in a recent UNESCO report (Kozma, 2011), in which a conceptual framework was suggested for formulating policies to enable educational change and reform. Four progressive trajectories are proposed (pp.22-23): a basic education approach to equip workforce and citizenry with basic skills to participate in formal economy; a knowledge acquisition approach to enhance the workforce and citizenry's ability to use technology; a knowledge deepening approach to increase the workforce and citizenry's ability to solve complex real-world problem; and the knowledge creation approach to enable the workforce and citizenry's ability to innovate and create cultural artifacts. Policy makers are advised to develop ICT policies to empower their citizenry in moving up the "knowledge ladder", the pinnacle of which is knowledge creation capacity. But how exactly could we use ICT for knowledge creation in higher education?

Engaging higher education students in knowledge creation

In this section, two case examples from reported studies are used to illustrate what knowledge creation with ICT looks like and how it can be implemented in higher education.

Engaging teacher participants as knowledge builders

In the first case example, Case A, Tan (2010) reported how he engaged teacher participants in a graduate-level course in knowledge creation. His approach is based on the knowledge building approach (Scardamalia & Bereiter, 2006) that uses Knowledge Forum, a computer-supported collaborative learning (CSCL) technology, to mediate knowledge creation practices of learners.

In Tan's class, the key focus was on understanding knowledge building pedagogies supported by technologies. The key pedagogical approach was to engage the participants in a knowledge building community to understand about knowledge building. It was a course that spanned 13 weeks where the instructor and participants interacted in both face-to-face meetings and through an online forum. There were three major phases in this course: the *initiation* phase for participants to explore the "what's" of knowledge building to form a mental imagery of what it might look like in a classroom; a *meaning-making* phase during which the participants discussed the theoretical underpinning and the principles for designing knowledge building environments; and the *consolidation* phase where the participants work towards a consequential task of redesigning their lessons using knowledge building pedagogy, which is a real and authentic challenge that the teachers faced.

The knowledge building environment of Tan's (2010) lessons has a few key characteristics. First, creating and improving knowledge artifacts form the main core activity throughout the course. For example, the participants were asked to read about the principles of knowledge building and create notes in an online forum to represent their understanding of the principles. They could then read and respond to their peer's notes to clarify the meaning of the principles. The discussion was progressively deepened to explore different instructional tactics that could help to achieve the principles; how the principles in working would be manifested in students' behaviors; and how technologies could facilitate the process. Through collaborative meaning making, this activity produced the knowledge artifact of a Google document that tabulated the various principles; their meaning of the principles; the instructional tactics; and the related assessment approach. In summary, through this process, the ideas of the participants were made accessible in the online forum, subject to queries and discussion, and consequently better ideas were formed collectively.

Second, there was a deliberate attempt to engage the participants in knowledge building practices, which include (1) engagement in knowledge building discourse, and (2) the constructive use of authoritative sources of knowledge. Knowledge building discourse was fostered through the use of scaffolds in the online forum, which were a set of sentence openers the participants could use to construct their notes. Examples of these sentence openers include "My theory is"; "I need to understand"; "A better theory is"; and "A different opinion". Knowledge building discourse was reinforced in the face-to-face meeting where the instructor modeled and facilitated productive "building on" discourse, rather than confrontational talks or simple agreement without proper justification of claims. Just like many other graduate courses, discussion of academic publications was a common activity in this course. However, these publications were regarded as authoritative sources of knowledge, which were discussed in service of the ultimate goal of developing deeper understanding of knowledge building pedagogy.

Finally, throughout the 13 weeks, the instructor was committed to developing a classroom culture which encouraged (1) the participants to assume collective cognitive responsibility in helping one another in learning and improving their knowledge artifacts, and (2) the participants in assuming

epistemic agency or ownership in their learning. This entailed the instructors' deliberate attempt to appeal to "rational authority" rather than "institutional authority", that is, to always justify claims based on theories or research studies, rather than using the authority of an instructor. In addition, other instructional tactics were used, for example, the participants contributed to reciprocal teaching by presenting and teaching their peers on topics they have expertise in.

Student-podcasting for knowledge building

In Case B, Lee, McCoughlin, and Chan (2007) reported the knowledge building effort of eight undergraduate students who volunteered as student-producers to create podcasts for their peers. These student-producers created podcasts on topics related to information technology, for their peers who were studying the unit Information Superhighway and other related units. The topics, decided by the producer teams, could be relevant to the course content (*e.g.*, Human Computer Interface) or could be topics that the team felt useful to their audience (*e.g.*, what happened in the first lesson).

The podcasting production involved four phases (Lee, McCoughlin & Chan, 2007, pp.506-507): (1) script writing and editing; (2) presentation; (3) audio-recording and editing; and (4) publishing and distribution. The team leveraged each member's expertise and worked collaboratively to complete the production. In the presentation, for example, members could take on different roles and developed their own "persona"; while rehearsals were conducted, the members allowed certain degree of impromptu variation and improvisation.

Similar to Tan's studies (2010), the theoretical underpinnings for this project include the knowledge building pedagogy (Scardamalia & Bereiter, 2006) and the knowledge creation metaphor of learning (Paavola & Hakkarainen, 2005). Lee, McCoughlin, and Chan (2007) found that within the producer team, the members demonstrated high degree of self-directedness in searching for resources for writing scripts. The members engaged in knowledge building discourse, generating ideas and improving one another's ideas and they displayed collective cognitive responsibility in generating their podcasts.

There is a slight difference in the roles of technologies. In Tan's studies (2010), the learners created the knowledge artifacts (notes) in the online forum and they built on one another's ideas through the forum and via face-to-face interactions. The forum recorded and tracked the changes in ideas embedded in these knowledge artifacts. In the study by Lee, McCoughlin and Chan (2007), the podcasts represented the final knowledge artifacts of the students, but the trajectory of idea improvement was not captured and the knowledge building process happened only through the face-to-face interactions.

Comparisons of the learning scenarios and cases

Table 1 compares the two cases of learning through knowledge creation with the two scenarios discussed earlier in the paper. This comparison illustrates how different perspectives of learning could have an impact on various aspects of learning processes and outcomes, and the roles of instructors, students, and technologies.

Bearing in mind the demand of the knowledge-based economy in the 21st century, to assess the values of each approach of learning, we could focus on comparison of the roles and identity of students. In each of the two scenarios and the two cases, the students are engaged in different ways, cognitively and socially. In Scenario A, students are likely to be engaged in cognitive processing of information, and will memorize the content and demonstrate their understanding through tests or examinations. In addition to cognitive engagement, social interactions with peers and instructors are featured more prominently in Scenario B and the other two cases. In Scenario B, the social interactions are designed and directed by the instructor. For the two knowledge creation cases, the students produced knowledge artifacts through collaborative discussion. In Case A, the students continue to improve their knowledge artifacts through face-to-face and online discussion. In Case B, the students engaged in idea improvement face-to-face, before producing the final knowledge artifacts (podcasts).

Table 1. Comparisons of the various scenarios and cases of technology-mediated learning in higher education

	Scenario A LMS	**Scenario B MOOC**	**Case A Knowledge Forum**	**Case B Podcasting**
Perspective of learning	Learning as acquisition	Learning as participation	Learning as knowledge creation	Learning as knowledge creation
Learning approach	Transmission of knowledge	Meaning making	Creation and improvement of knowledge artifacts	Creation of knowledge artifacts
Roles of instructors	Source of expert knowledge and instructor	Source of expert knowledge, instructor, and facilitator of meaning making	Source of expert knowledge, instructor, facilitator of knowledge creation	Facilitator of knowledge creation
Roles of students	Receive knowledge, retain knowledge in the memory	Receive knowledge, make meaning through discussion, retain knowledge in the memory	Make meaning from various sources of knowledge, create knowledge artifacts to represent understanding and collaboratively improve ideas in the knowledge artifacts	Make meaning from various sources of knowledge, create knowledge artifacts to represent understanding and collaboratively improve ideas in the knowledge artifacts
Identity of students	Learners	Learners	Learners, knowledge creator	Learners, Knowledge creator, advisor to other students
Roles of technologies	Repository for resources, Platform for communication and discussion	Repository for resources, Platform for communication and discussion	Support creation, improvement and tracking of knowledge artifacts, platform for communication and discussion	Support creation of knowledge artifacts

In Case A and Case B, there is an intentional attempt to engage the students in social collaboration and in producing knowledge artifacts. There is also a strong feature of fostering students' epistemic agency (Damşa, Kirschner, Andriessen, Erkens, & Sins, 2010), which refers to the students' ownership and self-directedness in learning and capacity to engage in knowledge work. In both cases, as a productive member in a team, the nature of the students' work is collaborative and intentionally directed at advancing understanding by improving knowledge artifacts. The students need to know how to engage in progressive discourse, involving reasoning and reflections, so as to improve their collective knowledge artifacts on a topic. Cognitively, the process of ideation and idea improvement entail the ability to synthesis information from various sources, which is also a central feature of design thinking (Cross, 2007). In other words, the students are representing abstract concepts through knowledge artifacts and continue to improve them, which are also vital processes for construction of new knowledge (Brown, 2009).

As we assess the learning processes of the scenarios and cases, it seems that in Case A and B (and to some extent, Scenario B), the instructors have created learning environments that help the students develop skills, knowledge and disposition that could meet the demands of the knowledge-based economy. It is not the case that Scenario A will not produce students of inventive and innovative capacity, but there is a lack of an intentional design of the learning environments to develop students' competencies and disposition of the 21st Century.

Concluding remarks

Many institutes of higher education have invested in ICT infrastructure and equipment with the belief that ICT could revolutionize higher education. It is pertinent to ask whether such investment could change the teaching and learning processes and outcomes in higher education. We need to be mindful of potential challenges that could impede such effort, such as alignment of competing policies, culture and practices. This paper explicates the issues of epistemological and ontological beliefs of learning, and the corresponding design of ICT in supporting teaching and learning. We advocate the use of ICT to support knowledge creation, which entails creation of knowledge artifacts and discursive practices that aim at continual improvement of these artifacts. Such practices, we suggest, would help develop in students the innovative disposition and epistemic agency to explore new perspectives, propose new ideas and experiment with their ideas. It is a more promising approach that could help prepare students of higher education to meet the demand of the knowledge-based economy.

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