Research on Education in the Knowledge Creation Paradigm

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2006) recommend inclusion of 21st Century skills in school curriculum. There are also calls to revolutionize education in response to the opportunities and challenges from the rapid advancement in technologies (Collins & Halverson, 2009) and the new culture of learning (Thomas & Brown, 2011). Collectively, the calls for change in education seek to better prepare learners for living, working, and learning in a knowledge society.

The “knowledge society” is characterized by the transformation of information into resources that benefit society. Peter Drucker, one of the most influential and far-sighted thinkers in management, introduced the concept of “knowledge worker” in a book published in the sixties (Drucker, 1969). A knowledge worker has a vital role to play in transforming information and creating knowledge in a knowledge society. In such a society, knowledge, rather than physical resources, is regarded as a more important asset for the health and wealth of an economy. Drucker’s conception of a knowledge worker and the related notion of a knowledge society are closer to realization with the arrival of tools that enhance individuals’ ability to “work” with information and knowledge to benefit society.

The Internet technologies, coupled with mobile devices, immensely enhance communication among people and facilitate sharing of information. The recent proliferation of Web 2.0 tools further breaks the provider-consumer divide and allows us to capitalize on collective intelligences and distributed expertise.

While technologies facilitate sharing of and access to information and data, it is the effective use of information and data that could result in productive actions. This highlights the importance of knowledge workers who could adaptively apply information in a new context to innovate and create new ideas or products. It is for this reason that skills like communication, information and communications technology (ICT) literacy, information and media literacy, and critical thinking are commonly listed as 21st Century skills (Anderson, 2008). That said, however, there are new challenges in the knowledge societies (UNESCO, 2005): hegemony of techno-scientific knowledge, suppression of local and indigenous knowledge, digital divide, digital immigrant–native divide, and excessive commoditization of knowledge.

UNESCO takes a more integrative, pluralistic, and developmental perspective on knowledge societies. Knowledge is not only for economic growth, but also for empowering and developing all sectors of a society. A knowledge society is also a learning society, which has a culture of innovation and continual renewal and is characterized by learning through multiple modes and means, learning to learn, recognition of multiple intelligences, and lifelong learning for all.

In response to these calls for changes in education, Singapore, a small Asian country that relies mainly on its human resources for economic survival and growth, has also embarked on her journey in experimenting with knowledge creation pedagogy in the new millennium. To further coordinate our effort in this aspect, the Knowledge Creation and Innovative Design Centre was set up in June 2013 at the National Institute of Education (Singapore). Before we discuss the agenda of this Centre, we first provide an account of the historical development of this line of research in Singapore, which documents our effort in sustaining and scaling the pedagogy in the past decade.

In this article, knowledge creation is used as the inclusive term to refer to all practices that aim at creating new knowledge products, whereas knowledge building refers to the specific pedagogical approach pioneered by Scardamalia and Bereiter (2006).

**Introducing Knowledge Creation Pedagogy to Singaporean Classrooms**

The introduction of knowledge building pedagogy to Singaporean K–12 classrooms could be traced to the beginning of the 21st Century. The initial introduction of the pedagogy into schools in Singapore took place with researchers leading pedagogic and curriculum innovation in schools. Tan (first author) started a trial with three schools between the years 2001 to 2004. Two of the schools dropped out after one semester because of technical issues and lack of students’ motivation to continue. A modest success was achieved in the third school, where the researcher co-taught a science inquiry class and an after-school enrichment program for selected students. Focusing on developing science inquiry skills among the Seventh Grade students, the students were found to perform better in some aspects of scientific inquiry skills and in achievement test scores (Tan, Hung, & So, 2005).

Coinciding with the establishment of the learning sciences research lab at NIE in 2005, more researchers joined the effort in integrating knowledge building pedagogy into Singaporean schools. This phase of intervention was characterized by a collaborative effort between researchers and school teachers to co-design lessons and improve the lesson implementation through iterative cycles.

The work to introduce a knowledge building pedagogy during this phase happened roughly between 2005 and 2009 at two research sites (see Ow & Bielaczyc, 2008; Tan & Seah, 2011; Yeo & Tan, 2011), one working with Fourth Grade students and another with 11th Grade students. We saw more significant changes in schools and more substantial evidence of students’ progress during this phase of intervention.

Since 2010, our approach to introduce knowledge building pedagogy in schools focuses on engaging teachers from different schools in a knowledge creation
community. Coordinated by researchers from the Ministry of Education and NIE, teachers from five different schools participate in school-based professional learning teams (PLT). Each week, about four to six teachers meet to discuss implementation of knowledge building pedagogy in their respective schools and to spread the practice to more departments within the schools. Each PLT is led by a teacher who has more experience in the knowledge building pedagogy. Monthly, leaders (and sometimes teachers) from each school meet with the researchers to share their experience and to discuss issues. Special events are also organized for the teachers to advance their professional practice. For example, a study trip to Hong Kong schools was organized, and a one-week workshop facilitated by Marlene Scardamalia and Carl Bereiter was conducted.

Incidentally, tracing this historical development could be a worthy research study on sustaining and scaling knowledge creation practices. Our initial approach could be characterized as the dissemination approach (Rogers, 2005), where the researcher champions the innovation, with school teachers acting mainly as recipients. The mid-term approach could be regarded as the collaborative learning approach (Tenkasi & Mohrman, 1995), where teachers and researchers work collaboratively to design and implement lessons. The latest approach, incidentally, leans toward a situative knowledge building community through which the teachers not only take up the main responsibility of enacting effective pedagogical practices in their classrooms, but also assume the agency of spreading the practices to other classrooms and schools. This piques our interest in widening the scope of research on education in the knowledge creation paradigm, for example, in developing teachers’ epistemic agency in creating professional knowledge. In the next section, we discuss a few potential areas of research that could be explored.

**Potential Areas of Research**

Currently, there exist a few major perspectives of knowledge creation that are different along several dimensions, including contexts of knowledge work, experiences of participants, epistemic tools used by the participants, and goal orientation towards knowledge outcomes. Each of these differences could be examined to explain the variation in practices and outcomes. For example, Knorr-Cetina (1999) studied the epistemic cultures of different scientific communities, where creation of knowledge new to the world is their key mission. Nonaka and Takeuchi (1995) examined knowledge creation in commercial organizations (e.g., Honda) where innovation and new ideas are critical to the survival of the organizations. From the lens of cultural-historical activity theory, Engeström and Sannino (2010) uncovered the mechanism of expansive learning as workers, in ordinary work settings, attempted to resolve the tensions that arose from the contradictions within or between their activity systems. Scardamalia and Bereiter (2006) have been working on knowledge building pedagogy that aims to develop knowledge creation capacity in students to prepare them for knowledge societies.

While a fair amount of research work has been conducted, there are still some apparent research gaps on knowledge creation in education. First, there is still resistance to the notion that K–12 students could engage in knowledge creation, even though research studies have shown that students could engage productively in idea improvement (Scardamalia & Bereiter, 2006). It is important to study ways to sustain and scale up knowledge building practices in schools. Second, beyond formal learning, do people engage in knowledge creation in informal learning environments? For example, in an online community of interest (e.g., interest group on photography), is there a place for knowledge creation? If so, what is the mechanism? Third, in the sector of continuing education, where workers engage in professional development or are reskilled for other jobs, is there a place for knowledge creation?

Within a learning organization, we could also examine knowledge creation of different groups of participants and how they work as a system. In a school, for example, we have school principals, administrators, teachers, and students. While knowledge building pedagogy could be introduced in a classroom, what about the teachers’ capacity to conduct the lessons? More critically, could teachers also assume epistemic agency in creating professional knowledge about teaching? While there are advocates for schools to be knowledge creation organizations (e.g., Hargreaves, 1999), and models have been proposed for research and development (Harris, 2008) and for a teachers’ community (Tan 2010), research reports in this area are still lacking. Extending the study on knowledge creation to different groups of participants in a learning organization, we could also take a systemic view to examine the organizational conditions and strategies that facilitate or encourage knowledge creation within an organization. This requires a systemic view of the relationships among many variables—for example, leadership, policy, infrastructure, teacher’s actions, teacher’s capacity, and student’s learning processes.

Within a classroom environment, we could expand the epistemic repertoire of knowledge creation. For example, besides a dedicated technological platform like the Knowledge Forum, could we leverage various Web 2.0 tools as different modes of knowledge representation? An elementary pupil, for example, could use VoiceThread to talk about his ideas instead of
using text to compose a note. Expanding the epistemic repertoire could also mean engaging students in different ways of thinking. For example, the topic of electricity could be discussed from the perspectives of a physicist, a chemist, a historian, or an environmentalist.

In addition, current research has been focusing on the cognitive outcomes and social interaction processes of knowledge creation, and we could explore other aspects of impact, for example, the ontological transformation of students' identities towards a knowledge builder. There exist some anecdotal accounts of students who began to realize their capacity in knowledge building and to see themselves as legitimate participants in knowledge building works (Scardamalia & Bereiter, 2006). This identity transformation could be a critical success factor in communities where participants' readiness and intentionality for knowledge creation are low. Other aspects of impact that have not received much attention include the emotional factors and outcomes related to knowledge creation pedagogy. A review by Sutton and Wheatley (2003) reported the potential influences of teachers' emotions that could affect teachers' cognitions, motivation, and their impact on students. Likewise, students' emotions and outcomes of their learning could be important areas of concern. Currently, a few knowledge building principles (Scardamalia, 2002) could be linked to emotional factors and outcomes, for example, epistemic agency of the learners, collective cognitive responsibilities, and democratizing knowledge building practices. Research that specifically uses the lens of emotion to study these factors is relatively silent.

We recognize that education in the knowledge creation paradigm offers vast research opportunities and, given the imperatives of the knowledge societies, such research would have potentially great impact on our societies. We believe that an alliance could be formed with researchers and educational professionals who share similar interest (e.g., Institute for Knowledge Innovation and Technology, www.ikit.org) to advance research in this field. At a local level, the Knowledge Creation and Innovative Design Centre is extending research on two fronts: (1) promote design thinking and develop epistemic repertoires among teachers and students in schools, and (2) advance knowledge creation practices with teachers.

**Developing Epistemic Repertoire Among Students with Technologies**

Paavola, Lipponen, and Hakkarainen (2004) proposed a new metaphor of learning—learning as knowledge creation—by reviewing three prominent knowledge creation models that include the knowledge spiral (Nonaka & Takeuchi, 1995), expansive learning (Engeström, 1999), and the knowledge building community (Bereiter & Scardamalia, 2006). Building on the metaphor of knowledge creation, we see value in the ideas about "the designerly ways of knowing" (Cross, 2007) associated with the knowledge creating work that takes place in the field of design and technology. These ideas suggest an epistemic turn for pedagogy that prepares learners for participation in a knowledge society. To develop epistemic repertoire for knowledge creation, we propose an approach for developing in learners a gamut of ways of knowing that they could use to make sense of the problems they are investigating or the phenomenon that they encounter.

This approach has a few characteristics. First, we leverage experiences of the learners to generate inquiry questions that demand explanation. It could be what the learners encounter through their daily experience (e.g., how does a light bulb work?) or an intentional learning experience (e.g., a demonstration, a field trip). Second, we require learners to create knowledge artifacts or epistemic artifacts as an important part of learning. The artifacts could be as simple as a note in an online forum, a drawing, or even a voice message (e.g., in VoiceThread). It is essential that these epistemic artifacts contain ideas to represent understanding of the phenomenon under investigation. We view the students’ initial ideas as a display of their epistemological resources (Hammer & Elby, 2002) or knowledge elements (e.g., p-prim theory by diSessa, 1993) that are activated with the learning activities. Third, we recognize the dialectical relationship between individuals and group in the process of knowledge creation. As individuals contribute to the group, reciprocally, they benefit from collective intelligence. We hope to capture knowledge creation through group interaction processes, as well as to track development in an individual's changes. Fourth, to develop epistemic repertoire in learners, besides the use of multiple modes of knowledge representation, we also plan to introduce the approach to a range of subjects and topics in the school. The same topic (e.g., electricity) could be approached from different discipline perspectives (e.g., chemistry, physics, and social sciences) either concurrently or at different points in a school curriculum. Finally, although traditional forms of technologies (e.g., paper and pencil) could support the learning process, we prefer digital technologies because they could support multiple modes of knowledge representation (e.g., an online note, a voice message, a concept map), facilitate sharing and communication, allow access across time and locations, and record a trajectory of idea development. More importantly, we envision future development of learning analytics that could provide real-time data to teachers and learners as formative feedback to improve the learning processes. Using digital technologies also enables us to track the learners’ patterns of resource activation.
Our approach is founded on the belief that emerging problems and phenomena in the current world originate from all aspects of our lives, and they are better addressed through multiple ways of knowing. These ways of knowing, which may also be associated with discipline-specific or inter-disciplinary approaches of knowledge creation, could offer different perspectives and solutions to the problems. Building epistemic repertoire among learners enhances their adaptive ability to adopt multiple perspectives to the same phenomenon. In addition, we believe that an epistemic repertoire is more effectively built through collaborative knowledge creation, that is, working on improving ideas supported by a range of technologies that function as cognitive, metacognitive, and epistemological tools.

**Advancing Knowledge Creation Practices with Teachers**

Despite our experience and effort in bringing knowledge building pedagogy into classrooms, we still face challenges in introducing this pedagogy to schools and teachers who are new to this pedagogy. There are several possible reasons for the high inertia towards acceptance of this pedagogy. First, the design and implementation of knowledge building is different from the predominant modes of instruction that are highly structured and predictable. For example, 5E inquiry science (Bybee et al., 2006) suggests five phases of instruction, whereas knowledge building requires principle-based design that teachers are less familiar with. Second, the manifestation of students’ learning outcomes in discourse (e.g., improvement in ideas) compared with measurements using tests is again something teachers are less comfortable with. Third, there is a commonly held belief that knowledge production work is for the high-ability students and that the constraint of curriculum time does not allow such practices. In addition, the integration of technologies to support knowledge creation work could aggravate apprehension of some teachers who are less inclined towards the use of technologies in education. In other words, designing and implementing knowledge building demands not only changes in instructional practices, but also epistemological beliefs about students’ learning.

Ironically, the factors that have impeded educators to implement knowledge creation practices are precisely the factors that will help a business organization to thrive (Nonaka & Takeuchi, 1995). Two key characteristics of flourishing business models are (i) the intangibles as the source of progress and inspiration of creativity, and (ii) innovative ideas as the true force behind productivity improvement.

Borrowing these business concepts, and drawing the parallel between knowledge building practice as one that mimics the fluidity of the real economy, we have initiated a research study that aims to investigate knowledge building practices, with dual foci. First, we aim to identify the source of intellectual productivity in a knowledge building environment. That is, among the many ideas that students generate in the initial phase of knowledge building, how do teachers identify promising ideas to advance and provide relevant scaffolds to the students. Second, what design principles and strategies do teachers employ to engender a knowledge building environment?

We leverage the expertise of a group of teachers experienced in knowledge building to tackle the complex problem within the real classroom setting. These teachers work as designers to iteratively improve their lesson design. In this process, newcomers sit in on the discussion as apprentices. As a newcomer is ready to try the pedagogy, the support structure is ready to support the iterative improvement in lesson design and implementation. With the researchers, lead teachers from different schools form a community of practice to discuss practices across different school contexts and subjects. The teachers assume the epistemic agency in improving their professional practices and creating professional knowledge; they also act as agents to influence other teachers. On the other hand, the researchers study the discourse of the teachers to develop a profile that characterizes the specificity of knowledge building practices and to identify factors and sources of knowledge that could be introduced to more teachers for better adoption. This teacher community, incidentally, also leverages technologies to record their idea generation and track the development of ideas. In other words, parallel to the students’ knowledge building effort, we are developing a knowledge creation community among the teachers to advance knowledge building practices in schools.

Our approach is also a departure from the predominant methods of advancing teachers’ epistemic agency. Commonalities with other methods of teacher professional development, for example, the lesson study approach, are apparent. Our approach hence shares similar strengths of fostering a sense of community and the creation of meaningful artifacts to the community. Consistent with our beliefs in the importance of developing the epistemic repertoire of learners to enable knowledge creation, our approach builds on the strengths of existing models of professional development by developing teachers’ adaptive expertise (Hatano & Inagaki, 1986) and capacity to create knowledge.

**Concluding Remarks**

The arrival of the knowledge society disrupts the entire education ecology, including K–12 education,
higher education, adult education, and workplace learning. Educators and researchers are convinced of the need to prepare learners to be productive citizens in knowledge societies, and many initiatives have been launched worldwide. In this exciting time, although a fair amount of research has been initiated, research on education in the knowledge creation paradigm is still in its infancy stage.

In Singapore, despite a decade-long journey to bring knowledge building pedagogy into K–12 classrooms, sustaining and scaling these pedagogical practices are still a challenge. In addition, we see the potential to expand this line of research in different contexts and at different levels in an organization. The establishment of the Knowledge Creation and Innovative Design Centre at the National Institute of Education (Singapore) represents only a small step taken by a small group of researchers towards achieving our goals. We hope our community will grow in strength locally, and create alliances with larger international communities.

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