Critical Aspects in Learning *with* Technologies

Ching Sing Chai, Nanyang Technological University, chingsing.chai@nie.edu.sg
Choon Lang Quek, Nanyang Technological University, choonlang.quek@nie.edu.sg
Chwee Beng Lee, University of Western Sydney, chwee.lee@uws.edu.au
Huang-Yao Hong, National Chengchi University, Taiwan, hyhong@nccu.edu.tw
Joyce Koh Hwee Ling, Nanyang Technological University, joyce.koh@nie.edu.sg
Naomi Miyake, University of Tokyo, nmiyake@p.u-tokyo.ac.jp
Peter Reimann, University of Sydney, peter.reimann@sydney.edu.au

Abstract: In this symposium, we present a comprehensive overview on the unique position of technologies in the context of learning sciences. According to Jonassen, Howland, Marra and Crismond (2008), learning with technology necessitates the designs of learning and the learning environments in order to engage learners. The overarching purpose of this symposium is to bring forth a comprehensive discussion on the critical aspects of learning with technologies which are fast becoming an integrated part of learning. To accomplish our purpose, the presenters will (a) *provide* an overview of the context of learning by discussing the importance of technological pedagogical content knowledge and socio-cultural issues, (b) *examine* issues related to the designs of learning, this includes scaffolding learning and intentional knowing, (c) *discuss* one of the most important outcomes of learning, which is conceptual change. In our symposium, our presenter will also discuss the roles of technologies in fostering conceptual change.

Introduction

Technologies are pervasively used in education. But are we using it for productive thinking and meaning making? What are the critical aspects to consider when we intend to integrate technologies into meaningful learning? Have we made progress in designing for learning *with* technology rather than merely from technology? With these questions in mind and relating to the emphasis of the powerful role that technologies play in transforming learning (Sawyer, 2006), we seek to assess the position of technologies in the context of learning sciences. According to Jonassen, Howland, Marra and Crismond (2008), when learning with technologies, it necessarily consists of the designs and the environments that engage learners. Most importantly, technologies should function as intellectual partners where the cognitive responsibility is distributed to the partner that performs it better.

The overarching purpose of this symposium is to bring forth a comprehensive discussion on the critical aspects in learning with technologies. To accomplish our purpose, the presenters will (a) *provide* an overview of the context of learning by discussing the importance of technological pedagogical content knowledge and socio-cultural issues. Learning scientists argue that deep learning is most likely to occur in complex social and technological environments (Sawyer, 2006) and this is supported by Koehler and Mishra (2009) while previously Mishra and Koehler (2006) who also argue that good teaching requires knowledge of content, pedagogy, and technology. Understanding the situative perspective (Greeno, 2006) of learning is critical as this helps researchers and educators to understand the complexity nature of learning for better design of learning environments, (b) *examine* issues related to the designs of learning, this includes intentional knowing. One of the main concerns of learning sciences is to provide powerful learning environments that foster deep learning (Sawyer, 2006). Our symposium will also examine the importance of intentional knowing in relation to the use of technologies for learning, (c) *discuss* one of the most important outcomes of learning, which is conceptual change. According to Vosniadou (2008), perhaps one of the biggest breakthroughs in the learning sciences was the examination of conceptual change. In our symposium, our presenter will also discuss the multiple roles of technologies in fostering conceptual change.

Our discussion begins with *Ching Sing Chai, Huang-Yao Hong, Joyce Koh Hwee Leng* giving the general perspectives of technological pedagogical content knowledge and design thinking. Next, *Naomi Miyake* will address socio-cultural issues such as collaborative learning and the contexts of learning. She will discuss urgent needs for researchers pay more attention to these "harder to observe" collaborative processes. *Chwee Beng Lee* and *Choon Lang Quek* will discuss the components of intentional knowing and its role. Lastly, Peter Reimann will focus on the pivotal roles of technologies in the context of conceptual change research.

Technological pedagogical content knowledge and design thinking

Ching Sing Chai, Nanyang Technological University

Email: chingsing.chai@nie.edu.sg

Huang-Yao Hong, National Chengchi University, Taiwan
Email: hyhong@nccu.edu.tw

Joyce Koh Hwee Ling, Nanyang Technological University
Email: joyce.koh@nie.edu.sg

The advancement of networked technology and the development of myriad e-learning platforms and social networks have provided ample opportunities where ideas, insights, experiences, and knowledge can be articulated, shared, co-constructed and distributed (Chai & Lim, 2011). These ideas, insights, experiences, and knowledge can be referred to as conceptual artifacts or world 3 objects (Bereiter, 2002; Popper, 1978). Once publicized through networked technologies or traditional media, these cognitive objects become improvable ideas. They are subjected to examination, critique, refinement, elaboration, re-contextualization etc. Bereiter and Scardamalia (2006) argue that ability of an individual to participate and contribute to a community effort in improving the ideas is the key competency that citizens of the Knowledge Age must possess. Many educators have also advocated shifting the focus of education from reproductive transmission to that of creative construction (Collins & Halverson, 2010; Paavola, Lipponen, & Hakkarainen, 2004). In this paper, building on Bereiter and Scardmalia's (2006) proposal of building students' "ability to work collaboratively with conceptual artefacts in design mode" (p. 702), we propose that teachers need to develop and create the corresponding technological, pedagogical and content (TPACK) knowledge (Mishra & Koehler, 2006) through continuous design thinking. We also argue that nurturing design epistemology is the key task that educators should focus on, beginning from the teachers and cascading down towards the students, especially when supported by the affordances of collaborative learning platforms. In other words, we argue in this paper that teachers need to become knowledge creators who generate the know-how in using collaborative technologies to help students to co-construct knowledge. This involves teachers' capacity in providing the epistemic framing (Elby & Hammer, 2010) for classroom learning, scaffolding students' collaborative sense making processes and building students' epistemic repertoire before, during and after their learning episodes.

The learning of a monitor: How much and why

Naomi Miyake, University of Tokyo
Email: nmiyake@p.u-tokyo.ac.jp

One intriguing outcome of socially well-organized collaborative learning is the students who sat silent during the group work still come out with high performance at the end. In this presentation, I will showcase three examples of this "learning of a monitor," give some theoretical framework to understand how this could happen, and then propose promising use of technology to promote this kind of learning.

I will take examples of the learning from "the Hypothesis-Experiment Instruction," (Itakura, 1997, henceforth HEI), "the Knowledge Constructive Jigsaw," (Miyake, 2010, henceforth KCJ), and "Manabi-no-Kyodotai (Comminity for Learning, Japan, led by Manabu Sato, henceforth MK). They differ in their basic curriculum designs, but all support strongly the learners' discussions either in whole class (HEI), in small groups with member change (KCJ), or four-member groupings (MK). Careful analyses of the students' learning processes and the associate learning outcomes often reveal that the students who mainly monitored during the class did show substantial learning toward the end of class. Theoretically this could be the case, as suggested by studies on two-person, understanding and problem solving process such as trying to find an answer to how a sewing machine makes its stitches (Miyake, 1986), because in her analyses, the monitor, who took the role of listening and integrate what the other member, the task-doer, tried to explain to her/his own understanding, did progress her/his part of understanding almost independently from the task-doer's. It was not rare in her other analyses that the monitors played the critical role to bring the pair to find a hidden course to solve the problem, mainly because they were pursuing some different course from the task-doers. If this theoretical framework should work at classrooms where more than two people engage in the groups simultaneously, we should be able to identify cases where those students who mainly stay silent should also learn, as well as those who actively participate in the group work. For the HEI, I will take a case where 21 third graders discussed to predict forthcoming results of experiments, to build a first stage understanding about the air as substance, (i.e., to understand and become able to explain why the air does not share the same space with water), based on Saito's analyses (Saito & Miyake, 2010). She analyzed the frequency and the order of class utterances of all of the students, and found that the frequency of talk differed greatly, but all of them could predict the result of the last experiment correctly. In addition, all of them could write after the class the reason for their choice in scientifically acceptable forms. The KCJ is a jigsaw class, with a carefully designed "class question" to be answered only by integrating different pieces of information contributed by different expert groups into the jigsaw. For the KCJ, I will report three cases which all showed that those relatively silent students could write what they learned during the class as well as those who had been active during the class. The MK uses group work more flexibly yet the recommended form of grouping is four, so that when a teacher asks the class to solve a problem with expected answer rate of 50%, there is some assurance that often two of the members could explain how and why of the solution. In MK also, there has been observed that the students who had been identified as "not fit" for the subject of the class sometimes gives a critical utterance to lead the whole class to clear understanding. After showcasing these examples, I will develop a model for this type of "learning of monitor" based on my constructive interaction framework.

To conclude my presentation, I would like to discuss urgent needs for us to collect and study the learning processes in more detail during both those experimental and regular classes, so that we could pay more attention to these "harder to observe" processes. I will illustrate how technology could help us do this more extensively, with more ease, so that not only researchers like us but teachers could participate in this endeavour to understand how people learn, and how we could support the learning.

The role of intentional knowing in learning with technology

Chwee Beng Lee, University of Western Sydney, School of Education
Email: chwee.lee@uws.edu.au

Choon Lang Quek, Nanyang Technological University
Email: choonlang.quek@nie.edu.sg

Berieter and Scadamalia (1989) highlighted that learners are not only active in their construction of meaning, but they can be intentional. They are intentional because they are fulfilling their goals that in turn determine their human behaviour. This would also mean that they are cognitively engaged in the learning process, monitoring and regulating their learning (Sinatra & Pintrinch, 2003). To learn intentionally, students must consciously understand and be able to define their strengths and weaknesses, their learning processes, how they examine the way they execute learning tasks, monitor learning, evaluate learning and whether they innovate in order to learn intentionally. Berieter and Scadamalia (1989) used the term intentional learning to refer to cognitive processes that have learning as a goal rather than an incidental outcome. It is an "achievement, not an automatic consequence of human intelligence." (pp. 366). As put forth by Scadamalia and Berieter (2002), intentional cognition is more than self-regulated learning; it is the active pursuit of a mental life whereas self-regulated learning is usually a set of study skills and learning-to-learn strategies. They mentioned that there is a need for metaknowledge to foster intentional learning. Such an understanding is very much aligned with Efklides's (2008) metatheoretical model in which at the personal-awareness level, there are conscientious efforts in monitoring and controlling processes. Bereiter and Scadamalia (1989) defined it as knowledge about knowledge, access to one's own knowledge, and skills, which take the knowledge as an object to operate on.

From a constructivist standpoint, learners are aware of the central role of ideas in the development of knowledge and how ideas are revised through a process of conjecture, argument, and test (Smith, Maclin, Houghton, & Hennessey, 2000). This type of processing is not a mere response to the external circumstances or environment. In a sense, "intentional level processing is not only initiated by the learners, it is under the learner's conscious control" (Sinatra & Pintrich, 2003, pp. 4). On the other hand, if a learner is not intentional, the learning process is determined largely by the external factors such as prior knowledge, types of tasks, facilitating conditions, etc.

In this section of the symposium, we will introduce the term intentional knowing through the lens of metacognition and we argue that it is a critical element to propel intentional learning. We have conducted several empirical studies to re-conceptualize metacogntion and a six-factor model was found to explain intentional knowing. Next, we argue that intentional knowing plays a pivotal role in learning with technology. This stance aligns with what most learning scientists would advocate, and that is the emphasis of technology in fostering deep learning, for instance, helping learners to collaborate meaningfully or to reflect on their understanding (Sawyer, 2006). Using technology to represent knowledge, articulate thinking, manipulate and revise conceptual understanding and to reflect upon knowledge and learning process are effortful and goal-oriented activities for the learners. Such activities necessarily require intentional knowing which is the conscious knowing of one's capacity and learning process, the knowing of how one examines his or her own monitoring, evaluation and execution processes, in addition, how he or she innovates to cope with the demand of tasks. Intentional learners not only cognitively engage in the learning process, but also regulate their learning. For instance, Vosniadou and Kollias (2003) reported that when using Knowledge Forum for science learning, students were able to collaborate effectively and question their own conceptual framework. From the pedagogical perspective, in order to develop learners who have the intentionality to learn, we suggest that educators not only create learning opportunities to cognitively challenge the students, but also embed meaningful tasks and activities in technology-rich environments to them to apply thinking skills and take stock of their own strengths and weakness in the learning process.

In this section of our symposium, we discuss the components and importance of intentional knowing in using technology for learning through our recent empirical study (N=2404). In this study that was conducted with high school students, we developed a statistical model to explain the intricate relationships between intentional learning and intention to use technology.

The multiple roles of technology for learning: Lessons learned from conceptual change research

Peter Reimann, University of Sydney, Faculty of Education and Social Work
Email: peter.reimann@sydney.edu.au

Research on conceptual change is an interesting case for studying various conceptualizations of the role educational technology can play for learning. While the notion of technology as a tool to learn *with* has probably found its strongest expression in math education, science educators have seen the role of technology more conservative: more to learn *from* than to learn with. At the same time, research on science education particularly concerned with conceptual change has been strongly influenced by Vygotskian notions of symbolic and social mediation. Scientific concepts and theories are cultural resources provided through (school, university, adult) education. Vygotsky made a crucial distinction between experiences produced by the immediate contact of the individual with the environment, and experiences mediated by symbolic tools, with writing as the major class of symbolic mediators (Kozulin, 2003). With respect to science education, unmediated contact gives rise to empirical learning, leading to the acquisition of spontaneous conceptions (of which some will be misconceptions), whereas the second, mediated form of contact affords theoretical learning, resulting more often in scientific conceptions (Karpov, 2003). In effect, for the case of theoretical learning, this does away with the dualism between process and content: How humans learn is largely dependent on the kind of concepts they master in the course of learning. In a profound sense, human learning is all about “learning to learn”. Process and content are thus two sides of the same coin.

While a socio-cultural perspective allows us to overcome some of the problems inherent in the process-content dualism, it is committed to the mind-environment dualism (with environment comprising the social as well as the natural). Due to the commitment to *internalization*, problem solving and thinking are achieved in the mind, by operations on a *represented* environment. In socio-cultural theory, the focus on the symbolic nature of tools goes along with a focus on internalization: Those tools are ‘out there’, and provided to us through education, but in order to use them we have to gain command over them by making them part of our cognitive repertoire. Cognition is seen as rooted in the mind/brain, 'between our ears'. However, for a number of reasons, not the least the rapid growth of mobile devices, the question of what needs to be learned *from* tools versus what we can accomplish *with* tools (Salomon, 1990) needs to be revisited. This requires us to make a less strong distinction between mind and environment. Jonassen’s (1996) for instance, identified the role that widely available computational tools, such as spreadsheet software, can play as “mindtools”.

Despite its success, and the publication of a second edition (Jonassen, 2000), it is probably fair to say that the central idea has not been fully taken up. What we find today in (science) education is the acceptance of computers as ‘productivity tools’, which are good for creating artifacts such as essays and graphs and models. Learning, however, is still seen as resulting from these activities only in the form of ‘cognitive residues’, as changes in long-term memory. What is true for education in general also holds for the perceived value of ICT for conceptual change: the predominant question asked is: How does technology x contribute to fostering change? And the place we look for the answer is in the learner’s head, typically in a setting where the use of the technology is not allowed.

To fully unravel the potential of computers, this view needs to be widened; the vision articulated in Jonassen (1996) needs to be revitalized. This should not be so hard, given that the socio-cultural perspective widely accepted by educators provides us with an appropriate conceptual framework: Learning scientific concepts means learning to make use of cultural tools, of the concepts and methods that science has developed and continuous to develop. If we are willing to entertain the idea that the distinction between psychological and technical instruments (Vygotsky, 1930/1981) is getting increasingly blurred, then the notion of learning as extending to changes in the use of external tools—not confined to changes to long term memory—should be a rather natural one. For instance, the notion of learning *by* modeling has evolved from a notion of learning *from* models (Reimann & Thompson, 2009), but to play out the full potential we need to move on to the notion of knowledge creation/problem solving/decision making *with* modeling. When the formal learning ends, tool use does *not* necessarily end. For example, students today can continue to carry their Netlogo software (Tisue & Wilenski, 2004) with them – on their laptop, hopefully soon also on their smartphone or tablet device. Indeed, further learning (including communal and societal learning) requires the continuous use and further development of such tools. In order for such a (realistic) view of technology to take hold in schools, what is required are changes in the manner we assess learning.

A still largely underconceptualized and underused potential of technology lies in its role for enhancing perception (Young, 2004). The main value of ICT may be that it provides ways to 'see things differently' by providing conceptual tools, and to make those tools available persistently and ubiquitously. The best use of ICT maybe *augmentation*--scaffolding without the fading. Computer tools for augmenting 'reality' can enhance perception in addition to thinking and problem solving.

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