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| Abstract | This chapter discusses one of the research perspectives of the Learning Sciences and Technologies academic group in the National Institute of Education (Singapore). Premised on social constructivists' view of learning, we explore design for learner agency and voice by adopting design experiment approach to study knowledge building and distributing the power of design decisions to the learners. We illustrate our efforts with vignettes of two of our research studies: one that demonstrates the importance of students' agency in knowledge construction and another that incorporates the diverse voices of stakeholders, including students, in developing a game for learning Earth system science. |





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| Keywords (separated by '-') | Agency - Learner voice - Knowledge construction |

# Learning with Technology: Learner Voice and Agency

**Seng-Chee Tan, Beaumie Kim, and Jennifer Yeo**

**Abstract** This chapter discusses one of the research perspectives of the Learning Sciences and Technologies academic group in the National Institute of Education (Singapore). Premised on social constructivists' view of learning, we explore design for learner agency and voice by adopting design experiment approach to study knowledge building and distributing the power of design decisions to the learners. We illustrate our efforts with vignettes of two of our research studies: one that demonstrates the importance of students' agency in knowledge construction and another that incorporates the diverse voices of stakeholders, including students, in developing a game for learning Earth system science.

**Keywords** Agency · Learner voice · Knowledge construction

## Introduction

The field of instructional design and technology (IDT) is facing challenges posed by several forces – advent of knowledge-based economy, rapid development in technologies, and growing interest in the competing field of learning sciences. We are living in the Knowledge Age, a time when knowledge is regarded as the key asset for socioeconomic development of a country. The economic well-being of a

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country is now dependent on workers who possess in-depth understanding of a field of knowledge, who can search for relevant information, interpret, and critically analyze information and design innovative applications. In short, new economies need *knowledge workers* more than productive factory workers. The traditional mindset of IDT that focuses on training workers for efficiency and productivity has to be transformed to approaches that develop knowledge-building capacity among the workers.

Technologically, we are living in the Digital Age, where digital technologies have stealthily seeped into every aspect of our lives, making their ubiquitous presence in many objects surrounding us. We have witnessed how Internet has significantly multiplied the speed at which information can be communicated and, most critically, affords a platform where collective intelligence ~~and~~ of the worldwide  community can be leveraged for rapid development of new ideas. Building on the Internet, we are now experiencing another wave of technological revolution, the Web 2.0 technologies, which challenge the reader–author relationship and spawn the development of new literacies. These networking technologies and user-generated contents are also hugely influencing the game industry, where online games and user-created virtual worlds are at its center. The use of technologies to *teach* has to be changed to the use of technologies to *learn* or *create with.*

Concomitantly, learning sciences as a field of study is gaining momentum. It brings together a synergy of expertise in cognitive science, educational psychology, computer science, and even instructional design to focus more on basic theory and research on learning. Learning sciences, as a field of study, aims to study the cognitive and social processes for learning and uses our understanding on learning to design more effective learning environments and to develop prototypes and tools for learning. Thus, rather than designing instructions, the focus is on researching and refining theories and practices of learning.

In the context of these changes, the Instructional Sciences academic group in the National Institute of Education, Singapore, has repositioned itself and was renamed to Learning Sciences and Technologies academic group (http://eduweb.nie.edu.sg/LST/home/default.asp). In this transition stage, we take an inclusive view that embraces pluralism in ideology and theoretical base. For instance, we offer Master of Arts in Instructional Design and Technology, as well as Master of Education (Learning Sciences and Technologies); our researchers conduct studies in the areas of new literacies, mathematics and problem solving, and knowledge building (http://www.lsl.nie.edu.sg/). Given the longer history of instructional science, we assume that the readers are familiar with research and practices in this discipline. In this chapter, we discuss the learning sciences perspective among our local research community, in particular one that focuses on empowering learners by giving them voice and agency for learning and design.

## Learning with Technology

We believe in learning and creating with technology, as opposed to teaching with or through technology. The differences have been clearly explained by proponents of using technologies as cognitive tools (Jonassen & Reeves, 1996) and Mindtools (Jonassen, 2006). In essence, rather than using computers to replace tutors in giving instructions, computers are used as "intellectual partners to enable and facilitate critical thinking and higher order learning" (Jonassen & Reeves, 1996, p. 694). Unlike computer-based tutorial programs or intelligent tutoring system, the information or content knowledge are not hard-coded in the program and presented to the learners. The computers facilitate meaning making and knowledge constructions by and among the learners. For example, an asynchronous online discussion forum allows a group of learners to discuss an issue or debate about a topic; an online role-playing game requires players to dynamically form groups in order to play a role (e.g., making sure team members are in good health) and acquire skills that help them progress in the game. With proper scaffolding, the learners can be engaged in higher-order thinking processes: make meaning about what they have read, put forth their ideas, discuss their positions, apply what they have learnt to solve a problem, and many other cognitive processes.

## *Development in Technologies*

The idea of using technologies as Mindtools revolutionizes learning using existing technologies. Many software used as Mindtools are initially developed as productivity tools that facilitate our works, for example, word processors. Thus, Mindtools is a learning technology that helps educators to look at existing computer programs (e.g., word-processing software and spreadsheet) from a different perspective. For educational applications, terms like "open tools" (Lim, 2009) are used to describe these tools. They are *open* because unlike tutorial programs, their epistemic values lie in the scaffolds/constraints they provide for/impose on learners to engage in critical thinking, rather than hard-coded content knowledge to be communicated to the learners.

In recent years, a new wave of technology development, collectively known as social software, has created new opportunities on the ways learning can be supported. Social software includes a wide range of social tools like discussion boards, messaging, web blogs (e.g., www.blogger.com), social book-marking tools (e.g., www. blinklist.com), wikis (e.g., en.wikipedia.org), and others. These tools capitalize on the collective intelligences and dynamics of a wide community connected through the Internet, beyond the physical boundaries. Initially, they are used for social purposes, for example, sharing of music, pictures, and opinions. It has become increasingly apparent that these technologies begin to challenge the traditional notion of literacies and literacy practices, giving rise to *new literacies*. Beyond reading and writing, new literacies include "socially recognized ways of generating, communicating and negotiating meaningful content through the medium of encoded texts within contexts of participating in Discourse" (Lankshear & Knobel, 2006, p. 64). Thus, participating in online forums or multi-user games, publishing personal blogs, and writing in wikis can be examples of new literacies. It requires the technical skills to participate in these activities, as well as a change in mindset

(Lankshear & Knobel, 2006, 2007), especially in the participants' agency. The participants have greater control in participating (e.g., as a participant in an online forum or game rather than a reader of a website), but at the same time, need to have awareness of the social codes and norms to participate in these activities.

An important development in social software is multi-user immersive virtual environments. These environments use rich 3D graphics to create a virtual space where participants can interact with each other, usually through informal communication styles, and experience a sense of being in a virtual world, in the company of other people (Bartle, 2004). According to Gee (2003), participating in video games is also a form of new literacy where the learners "situate meaning in a multimodal space through embodied experiences to solve problems and reflect on the intricacies of the design of imagined worlds and the design of both real and imagined social relationships in the modern world" (p. 48).

## *Social Constructivist View of Learning*

Underpinning learning with technology is the ontological and epistemological view of social constructivism, one that treats reality as constructed by individual's mind rather than the mind as a reflection of the objective reality, and learning involves active and agentive participation among learners who engage in collaborative knowing through social interactions. The constructivist views of learning, though a relatively recent development in the field of IDT, have received growing interest among many researchers and catalyzed the convergence between the discipline of learning sciences and instructional design. They partly explain the coexistence of "traditional" IDT and learning sciences programs in many universities (e.g., Indiana University, Pennsylvania State University, and Nanyang Technological University).

Building on constructivist views of learning, Lipponen, Hakkarainen, and Paavola (2004) further differentiated between the participatory approach and the knowledge creation approach of learning. The participatory approach of learning is epitomized in learning through apprenticeship in a community of practice. For example, in medical field, a novice pre-registration doctor is enculturated into the practice of medicine by first participating from the periphery as an intern, shadowing licensed medical doctors to learn the culture and practices of being a doctor. It takes many years for a foundation house officer to become a registrar and eventually a consultant, through formal examinations and years of embodied experience. Thus, learning is premised on situation cognition and the notion of identity creation, often in the context of a real-life community. However, this approach of learning seems to focus more on preserving the cultural capital of a community rather than being innovative. To address this concern, the knowledge creation approach advocates collaborative knowledge building, with the constant goal of improving cultural artifacts and collective knowledge. This approach of learning is exemplified in a scientist community where scientists constantly discuss and explore new ideas and build on existing body of knowledge to create new theories.

Extending this to K-12 setting, Scardamalia and Bereiter (2006) proposed the knowledge-building pedagogy. Knowledge building aims to develop students' disposition and skills in knowledge work in a learning community that consists of a cohesive group of learners with a culture and practice of collaboration and collective advancement of understanding (Bielaczyc & Collins, 1999). One of the central principles of knowledge building is collective idea improvement, which happens when individuals put forth their ideas in a public space (e.g., an online forum) to be discussed and critiqued with the goal of improving these ideas. The students need to be engaged in knowledge-building talk, a discourse that focuses on epistemic reflection on assumptions, evidence, and premises that support the ideas. Knowledge building sounds like a daunting task for the K-12 students, but it is important to note that we are not demanding the students to report new discoveries or propose new theories like scientists do, neither are we engaging the students in nonproductive discussion that seems to "reinvent the AQ2 wheels." The goal is ~~to~~ not only put students in the trajectory of development of knowledge works but develop their dispositions, attitudes, and skills in knowledge building.

## *Learner Voice and Agency*

Several conditions need to be present for knowledge building to happen, among them, students need to possess the epistemic agency for knowledge building. The word *agency* connotes motivation and ownership. That means the students see it as their responsibility to discuss and improve their ideas or to come up with solutions to a problem. There is an element of self-directed learning – students initiate personally challenging inquiry and ~~developing~~ personal knowledge and skills to pursue the challenges (Gibbons, 2002). In addition, the students must possess the *epistemic* capacity to engage in knowledge building; in other words, the cognitive abilities to think and talk about knowledge work like asking relevant questions, communicating and putting forth personal ideas, seeking ~~for~~ relevant answers, and critically discussing ideas related to the object of inquiry. In short, a student with epistemic agency takes on the responsibility to engage in inquiry works, looks for information, makes meaning of the information, and uses appropriate criteria to assess the validity of an idea to the inquiry. Lest we are misunderstood for interpreting knowledge building as a personal pursuit of knowing, it is important to emphasize that knowledge building occurs in a learning community, where there is a reciprocal relationship between self-directed learning and collaborative learning: students assume both personal and collective cognitive responsibility to advance both personal and collective understanding of a topic.

Similarly, many learners are accustomed to speak through the voice of authority (i.e., textbooks and teachers) rather than through their personal beliefs and ideas in our school context. Bakhtin (1981) terms such discourses as *authoritative discourse* and *internally persuasive discourse*. As designers and researchers, we also often see learners as having empty vessels to be filled in with a flux of knowledge. However, learners' daily literacy practices outside of classrooms could influence their beliefs and ideas about the world. In the classroom context, both students and teachers assume that the authoritative voices from the textbook and traditional ways of interacting in the classrooms (i.e., quietly engaged in reading and listening) are what good students should foreground. In designing learning technologies, we should engage learner voices about what personal beliefs and ideas they have about the world, what excites them, and what kind of experience they have outside of classroom.

The notion of students' agency and voice possess great challenges to the instructional designers. What then are the roles of the instructors? Many ID models that build on the foundation of ADDIE approach (analysis, design, develop, implement, evaluate) will break down because they are premised on the assumption that a body of knowledge can be analyzed into parts (whole to parts) and presented to the learners sequentially so that the learners can construct the knowledge (parts to whole). There are, however, very few instructional design models that advise on constructivist learning, one of which is Jonassen's (1999) model that focuses on designing constructivist learning environments rather than prescribing instructions. In a constructivist learning environment, we present the learners with authentic problems and support the learners with related cases, information resources, and collaboration tools. The instructor supports the learners by modelling, coaching, and scaffolding. Researchers in learning sciences, on the other hand, suggest conducting design experiments that emphasize reciprocal relationship between theory-based design and analysis of practice in the learning environment. For example, a researcher works with a teacher to design a learning environment based on existing theories of learning; the analysis of the implementation of this learning environment provides empirical evidence of the process and outcomes of learning, which inform the next cycle of intervention. Through iterative research cycles, we refine both the theoretical models of learning premised on empirical evidence and the actual educational practices.

Another emerging development is the breaking of artificial barrier between experts and learners in learning designs. Designers have started to involve learners in the design process in order to reflect their voices in the design in various ways, namely, user-centered design, participatory design, and informant design approaches (Facer & Williamson, 2004). User-centered design views learners as testers for designs to assess whether their needs are met (Norman & Draper, 1986), whereas participatory design considers them as partners throughout the design process by assigning them more responsible roles (Druin, 1999). Informant design, on the other hand, combined these two approaches to involve informants (e.g., learners and teachers) in various roles in different stages. For example, learners may be asked to observe and evaluate existing designs and prototypes, and then become testers when the technology is ready (Scaife, Rogers, Aldrich, & Davies, 1997). The most challenging work for the researchers in this approach is to make sure that we hear "learner" voices without imposing our own views.

In the next section, we provide two short descriptions of our research effort: one is part of a design research that demonstrates the importance of students' agency in knowledge construction; another incorporates the diverse voices of stakeholders, including students, in developing a game for learning Earth system science.

## Vignette 1: Students' Agency for Knowledge Creation

One design research undertaken by a team of learning scientists from Learning Sciences Lab in National Institute of Education was the design of pedagogical supports for enabling inquiry learning through a learning community approach. This is a collaborative project conducted with a group of science teachers from a local high school to refine a Problem-based Learning (PBL) model~~, called THINK cycle,~~ they had developed to foster deep science learning. The ~~THINK cycle~~ is a five-stage collaborative learning process whereby students, presented with a (T)rigger problem, will (H)arness information by identifying and exploring learning issues, followed by carrying out tests to (I)nvestigate their hypothesis, and concluding the learning activity by presenting what they (K)now through a group report or presentation. In this learning environment, the teacher acts as a metacognitive coach.

One of the challenges in conducting a constructivist learning environment is supporting students' agency. For effective learning in a constructivist learning environment such as PBL, students need to work collaboratively with one another by keeping themselves up to date with the group's goals, knowledge, action, and status; engaging in sharing, questioning, negotiation, explanation, and reflection of ideas; and producing both cognitive and physical artifacts as evidence of their collaborative efforts (Dillenbourg, 1999). This is a challenge for both teachers and students in managing time, space, and cognitive processes. One of the ways this project supports collaborative learning is through a computer-supported collaborative learning (CSCL) system, Knowledge Constructor, which is an online discussion tool that represents discussion threads in a graphical form. A screenshot of Knowledge Constructor environment of one of the forum discussions is shown in Fig. 1.

Knowledge Constructor provides an easily accessible common space for registered students to share and negotiate ideas. The database of ideas and interaction on the asynchronous system provides a permanent record of individual and group deliberation over the problem, thus allowing ideas to be read and built on anywhere and anytime. The graphical representation of student's ideas, with links showing how each idea is built upon, displays the interconnectedness of multiple viewpoints. Exposing individual responses to ideas allows them to be scrutinized by others and helps to trigger cognitive activity around the ideas. However, technology alone may not be sufficient to support students' agency, as will be demonstrated by case example 1 below. Instead cognitive scaffolds, as will be illustrated in case example 2, are equally crucial to support students' agency.

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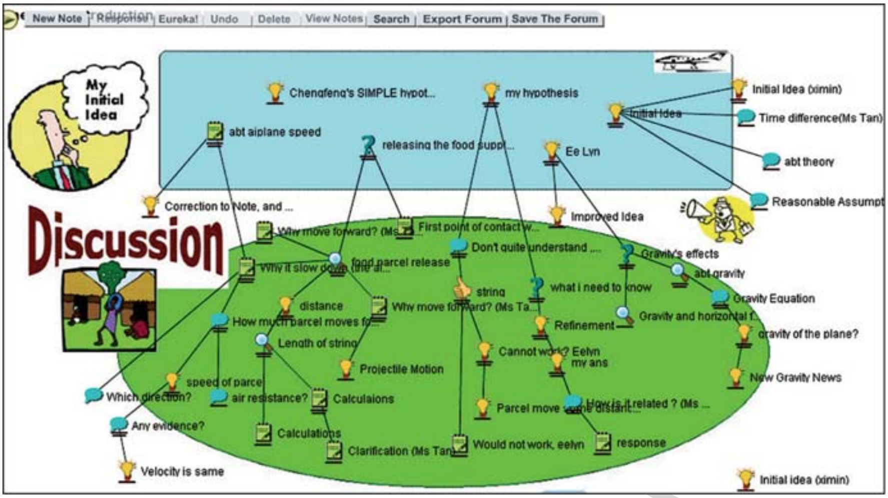



**Fig. 1** Screenshot of knowledge constructor environment

## *Case Example 1*

Case example 1 illustrates a group of five 14-year-old students solving a physics problem based on the topic of two-dimension kinematics. They were tasked to find out the length of a string needed to drop a parcel onto a pre-designated area from a remote-controlled car running on tracks placed above a table. In line with the PBL approach, students were to identify and explore learning issues and propose solutions to solve the problem with the newly constructed knowledge. However, ~~observation showed~~ little motivation from the students to discuss learning issues identified. For example, learning issues raised by individual students such as "does gravity affect velocity of the package as it falls to the ground" were dismissed by other group members to be irrelevant without any convincing justification. Similar questions that sought to understand the effect of "flying forward of the parcel (being) a factor in the experiment" and the effect of "velocity of the dropping parcel (on) the displacement of where the parcel would hit" merely drew cursory responses (~~i.e.,~~ "yes") from other group members. ~~The~~ result of an absence of exploration and critical discussion of the learning issues raised ~~was~~ many missed opportunities to advance the group's understanding of two-dimension kinematics. Having to propose a solution to the given problem, two of the students sought the help of their older sibling or school seniors to provide scientifically consistent answers. However, they were unable to explain their solutions when questioned. Another proposed solution was obtained through trial-and-error. When asked about their apparent lack of agency in searching for information, constructing new understandings, and solving the problem, one student said that she often did not know what to search for since she had little idea what topic was relevant to the problem context. Thus it was difficult to participate meaningfully in the online discussion with the little knowledge they had. In other words, while technological supports such as CSCL system may be necessary for ideas to be recorded, displayed, and built upon, technology alone may not be a sufficient condition for knowledge creation. Without appropriate cognitive structures to signpost the content area relevant to the problem, it may be difficult for students to be engaged in any meaningful talk.

## *Case Example 2*

To address the design gaps described in case example 1, two key interventions were introduced to the next design cycle to assist students in identifying and exploring relevant learning issues. First, the problem task provided clear indication of the topic area associated to the problem. This was meant to direct students' attention to the relevant topic so that meaningful and relevant ideas might be shared and discussed among the students. Second, a knowledge-building process ~~precedes~~ problem solving. The knowledge-building process, which ~~engages~~ students in building shared knowledge among the group members, was meant to encourage students to construct their understanding of the problem context before applying the knowledge to solve the problem. The result of these interventions was an improved demonstration of students' agency.

Case example 2 shows a group of five high school students trying to find out the causes of a roller coaster accident. They were instructed by their teacher (1) to derive a mathematical expression to explain how the roller coaster ride worked by considering energy changes as the roller coaster cart moved down a slope and (2) to test their hypothesis for the reason why the roller coaster cart overshot its usual stopping distance. By directing students' attention to the "energy changes" in the roller coaster ride, students were able to identify and explore learning issues relevant to the problem right from the start of the THINK cycle. A question raised by one of the students about the effect of friction on the roller coaster cart drew many built-on notes from her team members, who enthusiastically posted information that they found on the Internet. They posted information about the effect of friction on energy changes, the work–energy theorem, and interpretation of the relationship among the different forms of energy associated with a roller coaster ride in a coherent manner. While some of these threads might seem shallow in cognitive processes since most information was taken directly off the Internet, there were other threads that demonstrated a high degree of critical thinking. The excerpt in Table 1, which shows students evaluating a piece of information taken from the Internet, is one example.

In note 21, student M questioned whether it was possible to "eliminate other factors like air resistance, friction" as shared by student J in note 17. This led student J to evaluate the two effects of the two forces on the roller coaster (i.e., "friction would affect the roller coaster more than the air resistance" in note 30), justifying that "the roller coaster has more contact with the track than the air" in note 37. Although this interpretation might seem somewhat inconsistent with the scientific view, this thread of discussion nonetheless showed students' engagement, critically

**Table 1** Excerpt of students discussing information obtained from the Internet

| Note | Author | Date/time | Content |
|---|---|---|---|
| 17 | J | 2006-07-26 10:11:51 | Once a roller coaster has reached its initial summit and begins its descent, the forces acting upon it are gravity, normal force and dissipative forces such as air resistance. . . . air resistance is able to do work upon cars, draining a small amount of energy from the total mechanical energy which the cars possess . . . Since the effect is small, it is often neglected. By neglecting the influence of air resistance, it can be said that the total mechanical energy of the train of cars is conserved during the ride. . . . Energy is neither gained nor lost, . . .. http://www.glenbrook.k12.il.us/gbssci/phys/mmedia/energy/ce.html |
| 21 | M | 2006-07-26 10:18:45 | Iff u eliminate other factors like air resistance, friction etc, the roller coaster will never stopp in the first place since energy is neither gain nor lost if, u concentrate on factors like mass, speed the result wil be completly different from the one which includes air resistance and friction |
| 30 | J | 2006-07-26 10:30:13 | Friction would affect the roller coaster more than the air resistance and cannot be negligent. friction would cause energy to be converted to heat energy and thus lesser energy would be available for kinetic energy, and distanced object moves is reduced |
| 34 | Ms Cho | 2006-07-26 10:35:57 | Why do you say that the effect of air resistance is less than friction? |
| 37 | J | 2006-07-26 10:39:15 | The air resistance is smaller than friction because the roller coaster has more contact with the track than the air. furthermore, there is gravity acting on the train, pulling it to the track which makes friction greater as gravity has to be overcome to create horizontal motion |

discussing the ideas related to the problem context. This was an improvement from the shallow responses to learning issues raised in case example 1. The result of this sharing of information and critical discussion of ideas was a mathematical expression that describes how the roller coaster cart worked. However, due to an error in assumption made about the effect of friction on the roller coaster ride, the students found that the empirical evidence they obtained from the model setup of the roller coaster was not consistent with their derived expression. This led student D to question, “what have we neglected in e process of driving e final equation?” Her question triggered another round of inquiry into the construction of the mathematical expression – a demonstration of students’ agency as they questioned the assumption made about the problem context, reexamined their interpretation of the work–energy theorem, refined the mathematical expression, and tested their refined expression against empirical evidences, all done without much prompting from the teacher. Eventually, they found that they had to take into account air resistance in this problem context as they wrote in their report that "Without adding in air resistance into external forces, the stopping distance is the same, so air resistance does affect the stopping distance, . . . ." The result of this design cycle was a significant advancement of the group's understanding of the work–energy theorem as the students had delved more deeply into the meaning of the theorem through repeated cycles of knowledge building and problem solving. One key attribute to the advancement of the group's knowledge was the motivation and ownership the students had in self-directing their learning process. High level of cognitive processes was also involved as students compared and evaluated different ideas they encountered about the problem context and eventually applied the ideas they had constructed to the problem.

In a nutshell, the two case examples show the importance of students' agency in knowledge creation. However, technology alone is not sufficient for supporting students' agency. Equally important are the cognitive and content scaffolds that provide students with a common direction in their learning process.

## Vignette 2: Design of Technologies and Learner Voice

The main thread cuts across the various projects in Learning Sciences and Technologies group, and Learning Sciences Lab is to work in partnership with the teachers and through observing how learners work with technologies for development and local adaptations. One such design approach is to incorporate the diverse voices of stakeholders in developing a game for learning Earth system science, named Voyage to the Age of Dinosaurs (VAD) (Kim, Miao, Chavez, & Shen, 2007). This game intents to provide an immersive experience by recreating and replaying portions of Earth's history using intelligent agent technology and a 3D multi-user game environment. The design process is largely dedicated to understanding and designing with learner voices by foregrounding learners' interests, opinions, and ideas about dinosaurs, earth dynamics, and games. This project attempts to address design problems of many artifacts and rules in educational games not fostering learning and many designers only talking to the users through the final product (Norman, 2004). The second author of the chapter is the principal investigator of the project, and we will briefly describe the past and future design workshops and how they are contributing to the design.

The research team is in the second year of collaboration with two secondary schools for the informant design process (e.g., Druin, 2002; Scaife et al., 1997). AQ4 One of the key intentions of the informant design workshops was to create tensions in which learners' role would shift from passive recipients of knowledge in the classroom to providers of ideas as the empowered and acknowledged experts in their own rights (Kim et al., 2009). The research team meets with teachers regularly without students to review the design workshop results and prototype development progress, and the teachers come back to the design workshop with their students (approximately 10 students from each school). We started the first workshop when the students were at the beginning of their Secondary 1 school year (Grade 7).

## *Workshop I: Learner Conceptions*

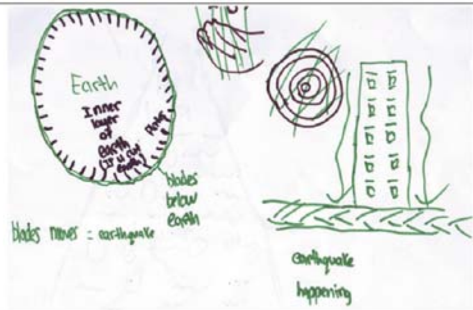
An after-school workshop was conducted in each school. Small groups of three to four students worked with a research team facilitator in order to elicit students' understandings of the targeted Earth systems science concepts and phenomena (Geography in Singapore; e.g., earth morphology, plate tectonics, volcanoes, earthquakes, and rock formation) and to understand students' processes of reasoning and explanations. The team developed a set of open-ended questions and asked them to explain individually using diagrams and writing. Gobert and Clement(1999) found that diagramming helped students understanding of both the spatial/static and causal/dynamic aspects of Earth's processes and, therefore, better represents their understanding.

Regardless of their exposure to formal lesson on these topics, students' depth of understanding and explanations were mostly shallow with few exceptions, and the level of vocabulary and scientific terms used varied quite a bit. Students wrote their responses individually or as a group (with text and diagrams) and discussed their ideas (see Table 2). In Table 2, drawing and the quote from one of the workshop I participants exemplifies how he was dependent on an authoritative voice (his mother) describing his ideas of earthquake, but at the same time, he, presumably, interpreted it in his own ways by hearing "plates" as "blades." The research team found that participants during the first workshop were generally more passive, looking for "credible" sources of information (i.e., recalling some facts or images and fitting their explanations to what they remembered from lessons, textbooks, television programs, popular books, magazines, etc.), and trying to find out whether or not their answers are acceptable to the facilitator.

## *Workshop II: Stories of Earth and Dinosaurs*

The second workshop was held over 2 days during school holidays in order to give students an opportunity to work together in groups of four (mixture of students from two schools), outside of school in a different environment, and to brainstorm and develop ideas about dinosaurs, fossils, and the prehistoric environment by beginning to draft stories about dinosaurs based on their interests and ideas. The same group of students from the first workshop was engaged in various activities: on the first day at the Singapore Science Centre they visited the Dinosaur Alive! Exhibit and watched an IMAX movie about dinosaur excavation; on the second day at the Singapore Botanic Garden and NIE's MxL Lab they visited the evolution garden, generated and presented their stories and scripts, created short movies from their scripts, and so forth.

Table 2. Design workshops and example artifacts

| Workshop | What it looked like | Artifact | Discourse |
|---|---|---|---|
| Workshop I: Learner conceptions |  |   | "My mother said that the blades move, then it shakes the ground which will start to crack." |
| Workshop II: Stories of earth and dinosaurs |  |   | "Later I cry then you start… Ok ready. Then you say 'eh, I found something leh.' Don't say you found a bone. Then you cry with me like that." |
| Workshop III: Dinosaur game Play and ideas |  |   | "They (dinosaurs) invent a, the time traveling machine from the past, go to the future." |

The common characteristic of their movies across different groups was "role-playing." They liked to play the role of paleontologists who find fossils of dinosaurs. One of the groups described, "Back in the laboratory situated in the city of Beijing. We, the group of paleontologists, took out the fossils we found for research." The climax of their stories tended to include dinosaurs fighting before their resulting death and burial. Dinosaurs' actions in these scenes usually reflect how they were depicted as fossils in previous scenes about fossil findings. Below is one example of such scenes:

> The Meilong gave a loud screech that frightened its prey so badly that it appears to have its leg rooted into the ground. As it ate its prey in satisfaction, a Dilong Paradoxus jumped in to snatch the Meilong's delicious lunch. Seeing its own food being snatched away, the Meilong decided to attack the Dilong Paradoxus.

Table 2 shows how students were making movies together with the props and backdrops provided by the research team. Students chose what dinosaurs they would like to feature in their movie (from early Cretaceous, China Liaoning province), wrote their scripts of present and past (paleontologist finding fossils as well as how the dinosaurs found in the fossils were interacting with each other in the past), and filmed their movies by acting out various emotions, Earth processes, and actions of dinosaurs and paleontologists. The figure inside of the example artifact is the screen capture of the movie made by one of the groups, called T-Rex. In that particular scene, two students were acting as paleontologists who finally found some fossils after a long search. The excerpt beside it is from the conversation during their filming, in which the group was detailing the interactions: they were crying while going back to their car without any finding, but stumbling onto something that turned out to be a fossil. This particular group started their script writing by imitating the movie and a short script example written in the script-writing template. However, they started to speak through what Bahktin (1981) called "internally persuasive discourse" as they tried to represent volcanic eruptions, paleontologists' excavations, and fossilization of the dinosaurs they featured. By observing how they are making meanings about actions, emotions, and cognitions of the whole movie script, the research team is able to capture ideas about how to distribute such emotions and cognitions within the 3D game environment.

## *Workshop III: Dinosaur Game Play and Ideas*

The third design workshop was held at one of the schools to elicit students' ideas on game design. The research team brought laptop computers with the prototype version 1 installed, video cameras, and blank flip charts for them to draw and write their ideas. Students initially played the prototype and discussed with their group members as to what are the things they would like to see in the next prototype. They basically wanted more complexity, challenge, and advanced weapons in the game that are more comparable to the commercial games. They were given chance to evaluate two existing commercial games featuring dinosaurs as characters and come up with their own "hottest" game in town. In Table 2, Workshop III, the group is discussing and putting the information on the project website and also writing their ideas on the sheet (on the table in the picture) to share with others. During the sharing session, students as well as researchers walk through each group's station to hear their ideas and provide feedback. Out of classroom context and content, students were voicing out their ideas without being concerned too much about what adults (i.e., teachers and researchers who were present in the workshop) thought about their ideas and were not looking for confirmations from them. They were more critical to each other: one student was giving feedback to the sharing group by saying, “hey, the game is supposed to be educational. You have too much killing going on!”

Overall, first-person shooter genre, multi-missions/quests, and various skills for characters were reflected in their “hottest” games. For example, in Table 2, quote for Workshop III, one of the teams personified the dinosaur characters, which are intelligent enough to develop a time machine and attack people in the future. They also discussed level system, punishment and reward system (e.g., money and experience points as reward), and various weapons (e.g., FireGun, IceGun, WindGun, FreezeGun, Rocket Launcher, Bombs, Big Nets, etc.).

### *Workshop IV and Beyond: Experiencing the Story and the Concept of the Game*

The research team is currently developing the next prototype and planning for the next design workshops. As the team is shaping up the game, the previous workshops on learners' conceptions, story ideas, and game ideas are constantly revisited. The subsequent design workshops will be focused on experiencing the story and the concepts in the game in the physical setting as well as in the game itself, so that learners, teachers, and members of the research team can think more deeply about what kind of interactions could enhance their game experience and learning within 3D virtual world. Figure 2 shows the tentative map for the trail within NIE where learners will have a simulated experience similar to the current game prototype.

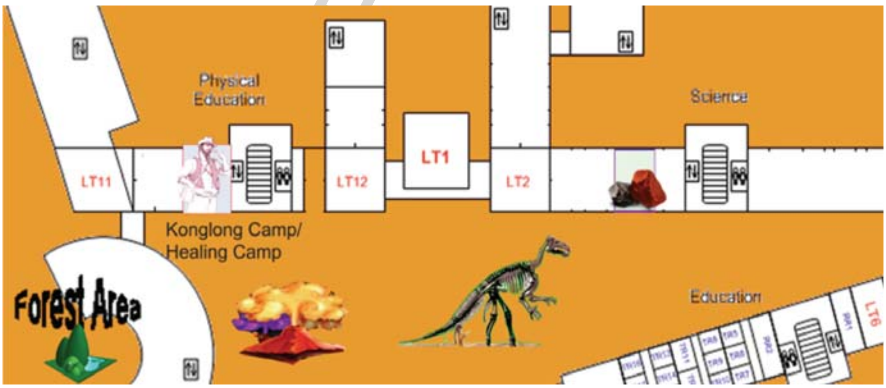



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**Fig. 2** Trail map for workshop IV

One of the trail stop is again for them to play the prototyped game and provide their ideas and feedback. The following design workshop (workshop V) is being planned to make a conceptually richer experience as to visiting actual place where learners can touch, see, and imagine the Earth processes, such as fossil site, rocky hills, dormant volcanic mountain, or hot springs.

## Conclusion

The above vignettes of our research effort feature one of the key characteristics of the nature of Learning Sciences research projects: working in partnership with students and teachers and through design experiments and observing how learners work with technologies for development and local adaptations.

In the past, misunderstanding about constructivist learning has led to futile effort by instructor designers, learners, and instructors. In some classrooms, we saw students bustling with activities, but when we analyzed the talks, there was not much meaning making and knowledge construction. We now take a holistic, multi-faceted approach that recognizes instructor's effort in designing and structuring the learning environments and also takes into consideration learners' agency and voice. The first vignette shows that even if a teacher were to relinquish power to the students, students may not readily take up ownership of their learning. Learner agency needs to be supported with technology and other resources for knowledge construction to occur. The second vignette shows our approach in involving students in learning design, thus creating conditions to encourage the students to shift from passive recipients of knowledge in the classroom to providers of ideas; in a way we are empowering them and signifying their contributions as partners of the design process. We begin to see evidence that such effort would lead to meaningful learning with technology, which gives us confidence to proceed with our approach.

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# Chapter 8

| Q. No. | Query |
|---|---|
| AQ1 | Please check the sentence “We have witnessed how Internet. . .” for clarity. |
| AQ2 | Please check the edit made to the sentence “The goal is to put. . .”. |
| AQ3 | Please provide better quality figure. |
| AQ4 | The usage of “tentions” is not clear in the sentence “One of the key intentions of the informant design workshops . . .” Please check. |