Making Knowledge Building Moves: Toward Cultivating Knowledge Building Communities in Classrooms

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Abstract: A major emphasis within the Learning Sciences has been to explore ways to create classroom cultures that mirror disciplinary cultures. The central focus of our own research has been on how teachers and students navigate the epistemological shift from traditional didactic classrooms to classrooms that function as *knowledge building communities* (Scardamalia, 2002; Scardamalia & Bereiter, 2006). We ground our inquiry in *Ideas First*, a design-based research program focused on creating a knowledge building community in science within a Singapore primary school (Bielaczyc & Ow, 2007; Ow & Bielaczyc, 2007, 2008). In Ideas First we view engagement in the disciplinary practices of science through the theoretical lens of *epistemic games* (Collins & Ferguson, 1993; Morrison & Collins, 1995). In order to support reflective discourse among teachers and students around epistemic game play, we have created a set of dialogic tools centered on specific types of knowledge building moves. We illustrate the design features of the tools and their role in fostering participation in knowledge building communities in science.

Education in the Knowledge Age calls for socializing students into the world of work with knowledge (Bereiter, 2002). A major emphasis within the Learning Sciences has been on investigating ways to create classroom cultures that mirror disciplinary cultures, thus socializing students into working with knowledge in ways consistent with disciplinary norms and practices (e.g., Gresalfi & Cobb, 2006; Herrenkohl, et. al., 1999; Songer, 2006). Such a framing is founded on theoretical perspectives emphasizing learning as a process of enculturation, with a focus on *learning to be* rather than simply *learning about* (Sawyer, 2006; Thomas & Brown, 2007).

In our own research, we have been interested in how teachers and students navigate the epistemological shift from traditional didactic classrooms to classrooms that function as *knowledge building communities* (Scardamalia, 2002; Scardamalia & Bereiter, 2006). For the past several years we have been engaged in a design-based research program in a Singapore primary school. *Ideas First* is a two-year science program co-designed with primary school teachers that has been operating in fifteen grade 3 and grade 4 classrooms since 2006 (Bielaczyc & Ow, 2007; Ow & Bielaczyc, 2007; 2008). The program is based on the vision of a knowledge building community where students work to advance the science understanding of the classroom community through engaging in collectively building knowledge in response to problems of understanding.

Knowledge building communities involve not only participating in knowledge building practices, but also engaging in reflective discourse on participation (Bielaczyc & Collins, 1999; 2006). Such meta-level discourse among participants is critical for agency, identity, and creativity within a dynamic community whose goal is to continually advance at the edges of the community's understanding. In Ideas First we have introduced several means of supporting reflective discourse. In the present paper we describe a particular set of tools meant to support inquiry into specific types of knowledge building moves among both teachers and students. We illustrate the design features of the tools and their role in fostering participation in knowledge building communities in science.

The Need for Dialogic Tools to Support Inquiry into Knowledge Building

Creating disciplinary cultures in classrooms is challenging because enculturation necessitates an immersive approach. If the classroom currently reflects a traditional didactic culture then change must occur along many dimensions of social and technological infrastructure (e.g., Bielaczyc, 2006; NRC, 2007). When the teachers are themselves new to such a culture, classroom change becomes even more challenging. In Ideas First we chose to work with teachers across all the grade 3 and 4 classes within the school in order to foster a community of teachers that could support each other locally, as well as connect to teachers and other educational stakeholders in the international knowledge building community[1]. In order to foster teachers' development as a knowledge building community and agents of change, as designers we wanted to create supports for critical, reflective discourse --- tools that provided both a lens for looking at the work of the knowledge building community and that helped participants develop a language for talking about it.

Like many designs, we have found that classroom videos provide a powerful means of reflection (e.g., Goldman, et. al., 2007). Further, *Knowledge Forum*, the online environment designed by Scardamalia and Bereiter to support knowledge building (Scardamalia, 2004), also provides a means of visualizing not only students' work with disciplinary content, but also processes of knowledge building. Knowledge Forum records

participants' work with ideas using the View feature, a public space where knowledge objects (multi-media content within the database that is represented via icons such as *Notes, Rise-Above's,* and *Build-On's*), their interconnections, and other organizational representations of the knowledge objects (e.g., timelines, maps) are visually displayed. The processes of knowledge building are thus captured in a visual form as the participants' work evolves.

However, while viewing rich visual spaces such as videos and Knowledge Forum where the work of the community occurs in all its "blooming, buzzing confusion" is important, we have found that it can be very difficult for teachers (and students) to "see" the critical events and features (refer to Frederiksen, et. al, 1998 for similar findings in teacher video clubs). Thus we wanted to complement the reflections on classroom videos and Knowledge Forum by creating a set of tools that focused on critical aspects of knowledge building. We thought that a powerful focal point for discussion would be "knowledge building moves," a way of conceiving possible actions to advance knowledge within a given problem space. Further, we wanted to create tools that could be used by *both* teachers and students to engage in inquiry about critical aspects of knowledge building. It should be noted that Knowledge Forum has a growing suite of tools (the Analytic Toolkit) that provide representations of knowledge building activities within the database, thus supporting rich, reflective discourse (Zhang, et. al., 2009). However, because computers are not readily accessible to students and teachers in their classrooms, we constrained our designs to mobile, physical artifacts that students and teachers could easily share.

As stated earlier, we felt that it was critical to work together with the community to develop not only a lens for seeing, but also a language for discussing new concepts. In the early years of the project, when we spoke with teachers about socializing students into working with ideas, it seemed that the notion of "working" was taken as some laborious set of tasks or indicative of routines or procedures. Hence, it became important to find ways to convey work with ideas in knowledge building communities as creative and playful. One useful framework for supporting discourse grounded in playfulness and creativity is *epistemic games* (Collins & Ferguson, 1993; Morrison & Collins, 1995). Using this framework, we have created a set of tools for engaging teachers and students in inquiry into knowledge building moves. We describe these tools in more detail below.

Knowledge Building Communities and Epistemic Game Play

In creating the theoretical lens of *epistemic games* (Collins & Ferguson, 1993; Morrison & Collins, 1995), Collins and his colleagues are concerned with characterizing the ways in which members of a community of practice work to construct knowledge. *Epistemic games* refer to strategic play with disciplinary knowledge and are based on the study of disciplinary communities such as Physical, Biological, and Social Scientists (e.g., the Cost-Benefit-Analysis Game, the Systems-Dynamics Game). The overall goal is to support learners in developing *epistemic fluency*, developing an understanding of the moves, constraints, and strategies for working with various forms of knowledge.

In Ideas First, we view epistemic game play as being of two major kinds. The first concerns science representational games involving target structures such as classification trees and graphs. The second concerns knowledge building games involving goal states such as the creation of knowledge useful for explaining a problem of understanding. The first kind correspond to those described by Collins and Ferguson (1993) where the game involves constructing a fixed representational target or *epistemic form*, such as playing a Multi-factor-Analysis Game with an And/Or Graph. The second are those where there is no specific epistemic form targeted, such as the Theory-and-Evidence Game (Collins, in press; Morrison & Collins, 1995).

Although we do not use the actual term "epistemic games," we do frame knowledge building in Ideas First in terms of game play and knowledge building moves. Scientists advance their understanding of problems in many ways. One way we represent play with ideas is the "Progressive-Investigation Game" (Figure 1). This representation is meant to capture a type of knowledge building progression that occurs both in the offline setting and online in Knowledge Forum. Carrying the game metaphor further, we discuss with teachers the similarity to sports teams where both full-length games and targeted practice sessions are a continual part of a player's development. Similarly, Ideas First involves a constant cycling of action and reflection in learning to play knowledge building games in science. In order to support teacher and student inquiry into knowledge building moves we have created two specific tools that isolate parts of the full Progressive-Investigation Game for practice and reflection, *Think Cards* and *hypothetical game-configurations*.

Think Cards can be thought of as concrete "game pieces" to facilitate game play (Figure 2). To provide consistency between offline and online game play, the cards are based on Knowledge Forum Notes (Scardamalia, 2004). The Think Cards are used to support one sequence of knowledge building moves that might be used to advance understanding of a problem --- generate an explanation for a problem and then gather new information that can be used to improve this explanation. Think Cards physically reify students' explanations (*My Idea is…*), the new information that they bring to their inquiry (*New information…),* questions that drive their inquiry (*INTU* stands for "I need to understand"), and improvements that they make to their explanations (*A Better Idea is…*).

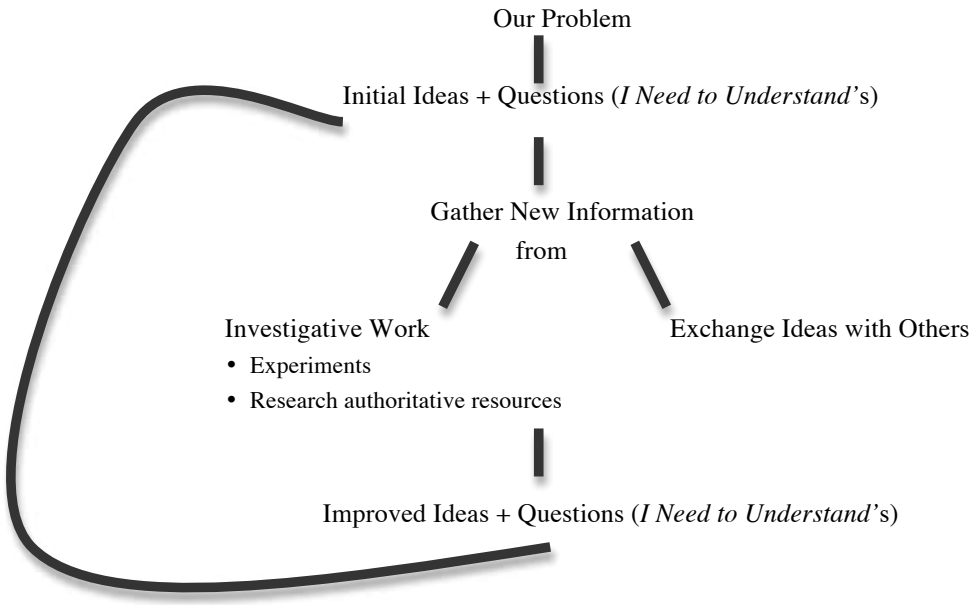

Figure 1. The basic flow of the "Progressive-Investigation Game"

Hypothetical game-configurations are used to reflect on the knowledge building moves made possible by a particular configuration of knowledge objects. The configurations consist of "snapshots" of hypothetical student work in Knowledge Forum, meant to capture game play at a fixed point in time in order to engage the community in asking: given this configuration, what types of knowledge building moves would best contribute to advancing our knowledge? Some configurations focus on single moves, such as presenting a possible initial explanation generated in response to the problem the students are working on. Students then generate a knowledge building move meant to advance this initial idea. There are also more complex game configurations that present not only a possible initial explanation in response to a problem, but also provide a series of possible knowledge building moves. In this case, students both evaluate the quality of the provided moves and generate a possible next move that contributes to the progressive improvement of ideas. In all cases, students each work on the same hypothetical game-configurations so that they can then compare and contrast their proposed knowledge building moves in whole-class discussions about issues such as what makes a "good contribution" and what does it mean to advance the community understanding.

Our design argument is that in full-blown game play in spaces such as Knowledge Forum and classroom discourse, it is difficult for beginning learners to see critical events and features, thus making it difficult to develop the necessary epistemological perspectives on community practices and an understanding of the moves, constraints, and strategies for working with various forms of knowledge (i.e. epistemic fluency). The Think Cards are used in the early months of Ideas First. After students have moved into full-game play in Knowledge Forum, the hypothetical game-configurations are introduced as a means of examining specific elements of epistemic game play, permitting further practice and reflection on participation in community knowledge building. The continued use across grades 3 and 4 makes it possible to highlight particular knowledge building moves such as how to advance an explanation or how to synthesize ideas, which are then related to student work in Knowledge Forum. We provide more detail on our use of the Think Cards as a reflective tool in the Ideas First program in the remainder of the paper.

Think Cards: Learning to Make Knowledge Building Moves

The Think Cards are used in the first two units of Grade 3 (months 1 - 3). This is students' first formal science experience in primary school. The unit opens with a whole class discussion of "How do Scientists make sense of the world?" and highlights the underpinnings of Ideas First, such as working as a science community to understand questions that we have about the world and how, like Scientists, we keep working to improve our ideas and explanations. The Think Cards are used to support actions consistent with this framing, but are limited to the *initial idea-new information-improved idea* sequence of knowledge building moves. The goal is to challenge the prevailing classroom culture where students' written responses tend to be viewed as static entities that either match a predetermined "model answer" or not. Instead, the first Think Card, *My Idea is…* , is used to encourage students to write down their initial idea, with teachers setting the classroom norm of respect for others' ideas and not worrying if one's idea is correct. These ideas are then shared in the public space (via the Whiteboard, or in small-group discussions) in order to make visible the diversity of ideas that are now

available as resources for the whole community. Because of curricular time constraints[2], students work on a problem of understanding that is provided to the whole class (e.g., How do we know if something is a "living thing"?). However students are encouraged to continually record their own questions (the *I Need to Understand…* section at the bottom of the cards) and to use the processes modeled with the class problem to advance their understanding of these questions.

The *New Information…* Card is used to introduce a possible knowledge building move toward progressively improving an initial idea. Rather than using resources to "find the answer," the focus is on using books, videos, the Internet, and other people as resources to improve initial ideas. In many classes, students begin bringing resources from the public library and home to share with the class. Class discussions center on issues such as why certain resources are useful (with some classes discussing the trustworthiness of science content in sources such as children's cartoons and television shows) and the mechanics of note-taking, which is a new skill for these 9 year-olds. Students also discuss the practice of citing resources (including people) in order to return to sources if necessary.

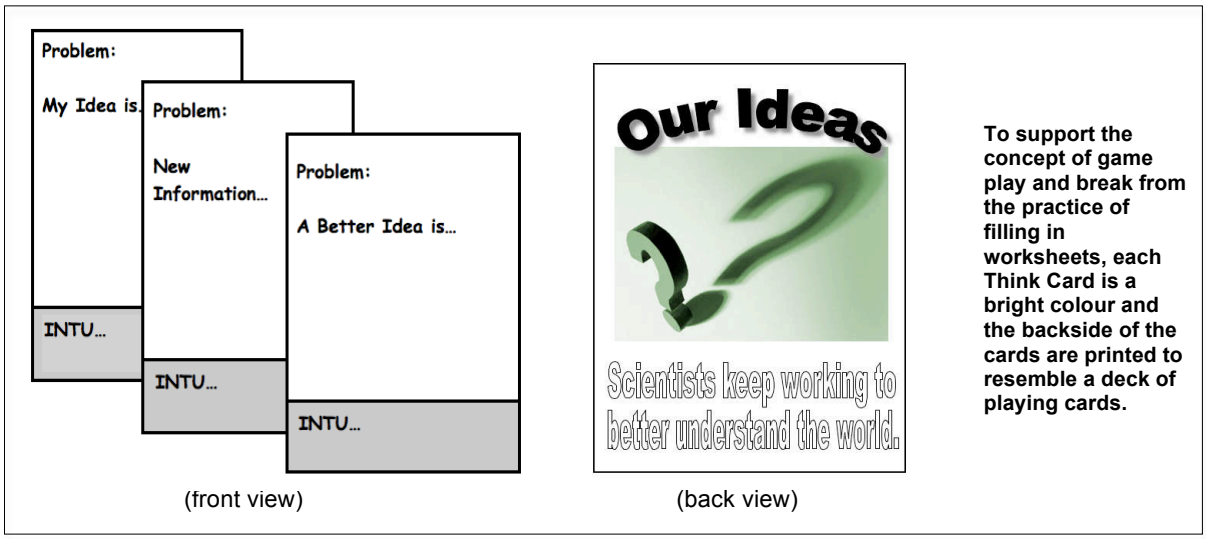

Figure 2. Ideas First Think Cards

The use of the Think Cards occurs over several weeks. The initial idea cards lead into research with various resources to collect new information centered on the class problem, but also including individual questions. Students generate as many New Information Cards as they wish, and share them with the class through whole-class and small-group discussions. This, in turn, leads to access and exchange of information across cards. This work culminates in *A Better Idea is…* Card, where students work to synthesize their learning into an improved explanation of their initial idea. This knowledge building move opens up a space for discourse concerning the meaning of idea improvement. For example, are we interested in looking at improvement in terms of comparison to the initial idea, or solely with regard to the quality of the end product?

The small, mobile nature of the Think Cards make it easy for children to work with their ideas --- jotting down notes in the library or during discussions, spreading their cards out to examine the collection of ideas, literally "exchanging ideas" with others, etc. We believe that it is important that a child can physically accompany the written form of his or her idea into a group discussion, thereby disrupting the conception that a written idea is a static response to a question when the child holding the Think Card is asked by peers to further elaborate the idea or the child defends the idea when it is challenged. The Think Cards also make visible the diversity of ideas that students generate for a particular problem of understanding and that can be collected from various resources, and the multiple pathways possible in moving from initial ideas to construct new knowledge.

Many of the visual affordances (in contrast to the physical) that we discuss here are also available in Knowledge Forum. Such similarity is seen as critical in order to create a consistent developmental trajectory within a semiotic space where knowledge and sources can be questioned and problematised --- from physical knowledge objects in a child's hand that co-located agents can act upon (months 1 - 3 of Ideas First), to "concrete" knowledge objects in the virtual space of Knowledge Forum that can be acted upon by multiple agents (months 4-24 of Ideas First), to broader disciplinary knowledge worked upon by members of the science community.

Teacher Reflections on the Use of Think Cards

Over the course of the year, teachers in both the Grade 3 and Grade 4 levels meet for bi-weekly reflection

sessions. One of the Grade 3 sessions during Unit 1 focused specifically on the use of Think Cards, with the eight teachers all writing written reflections and then sharing their perspectives in an open discussion. Here we briefly illustrate their descriptions of classroom experiences.

One teacher described the Think Cards as a "tool to initiate children into the Ideas First culture," and highlighted that their use "Helps the teacher reinforce the idea that "all ideas are important" by encouraging them to write down their thoughts, whether or not they think they are right." Other descriptions related to culture building included "Students get to experience the processes real Scientists go through in the work," and "*A Better Idea Is…* Card is good as pupils start to rephrase the main content's ideas with vocab and language like scientists. "

The teachers' reflections indicated that they used the Think Cards not only to help students participate in knowledge building practices, but also to engage in reflecting upon the nature of their participation and the ways in which knowledge is built. Based on initial analyses of the teacher responses, two categories emerged concerning the ways the Think Cards helped to support student reflection on knowledge building: *how to engage with ideas and advance understanding* and *how students can serve as resources for each other*. We briefly describe these two areas below.

How to Engage With Ideas and Advance Understanding

Based on interviews with the teachers of this school over the four years of the project, the typical classroom experience for these students involves answering questions (either verbally or on worksheets) and receiving positive or negative feedback with an explanation. The underlying processes for developing their own explanations are rarely made visible, beyond "studying" or "working harder." Learning that there are processes that can be undertaken to advance one's understanding is thus critical for helping students learn how to engage with knowledge. The teachers describe how the Think Cards introduced students to specific approaches to advancing their ideas and enabled students to see the growth of their ideas:

> *The cards allow pupils to take step-by-step approach in researching their ideas and problems.*
>
> *Helps students to appreciate their own work and observe how they had "grown" in their understanding of a problem.*
>
> *When pupils put their 3 cards together, they can see how their ideas have grown from rather vague and haphazard to something more detailed and specific to the problem or question.*

One teacher told of how using the Think Cards to reflect on their growth of understanding helped her students to "value the process":

> *I saw a shift in their attitudes toward the cards. When we first started out with the Think Cards they were asking me, "Why are we doing this?" And then, um, I had one session with them where they laid out their cards together after they completed one topic. And I got them to sort of like celebrate, or appreciate, the work that they had done individually and at the same time go around and see what their other friends have done. So, um, and to particularly look for how they had grown in their understanding of the problem. So, from there they saw that there was value to what they are doing. So by the time I gave them the second set of cards they quite readily worked without any more of these questioning.*

Through examining their work with Think Cards --- coming to understand that an idea can be a starting place rather than a terminal answer, observing that knowledge can be constructed via multiple pathways, discussing the similarities and difference between what they do and what scientists do --- the intention is for students to better understand not only the processes of knowledge building, but also their agency for participating in such practices (what Scardamalia (2002) refers to as "epistemic agency").

Although the teachers found it helpful that the step-by-step approach of the Think Cards provided an entry point into the processes of knowledge building, the teachers also felt it was important that such an approach did not lead to students following this sequence in a routinised manner, but instead led into more versatility in knowledge building. For example:

> ***Miss H**: I think at this stage when they first just started in this I think they need a little, some steps. So by the second set of cards they are quite comfortable. ...But I think that, um, as they get the hang of this, that the other Thinking Phrases[3] can start coming through. They need not follow this, um, steps, steps they have to follow, later on [inaudible] start using other Thinking phrases.*

> ***Researcher-Facilitator****: So you already foresee a time …*
> ***Miss H****: Yeah. Because I don't want them to just be thinking this way. First the yellow* [My Idea is card]*, then the purple* [New Information card]*, then the, the, yeah… I think in real life we don't do this, um, all the time. We need them to be very versatile in their thinking as well, not just thinking sequentially but perhaps concurrently with other issues that are popping up.*

It is critical when using supportive processes to guide student introduction to epistemic game play that the processes not be reduced to simple steps to be followed, but instead are viewed as moving students onto a trajectory leading to greater creativity.

How Students Can Serve as Resources for Each Other

Working together and serving as resources for each other are critical aspects of playing epistemic games in knowledge building communities. With regard to how to serve as resources for each other, the teachers described ways of using the ideas of others in one's own explanations or contributing to each other's advancements, as well as strategies for synthesizing ideas and resolving conflicts. One of the ways they did this was by connecting student use of the cards to the various design principles of Ideas First[4]. For example:

> *I strongly feel that the Think Cards help in Principles 3—"Working together to improve ideas."*
> *- Students share ideas aloud, teacher writes on board*
> *- Other students who do not have the idea will write in their Think Card and see their ideas GROW.*
>
> *It* [Think Cards] *is handy and enables pupils to pass them around to share their ideas.*
>
> *If ideas written on board has misconception, getting second or third student to rephrase the idea promotes Principle No.5—"Moving ahead…and help…"* [The community can only move ahead if we help all of the members of our community to move ahead] *where pupils themselves clarify their peers' idea. If this happen where 2 pupils help one another in clarifying his/her peer's ideas, tr* [teacher] *will write both names in brackets, to acknowledge their contribution.*

Although the Think Cards focus on "My Idea" and "My Better Idea," the teachers indicate that they keep the focus on *our* ideas through keeping ideas visible as public resources for all and through encouraging peers to exchange their ideas and help each other. Such a focus is related to Scardamalia's (2002) notion of "collective cognitive responsibility," a shared responsibility for advancing the community's understanding.

Supporting Teacher Reflections

In addition to supporting student reflections on knowledge building processes, working with the Think Cards also supported teacher reflections on pedagogy. For example, in the written reflections, one teacher raised his own *I Need to Understand* questions for the other teachers to consider:

> *INTU: How do we assess where we as teachers are in terms of the learning of our students? As a community, I feel that we have to move on as a class to create meaning of the lessons and the knowledge that we have built upon. However, how do we determine the cut off time to move on to a different of the lesson if we are constrained in terms of time?*

Further, the teachers got into a discussion about teaching problems that came up in their classes. One example involved students who write "textbook entries" on their cards rather than their own ideas. Another concern involved students who "got all the key science ideas in the first Think Card" and then they didn't know what to do for their New Information card so they wrote copious notes from other resources. These teacher exchanges led to examining more deeply the types of classroom practices and contexts that needed to be created to support knowledge building.

The teachers' discussion of their experiences touches upon the interplay of the nature of disciplinary practices, pedagogy and classroom enactments, and student participation and understanding. We feel that continued engagement in dialogue centered on such interplay is critical in order to support teachers in the creation of classroom knowledge building communities and toward an ever-deepening understanding of what Hogan and Corey (2001) call the "composite culture":

> The "composite culture" represents the classroom culture of science that students actually experience, which is a mixture of ideals of professional science practice… and pedagogical ideals… as filtered through the realities of classroom life and scientific practice. Finally, students' perspectives feed back into shaping the composite culture of the classroom. (p. 216)

This is also consonant with teacher education research on supporting the professional development of beginning elementary science teachers through focused dialogue regarding "(1) engaging in science, (2) organizing instruction, and (3) understanding students" (Mikeska, Anderson, and Schwarz, 2009, p. 678). The teacher discourse indicates that Think Cards can serve as a tool to support dialogue at the intersection of science knowledge building practices, classroom actions, and student understanding.

Conclusion

The use of Think Cards and hypothetical game-configurations permits guided practice and reflection concurrently with engagement in playing full versions of epistemic games such as the Progressive-Investigation Game. These tools are meant to work in conjunction with Knowledge Forum and video-based reflections in order to help teachers and students to problematise their participation in knowledge building communities. The advantages provided by the Think Cards include physical possession, which creates a strong sense of ownership and the ability to accompany one's ideas into social interactions in order to engage in extended discourse. Students are easily able to exchange ideas and lay out the cards in various configurations in order to see how different ideas are related. One disadvantage over Knowledge Forum is that physical limitations make it difficult for students to see how their ideas fit into the overall structure of the work of the whole class, and students are limited in the ease of creating different "views" on the knowledge base.

Beverly Caswell, a Canadian teacher who worked with the knowledge building communities model in her elementary science classes for many years, describes how as her students learned the processes of knowledge building that "it is almost as if they are thinking 'finally someone is letting us in on the rules of the game of science'" (Caswell & Bielaczyc, 2002). The work described in the present paper concerns ways to put Ideas First classrooms on a trajectory consistent with more skilled and creative playing of the epistemic games of Science. The research contributes to the growing literature on ways to create classroom cultures that mirror disciplinary cultures. Think Cards and hypothetical game-configurations scaffold scientific knowledge building processes, contributing to work with pencil-and-paper based scaffolds (e.g., McNeill & Krajik, 2009) and computer-based scaffolds (e.g., Bell & Linn, 2000). The work presented here captures only a small slice of the Ideas First design and of our work in facilitating a shift from didactic classrooms toward classrooms that function as knowledge building communities. In future work we plan to extend our analysis to classroom discourse around the epistemic game play described here, along with a more in-depth examination of the ways that students use the Think Cards and game-configurations in relation to their work on Knowledge Forum.

Endnotes

(1) Refer to www.ikit.org

(2) In Singapore, the school year comprises four 10-week sessions. In this school there were 2-2.5 hours of Science scheduled per week in Grades 3 and 4 and an exam period at the end of every 10-week session. There is also a national curriculum specifying science objectives to be covered in preparation for the Primary School Leaving Exam (PSLE), a national high-stakes exam given at the end of Grade 6.

(3) Thinking Phrases are based on the scaffolds found in the Knowledge Forum software. In Ideas First, the Thinking Phrases include: *My Idea is, New Information, A Better Idea is, INTU, Evidence for this Idea, Pulling Our Ideas Together,* and *A Different Idea is*.

(4) Scardamalia (2002) outlines 12 design principles for knowledge building communities. In Ideas First we have consolidated these into five key guiding principles. The teacher quotes refer to two of these five principles: *Principle 3: We work together to improve our ideas* and *Principle 5: The community can only move ahead if we help all of the members of our community to move ahead*.

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