# Bridging Technologies: Stepping-stones for the enactment of Knowledge Building Communities

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**Abstract**

The enactment of the *Knowledge Building Communities* model in classrooms with starting conditions of the social infrastructure very different from *Knowledge Building Communities* can be problematic. We propose the use of *Bridging Technologies* as stepping-stones to bridge the gap between the social infrastructures of these classrooms and *Knowledge Building Communities*. The design principles of *Bridging Technologies* are introduced. Research from *Ideas First*, is presented to illustrate the use of the principles to design the Think Card, an example of a *Bridging Technology*.

The paper contributes to the following KBSI Themes: *Sustained Work with Ideas and Social Innovation and Systemic Change*.

## Introduction

The *Knowledge Building Communities* model (KBC model) and its associated technology-based learning environment, *Knowledge Forum,* have been in the field of CSCL for over 20 years (Bereiter, 2002; Scardamalia, 2002; Scardamalia & Bereiter, 1993, 2006). Although exemplars of the KBC model exist in various parts of the world[1], a better understanding is needed of how to bring the model to life in classrooms (Bielaczyc, Kapur, & Collins, 2011; Chan, 2011). KBCs are not enacted on a clean slate. They are enacted in classrooms with existing social infrastructures. Developing the necessary social infrastructure is an important consideration when designing for the enactment of learning in technology rich environments (Bielaczyc, 2006). Classrooms that successfully implement the KBC model have developed social infrastructures consistent with KBCs (Bielaczyc & Collins, 2006; Moss & Beatty, 2010; Oshima et al., 2006; Seitamaa-Hakkarainen, Viilo & Hakkarainen, 2010). Some classrooms attempting to enact the KBC model, e.g. South Asian classrooms; may have an existing social infrastructure vastly different from KBCs (Chan, 2011). Consequently, a sizable gap exists between the starting conditions of the social infrastructure in these classrooms and that of the KBC model.

The presence of a sizable gap between the existing social infrastructure and that of the KBC model can be problematic. Baron (2009) describes how the introduction of communication technologies in society follow a general pattern; as technologies are introduced, they are first appropriated to recreate familiar practices, it is only later when the technologies become more established in a period characterized by change that new practices are created. *Knowledge Forum* is the goal-technology used to enact learning in KBCs in classrooms. Its introduction in classrooms with a social infrastructure considerably different from that of KBCs can be problematic in the sense that *Knowledge Forum* may not be easily appropriated and it does not recreate familiar practices. In other words, the technology does not support work in the classroom's "comfort zone," making it difficult for the technology to be established in the daily learning activities of the classrooms. Consequently, the possibilities of enacting change and creating new practices consistent with KBCs are reduced. It is therefore important to address the gap between the social infrastructure of these

[1] Refer to http://www.ikit.org

classrooms and those of KBCs.

We proposed the use of *Bridging Technologies* as a way of bridging the gap in classrooms with a social infrastructure considerably different from those of KBCs. In this context, *Bridging Technologies* are technologies that function as "stepping stones" for the enactment of practices and development of a social infrastructure more consistent with KBCs. In the first section of the paper, we outline the design of *Bridging Technologies*. The second section examines our design theories in practice, we describe the Think Card, an example of a *Bridging Technology* used in our research on *Ideas First*, a design-based research program involving enactments of the KBC model in Singaporean primary science classrooms (Bielaczyc & Ow, 2007, 2010; Ow & Bielaczyc, 2007).

## The Design of Bridging Technologies

Our work on *Bridging Technologies* draws from research on the history of communication technologies (Baron, 2009; Eisenstein, 1979; Ong, 2002), the lens of the social infrastructure framework (Bielaczyc, 2006) and the notion of designing for epistemological perturbations (Ow & Bielaczyc, 2007). From these areas we distilled the following design principles for *Bridging Technologies*,

1. Focus on key practices that provide high leverage
2. Create affordances that signal ways of working with knowledge that are consistent with the goal technology
3. Choose to implement the practice in a medium that is easy to use and access
4. Connect old practices with new practices
5. Create self-limiting aspects

In the following section we draw on our research on *Ideas First* to illustrate the use of our design principles for designing the Think Card. We describe the use of the Think Card to show how the *Bridging Technology* addresses the gap between the social infrastructure of the classrooms and KBCs.

## The Think Card – a Bridging Technology for the KBC model

*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). The program is based on the vision of a knowledge building community where students work to advance the science understanding of the classroom community by engaging in collectively building knowledge to better understand common problems of understanding. In tandem with the development of the curriculum for *Ideas First* we also developed resources to support students' enactment of the curriculum. One example of these resources is Think Cards. The Think Cards are used in the first two units of Grade 3 (months 1 - 6). Guided by the design principles for *Bridging Technologies*, they were designed to bridge the social infrastructure gap through the development of practices and a social infrastructure more consistent with KBCs. We elaborate on use of the design principles for the design of Think Cards below.

### Design Principle 1 - Focus on key practices that provide high leverage

One key problem area in enacting a KBC is the practice of improving ideas and explanations. According to Scardamalia and Bereiter (2006), "generating ideas appears to come naturally to people, especially children, but sustained effort to improve ideas does not" (p. 100). In the classrooms, this is evident by the enthusiasm shown by students when engaging in brainstorming activities. The ideas generated in these activities however are rarely subjected to efforts to improve them. This problem is also observed in the homework and classwork undertaken by students. The "question and answer" format of the work

encourages students to write down their answers to questions, await the evaluation of the answers and then, depending on the evaluation, write down the "right" answers as corrections or file away the assignment. In the absence of practices of improving ideas and explanations, we felt that it was key to introduce such practices.

Enacting practices of improving ideas and explanations also provided high leverage for bridging the social infrastructure gap. The enactment of these practices would impact on interrelated dimensions of the social infrastructures in these classrooms. For example, enacting practices of improving ideas and explanations would initiate changes to the cultural beliefs of classrooms about the nature of ideas, from the belief that ideas are static entities to the belief that ideas are improvable; it would necessitate changes to how the community worked with communities and ideas outside the classroom; and it would also have an impact on the physical arrangements in the classrooms as the community members interacted with each other to improve ideas and explanations.

To support actions consistent with the practice of improving ideas and explanations in classrooms starting to enact *Ideas First* we made explicit the *initial idea-new information-improved idea* sequence of knowledge building moves. A set of three Think Cards was developed to support practices associated with this sequence of knowledge building moves. The Think Cards were designed to resemble playing cards. The front side of a Think Card is brightly colored. The words "Our Ideas" are printed at the top of the front side of the card and the phrase "Scientists keep working to better understand the world." is printed at the bottom. These were chosen to signal to students the importance of improving ideas to better understand phenomena around them. On the reverse side of a Think Card, is the word "Problem" followed by a space for writing. Below this is one of three phrases "My idea is," "New Information" or "A Better idea is." We chose the word "Problem" to focus students' efforts to improve their ideas on problems of understanding. The phrases mirror a key sequence of knowledge building moves and support students' work to make explicit their initial ideas, work to gather new information related to the problem that would help improve ideas, and work to synthesis ideas to come up with a better idea to their problem of understanding. At the bottom of this side is "INTU" (I Need to Understand) followed by another space for writing.

We were interested in students' use of Think Cards for enacting practices to improve ideas and explanations. Data was collected from Primary 3 students' first use of Think Cards as they worked on the common problem for Unit 1: *How do we know if something is a "living thing"?* We focused only on Think Cards for which we had the complete *initial idea-new information-improved idea* sequence of cards. We evaluate students' use of "My Idea is" and "New Information" Think Cards for the relevance of ideas and information to the problem of understanding. Students' use of "A Better idea" Think Cards was evaluated based on the improvement of ideas and progress made to solve the problem.

Students' use of the "My Idea" Think Cards is presented in Table 1. We analyzed 246 "My Idea" Think Cards. Most students, 83.7% of primary 3 students, were able to contribute ideas related to the problem. Some students, 10.6% of primary 3 students contribute ideas unrelated to the problem, while 5.7% did not contribute their ideas in the "My Idea" Think Cards.

TABLE 1
Students' use of "My Idea" Think Cards

| | Most ideas are related to the problem | Some ideas are related to the problem | Ideas are not related to the problem | No evidence of contribution of ideas |
|---|---|---|---|---|
| "My Idea" Think Card | 80.9% | 2.8% | 10.6% | 5.7% |

Students' use of the "New information" Think Cards is presented in Table 2. We analyzed 246 "New Information" Think Cards. Most students, 79.3% of primary 3 students, were able to gather new information related to the problem. Some students, 8.9% of primary 3 students gathered new information unrelated to the problem. There were some students, 11.4% of primary 3 students, that did not have evidence of gathering new information.

TABLE 2
Students' use of "New Information" Think Cards

| | Most information are related to the problem | Some information are related to the problem | Information are not related to the problem | No evidence of gathering new information |
|---|---|---|---|---|
| "New Information" Think Card | 74.4% | 4.9% | 8.9% | 11.4% |

Students' use of "A Better Idea" Think Cards is presented in Table 3. Some students, 41.9% of primary 3 students were able to improve on their ideas in the "My Ideas" Think Card. A similar percentage, 39.8% of students generated ideas that did not improve the ideas in the "My Ideas" Think Card. There were also students, 18.3% of primary 3 students, who did not show evidence of improving ideas in the "My Ideas" Think Card.

TABLE 3
Students' use of "A Better idea" Think Cards

| | A better idea that improves my ideas | Ideas that do not improve my ideas | No evidence of a better idea |
|---|---|---|---|
| "A Better idea" Think Card | 41.9% | 39.8% | 18.3% |

From the results of students' use of Think Cards, we observed that students were beginning to develop the practices of improving ideas and explanations. The practice of doing "research" and gathering new information to improve initial ideas was new to many students. We are encouraged that the results suggest that the Think Cards supported the enactment of this practice. The practice of working with initial ideas and new information to come up with a better idea was also a new practice to the students.

Although less than half of the students were able to use the Think Cards to improve their ideas, we feel that the introduction of the "A Better idea" Think Cards sets students on a trajectory to enact practices more consistent with KBCs. First, the "A Better idea" Think Card creates among students an awareness of the complete process for improving ideas and

explanations. This is because the "A Better idea" Think Card is not used in isolation but as an essential card in a set of Think Cards that support the *initial idea-new information-improved idea* sequence of knowledge building moves. Thus even if students could carry out the first two moves and use the first two cards well, they are reminded by the existence of the third "A Better idea" Think Card of the need to carry out and work on the final move to come up with a better idea. Second, the problematizing of working with the "A Better idea" Think Card opens up classroom conversations about how to improve ideas. Consequently, as the students are working to understand and better their efforts to improve ideas, the accompanying classroom discourse shifts to support the transformation of existing practices. This has the effect of creating practices more consistent with KBCs.

Aside from the development of the practice of improving ideas and explanations, we also observed changes in other aspects of the social infrastructure. These will be elaborated as we describe the other design principles for the design of the Think Cards.

**Design Principle 2 - Create affordances that signal ways of working with knowledge that are consistent with the goal technology**

We were cognizant that the Think Cards were a *Bridging Technology*, and that *Knowledge Forum* is the goal-technology for KBCs. Within the limitations of the technology of the Think Cards, we create affordances that signal ways of working with knowledge that are consistent with *Knowledge Forum* in KBCs. This consistency would help develop the social infrastructure necessary to enact learning with *Knowledge Forum* in KBCs. For example we deliberately named the Think Cards the "My Idea" Think Card, the "New Information" Think Card and the "A Better idea" Think Card. This not only supports the idea improvement knowledge building sequence, it also enable us to introduce the classrooms to knowledge building discourse.

Another example was the design of the Think Cards to afford public sharing and collective work with ideas. At first glance, the Think Cards can give the impression that they are designed to support an individual's work with ideas. However the focus of the design of the Think Cards was to support collective efforts to improve ideas. Guided by this focus, we designed the Think Cards to be small and colorful, like playing cards. The size of the Think Cards enabled them to be passed around for others to work with enabling others in the community to contribute towards the understanding of the common problem. This also allowed for them to be displayed in communal spaces like white boards in the classrooms and tabletops to enable students to visualize and then work with idea diversity. Accompanying these new ways of working with ideas was a concomitant change in the configurations of tables and chairs in the classrooms to facilitate students' work.

A further example was the design of the "New Information" Think Card to provide an opportunity for students to work constructively with authoritative sources. We analyzed students' responses in the "New Information" Think Card to gain some insights as to whether students took up the affordances of working constructively with authoritative sources. Students' information sources in the "New Information" Think Card are presented in Table 4. We analyzed 246 "New information" Think Cards. Overall, 62.6% of students cited sources in their "New Information" Think Cards. There were three major sources of information cited by students. The first major source of information was the textbook, 29.5% of the "New Information" Think Cards had evidence of students cited textbooks as the source of information. Not all information cited from the textbook was related to the problem, 28.6% of information cited from the textbook was related to the problem while 0.9% of information citing from the textbook was not related to the problem. The next second major source of information was "friends and textbooks", 21.2% of the "New Information" Think Cards had evidence of students citing friends and textbooks as sources of information. All information

cited from friends and textbooks were related to the problem. The third major source of information was "friends", 11.9% of the "New Information" Think Cards had evidence of students citing only their as sources of information. Not all information obtained from friends was related to the problem, 10.6% of information cited from friends was related to the problem while 1.3% of information cited from friends was not related to the problem.

TABLE 4
Students' information sources in the "New Information" Think Cards

| | No citations of source | | Friends only | | Textbooks only | | Friends & Textbooks | Others |
|---|---|---|---|---|---|---|---|---|
| | Related | Not related | Related | Not related | Related | Not related | Related | Related |
| "New Information Think Cards | 28.6% | 8.4% | 10.6% | 1.3% | 28.6% | 0.9% | 21.2% | 3% |

Students' use of "New Information" Think Cards suggest that they were beginning to work with ways consistent with KBCs. Through their use of the "New Information" Think Cards, students appear to demonstrate their awareness of the current state of facts related to the problem, retrieving new information from their textbooks that can contribute to their explanation of the problem. They also appear to be aware of the work in their classroom community to explain the problem, gathering information from their classmates that can contribute to their explanation of the problem. Being able to use sources of information constructively also necessitates that students adopt a critical stance to information gathered. We feel that students are developing a critical stance to information as demonstrated by their ability to gather information relevant to the community's problem in the "New Information" Think Cards.

**Design Principle 3 - Choose to implement the practice in a medium that is easy to use and access**

In order to enact the new practices regularly it is important that the students in the classroom have ready access to easy to use technology that support these practices. Regular enactment of the new practices helps establish the practices in the classrooms. In our classrooms, students did not have access to computers. The computers were located in a computer laboratory. Ready classes were scheduled to use the computer lab once a week for an hour. Time in the computer laboratory was to be shared between the learning of English, Math, Science and Mother Tongue. Furthermore not all students were familiar with the use of the computer too. To support the regular enactment of the new practices in *Ideas First*, we choose to make the Think Cards from cardstock. This resulted in the cards being durable, portable and easy to write on. The students were familiar with the medium and had the skills to enact the practices in the medium. These features of the Think Cards enabled students to take the cards along with them for all their *Ideas First* lessons, visits to the library and even bring them home. Students could write down their ideas or new information on the cards, they could share their ideas and talk about them during discussions with friends and even family members.

**Design Principle 4 – Connect old practices to new practices**

We feel that it is important to ease the students in the classroom from old practices to new practices and possibly newer practices consistent with KBCs. As we designed the Think Cards we were deliberate about establishing a connection to old practices in the classroom even as we established practices consistent with the social infrastructure for KBCs. We designed the Think Cards to have a familiar "look and feel" to the prevailing technology in the classrooms used to support learning, the worksheet. Like the worksheet the Think Card was also made of paper. It also had blanks reminiscent of answer spaces in "fill in the blank" worksheets. Consequently, the students could recreate the practice of writing, on the Think Cards. The Think Card though was not like the worksheet; it was designed to look like a note in *Knowledge Forum*. The Think Card therefore did not have a question to answer. Students could not recreate this aspect of learning with a worksheet. Similar to a note in KF, in the place of a question and a space for its answer, is a space to write down the common problem and another space for ideas and information with knowledge building scaffolds to support the enactment of the practice of improving ideas and explanations.

We examined students' use of the Think Cards to better understand how Think Cards enable students connect old practices to new practices. The majority of students were able to establish new practices consistent with KBCs. In figure 1 we provide an example of student A's use of the Think Cards to enact the knowledge building sequence. It demonstrates the student's enactment of writing down their initial ideas, the gathering of information that can support the improvement of the ideas and finally the use of the information (along with ideas from his friends) to improve the initial idea.

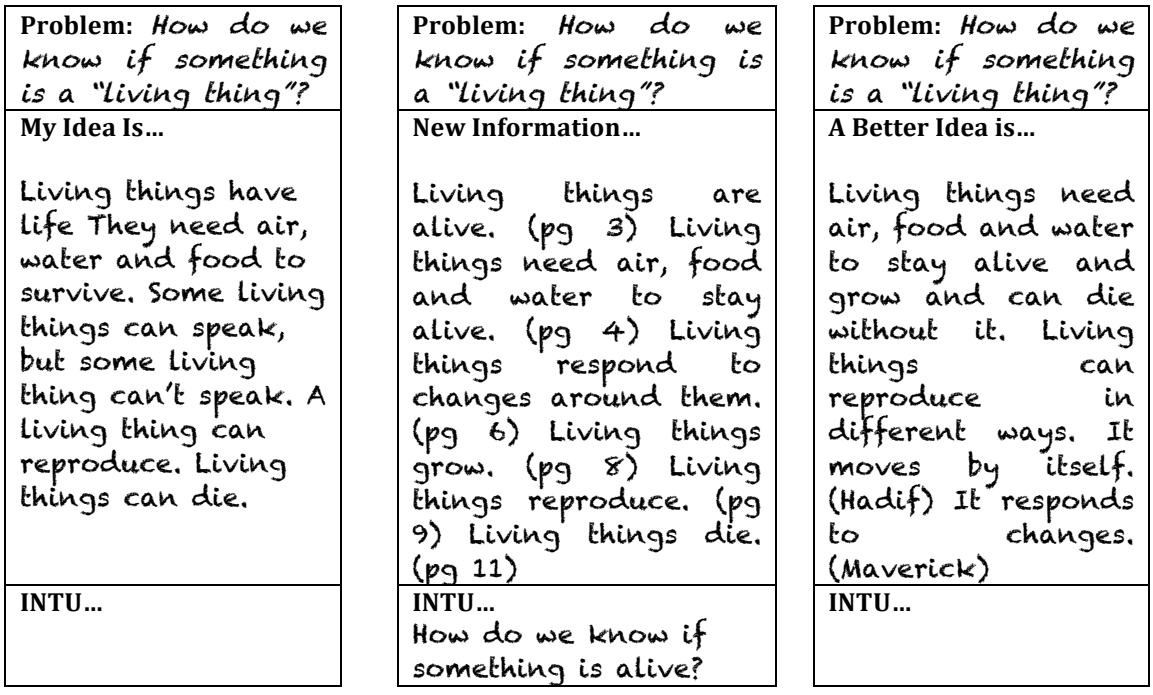


*Figure 1.* Example of student A's Think Cards for Unit 1

In a minority, we observed the use of Think Cards that bear some semblance to common practices in traditional classrooms suggesting the appropriation of the Think Card by some students as they attempted to connect with and recreate old practices. We illustrate in figure 2, how student B uses the Think Cards to re-create practices similar to a "show and tell."

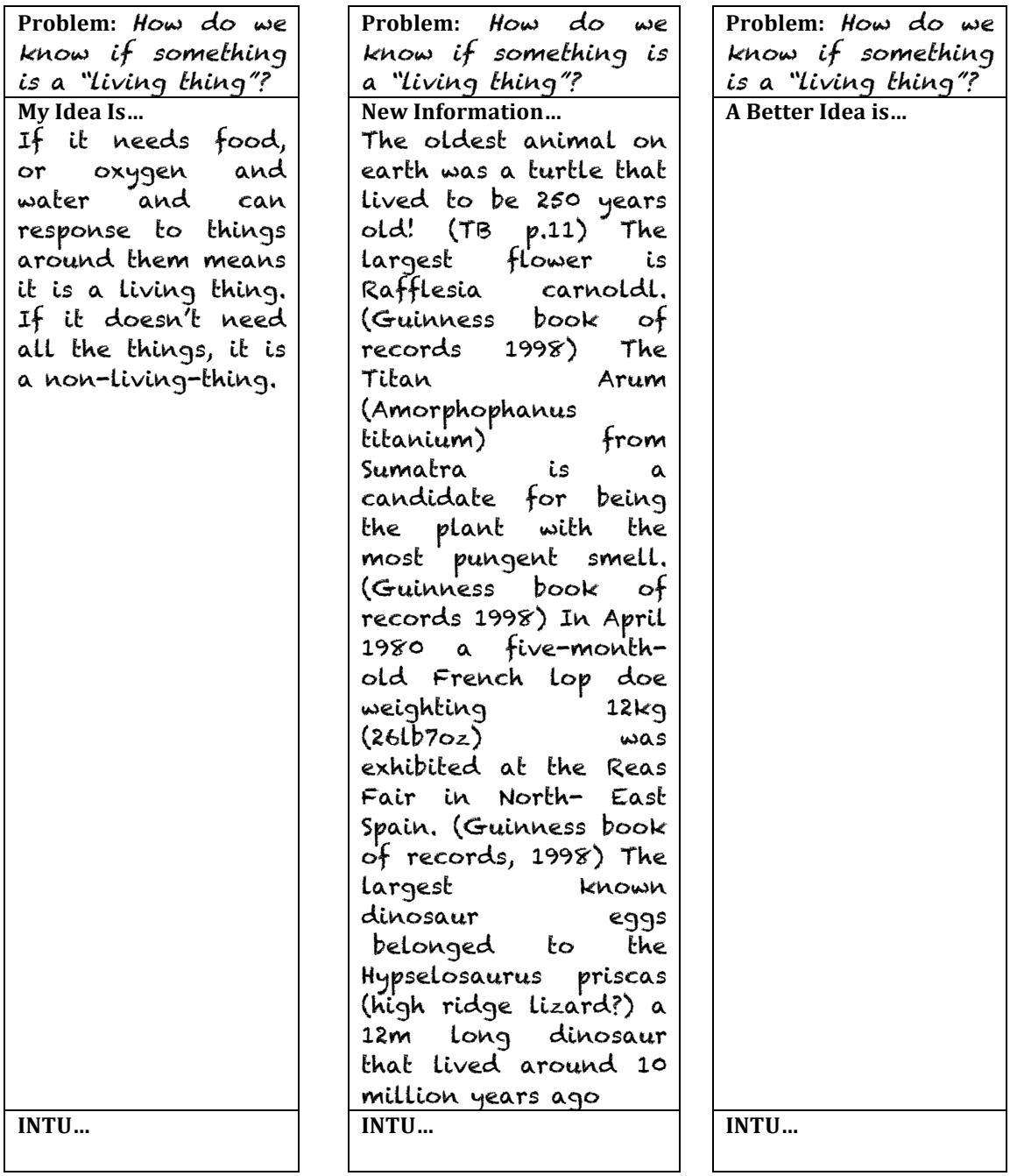


*Figure 2*. Example of student B's Think Cards for Unit 1

In the example of student B's use of the Think Cards, the "My Idea" Think Card appears to scaffold the generation of relevant ideas in response to the community's problems. Work on these ideas would help advance her understanding and the community's understanding of the problem. Her attempts to gather new information instead resulted in a collection of interesting facts unrelated to the problem. These facts do not help advance her

ideas or the community's ideas about the problem. It is possible that student B collected and shared information to "show and tell" from personal interest, not as part of a knowledge building effort. Student B could have appropriated the "New Information" Think Card as a tool for gathering information and showcasing her work. She does not continue with the next action in the "initial idea- new information- improved idea" sequence. Her "My Better Idea" Think Card is empty. We note that student B's "show and tell" efforts do not meet with success. She does not elicit a response from the community. The information she has gathered and shared was unrelated to the larger knowledge building effort of the community; consequently, other students could have disregarded it.

We provide another example in figure 3 of student C's attempts to use the Think Cards to possibly "find the correct answer".

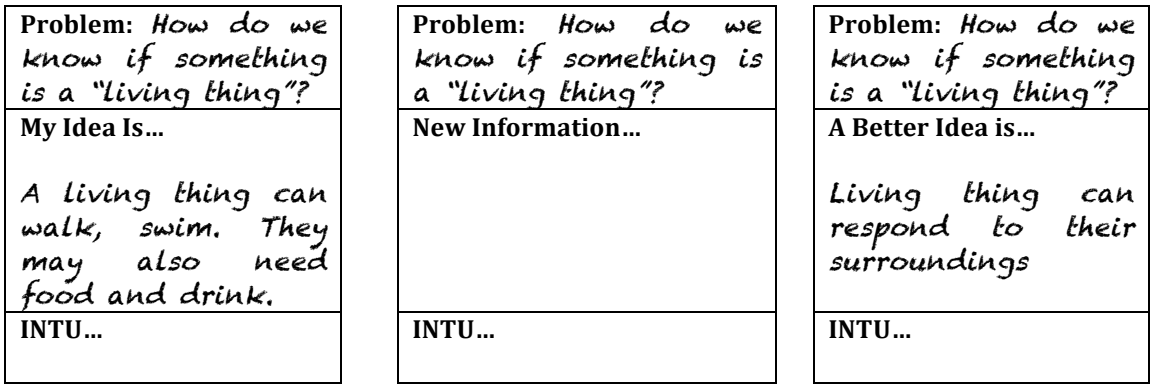


*Figure 3*. Example of student C's Think Cards for Unit 1

In this example, Student C could possibly be coming up with answers in the "My Idea" Think Cards in response to the question "How do we know if something is a "Living thing"? In the absence of external evaluation of the "correctness" of student C's response, the student could have felt that his response was incorrect. Instead of gathering new information to improve on the initial idea, the student tries another response surfacing another answer about living things in her "A Better Idea" Think Card.

These examples demonstrate that Think Cards can support students as they attempt to enact the new practices of improving ideas and explanations by providing a connect between old and new practices. However not all students are able to bridge the old and new practices. Cultural practices for learning, enacted in the years of schooling leading up to primary 3 as well as in the other subjects in primary 3 will come to the fore as these students interact with the Think Cards. The design of the Think Card and their affordances for practices consistent with KBCs makes the enactment of old practices for learning problematic. We view this positively as it provides opportunities for the classroom to engage in discourse around these problems and enculturate its members into the new practices.

**Design Principle 5 – Create self-limiting aspects**

While we designed the Think Cards as a stepping-stone for the classrooms to enact key practices and develop a social infrastructure more consistent with KBCs, we did not want the classrooms to stop their advance towards a KBC by becoming "too comfortable" with the *Bridging Technology* and new practices. As designers we knew that the technology of the Think Cards could not realize the vision of learning in the KBC model. In using the Think Cards, this also became evident to the teachers. For example, the Think Cards could initiate students into the taking collective cognitive responsibility for advancing ideas about a common problem. This can take the form of students sharing their Think Cards, working in

groups to improve the ideas in Think Cards or sharing Think Cards in a common space. However, without a better technology, students would not be able to access the ideas of the larger community at will and would not be able to be participants in sustained work with ideas in the larger community. With *Knowledge Forum*, the central communal space for knowledge building contains the conceptual artifacts, and is always available to all students. This supports reading, building-on the ideas of others, linking ideas, organizing ideas and creating new ideas as students work on a common problem.

Another example of the self-limitation of Think Cards was they did not allow students to organize and make meaningful representations of ideas. Although the Think Cards could be shared and moved around a whiteboard or a tabletop, without a better technology, once a card is removed and used by a student no other child would be able to access the card and use it to create their own representation. That representation has to be dissembled before other students can create their own representations. Consequently this limitation prevents the classroom from developing multiple perspectives of ideas in the communal space. With *Knowledge Forum*, students are able to create links between ideas and bring them together in different combinations through the creation of notes and views.

A further example of the self-limitation of Think Cards was their lack of support for transformative assessment of collective knowledge building. Think Cards afforded students the ability to evaluate the ideas of some students. It also provided students with some sense about which ideas were valued and used by others in the practice of improving ideas. However, without a better technology, students in classrooms would not be able to access a range of measures that provide important information for the assessment of knowledge building beyond the assessment of content. With *Knowledge Forum*, students have assessments tools (Scardamalia, 2004, Teplovs, Donoahue, Scardamalia & Philips, 2007) embedded in the software that can provide feedback on their interactions and insights about the content of notes to inform their collective knowledge building.

In a self-limiting way, the Think Cards created a necessity for a better technology to advance the collective knowledge building efforts of the communities.

## Conclusion

Our work to enact KBCs through *Ideas First* takes place against a backdrop of classrooms with social infrastructures very different from KBCs. We view this as problematic for the introduction of *Knowledge Forum*, the goal technology of KBCs. To bridge this gap and shift the existing practices and develop the social infrastructures of these classrooms, we introduced Think Cards, an example of a *Bridging Technology*. This technology is a stepping-stone to enact practices and develop practices more consistent with KBCs. The technology however is not intended to replace *Knowledge Forum* the goal technology. There are possibly other classrooms with similar starting points attempting to enact KBCs, the use of *Bridging Technologies* could possibly offer an alternative way of setting their classrooms on a trajectory towards KBCs. It is also possible that there are classrooms whose starting trajectories were unknowingly supported by the use of *Bridging Technologies*. These narratives could inform and deepen our understanding of the construct of *Bridging Technologies*. In making our design principles for *Bridging Technologies* explicit, we open the possibility for the design of *Bridging Technologies* to be applied in support of the initial implementation trajectories for learning with other technologies.

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