Because the light brightens the tree – Building on pupils’ naïve conceptions
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Abstract
This paper documented the effort of our pilot study to examine the outcomes of implementing knowledge building in a 4th-grade science classroom. It was an initial phase of a larger scale study that aimed to use the Knowledge Building approach (Scadamalia, 2002) to achieve deep science learning. Knowledge Building, in essence, aims to instill in pupils the dispositions and skills in refining ideas through active collaboration. It was introduced and implemented in the 4th-grade science classrooms (n=250) in a Singapore public elementary school. Teacher-centric didactic teaching used to be the prevalent mode of instruction in these classrooms. Using the Knowledge Building approach, pupils went through a cycle of idea generation, idea consolidation, experimentation, and rise above. Guided by their science teachers, they continuously generated, connected, and reflected on ideas related to heat and light. Collaborative inquiry occurred in groups of 4-6 pupils during which they had to co-construct group’s artifacts (for example, a summary of their ideas on a A3 paper) as well as individual reflection. At the end of each session, the teacher conducted whole class discussion to facilitate sharing of ideas and to bring closure to the session. A pre and post test was carried out in one of these classes (n=35) to investigate the effects of Knowledge Building intervention on the unit of light. We were interested to explore and document the effect of a new pedagogical innovation on children’s conceptual understanding and explanatory framework when trying to understand the phenomenon of the reflection of light during the knowledge building intervention. Although preliminary results shows that after the intervention of Knowledge Building approach, the explanatory framework of our pupils did not seem to have made tremendous improvement, it was encouraging to discover that our pupils had undergone active meaning making process during the intervention. From the pre and post test, it was obvious that all 35 pupils made attempts to modify their initial understanding. We believe that the knowledge building culture had created an impact on the way pupils construct their knowledge. Pupils’ ideas were valued and served as foundation for knowledge advancement.

Key Words: Knowledge building; elementary science classrooms; conceptual understanding

Introduction
There is a plethora of research concerning children’s conceptions in science, especially in the area of misconceptions or alternative conceptions children possess. Typically, such research aims to uncover misconceptions and document the failure of the removal of misconceptions. Strike and Posner (1992) emphasized the importance of students’ conceptual ecology in the process of change. Similarly, other researchers also investigate the impact of situational and contextual factors (Hallden, 1999), motivational (Pintrinch, 1999), and domain-specific aspects (Limon, & Carretero, 1999). Vosniadou (1999) argued that if children bring into the classroom their own interpretations and naïve theories of the phenomena around them, the key question to ask is how these are being formed and why they remain robust and entrenched (Vosniadou, 1999), and what type of instructional strategies we can then design and integrated into their everyday learning.

One instructional strategy consistent with Vosniadou’s view is knowledge building, which emphasizes the production and continual improvement of ideas of value to a community (Scardamalia & Bereiter, 2003, p. 1371). Knowledge building is an approach where contribution of individual is honored as it will “give rise to and speed the development of yet newer knowledge” (Scardamalia, & Bereiter, pp. 99, 2006). Under knowledge building, the ideas proposed by pupils, regardless of how naïve they are, are not condemned as misconceptions. Rather, all ideas are treated as valuable and meaningful contributions, and naïve ideas are perceived and regarded as a crucial starting point in the process of constructive idea improvement. Even though conceptual change was not a main focus in knowledge building research, it brings about an alternative perspective for study in this area.
Another alternative perspective that knowledge building offers is to extend beyond internal cognitive developments of learners, to look at external context needed to support conceptual change, particularly the social cultural environment where learning are built on through conversations among people (Pea, 1993) and through the process of mutual construction of understanding (Roschelle, 1992). As individual's ideas are put in a public space, there are opportunities for these ideas to be debated, queried, clarified, and built on by members of a community. Through this process, naïve ideas can be developed into "better" ideas. In the knowledge building community, knowledge advancement involves a community’s effort rather than individual’s effort. Members within the community synergistically create knowledge that is valued and useful as a resource to interpret and understand the world around them. It is the collaborative effort that generates the dynamicity of the community, pushing the community towards new frontier. The dynamism of the community is sustained through constant collaborative efforts and intensive interactions among the members, which drives the emergent of new knowledge and understanding.

Implementing knowledge building, however, can be a challenging task. For example, idea improvement is a gradual and iterative process. Educators and even learners must recognize the value of building knowledge as a community effort and continuously and conscientiously develop tolerance for multiple perspectives and the development of ideas. To promote a knowledge building culture, it is exceptionally clear and crucial that members of this community which includes the teacher and his or her pupils can be engaged in knowledge-building discourse which may be fundamentally different from any other discourses (Dunbar, 1997). In essence, the discourse is the driving force for commitment to progress, to seek common understanding, and to expand the base of accepted facts.

This paper documents the effort of our pilot study to examine the outcomes of implementing knowledge building in a 4th-grade science classroom. The teacher had decided to implement knowledge building in his classroom in an attempt to improve pupils’ science learning. As observers in the class, we were interested to explore and document the effect of a new pedagogical approach on children’s conceptual understanding and explanatory framework when trying to understand the phenomenon of the reflection of light. Children’s explanatory framework is a network of prestored, interrelated beliefs that constraints the mental models children construct to answer specific problems (Samarapungavan and Wiers, 1997). Such explanatory framework enables children to generate causal explanations and to make predictions leading to a feeling of understanding. Although explanatory framework is unlike specified theories, which sophistically answered to queries scientifically, it is primitive in scientific explanations, and it allows children to interpret and make sense of the world around them.

The key research question is “are there changes in pupils’ conceptual understanding and explanatory framework on the topic of Light after going through knowledge building activity?” We recognise that the social collaborative dimension is an important factor in knowledge building that we will investigate in subsequent studies.

Methods
This is a case study conducted in a neighbourhood elementary school from January to March of 2006. Our participants were 35 fourth-grade pupils from a class in the school. This class was chosen primarily because the teacher has decided to try the knowledge building approach. The topic on Heat & Light was chosen largely because it is an essential part of our everyday life and this is one important concept which many of the other concepts and principles build on.

Instructional approach
In an effort to create a successful knowledge building classroom, the teacher realized that it might be unrealistic to introduce a new approach into the class abruptly. As such, the main goal was to develop a knowledge building culture where there is collaborative idea improvement through discussion and sharing. So, unlike in many knowledge building classrooms, Knowledge Forum, an online discussion platform, was not used. The implementation has three main phases: (1) Idea generation, (2) idea connection, and (3) pulling them together.
The time spent on the topic was approximately four hours (8 periods). Our pupils began their lesson on light with their science teacher laying down ground rules for learning. Adopting Berieter's (1994, 2002) principles for knowledge building discourse, the pupils were taught and encouraged to use discourse that involves commitment towards idea improvement. For instance, at the beginning of the lesson, the teacher laid down ground rules such as: “no criticism, no idea is stupid” and he constantly reminded his pupils to allow their peers to contribute ideas and to focus on idea improvement instead of giving unconstructive criticism.

This was then followed by “idea generation” activity. Pupils were seated in groups of 4-5 members. Pupils were given “think cards” to jot down their ideas on what light is about and they pasted these think cards on the class white board after they have completed generating ideas. The think cards are custom-made A5 size cards with two sections: the top section is green and it contains the cue “My idea is…”; the bottom section is red and it contains the cue “I need to understand…”

Next, the teacher then encouraged his pupils to paste their think cards on the classroom white board. During the “idea connection” stage, pupils took turns to arrange the think cards accordingly. The pupils were given the flexibility to arrange and reshuffled the cards according to the way they would like the cards to be categorized. During this process of trying to connect ideas, the teacher prompted pupils to think about the way they categorized the cards by encouraging them to justify their reasons. In the next two periods, teachers distributed the think cards randomly and instructed them to suggest improvement for their peers’ ideas. This process enabled the pupils to reflect upon the ideas they have generated previously and connecting it to their peers’ ideas. While the pupils engaged in the reflection and idea connection process, their teacher walked round to provide clarification and scaffolding.

In the final phase of “pulling it together”, each group was given a large white chart paper. A circle was drawn in the middle with the key question “What is heat and light?” Lines were drawn so that the space around the circle was divided equally into different sections. Each pupil was to write the main ideas they have learnt in the class in his/her section. The groups then took turn to present their ideas to other groups in the class.

Assessment

All pupils were given pre and post test before and after the intervention for assessing their knowledge on concepts pertaining to light. Due to time constraint, the researcher has decided to focus on knowledge test on the topic of light. The items of the tests were reshuffled in the post test and both tests were administered by trained personnel. Both testes consisted of three main questions asking for pupils’ drawing and justifications for the drawings. Fieldnotes on classroom observations and interview transcripts served as supporting evidences.

For the sake of an in-depth discussion, we only discussed the results gathered from one particular question, which is on the reflection of light in this paper. In this particular question, there is a diagram with a sun, a tree, and a boy. We required our pupil participants to illustrate their understanding on how the boy could see the tree by drawing lines to show the reflection of light and then explain his drawing using two to three sentences. This question (figure 1) was crafted based on the work of Eaton, Anderson, and Smith (1984). To obtain consistency, two coders coded ten pre and post test scripts. Thereafter, all test scripts were coded by a single coder, whose work was checked by the other coder. The purpose of such coding was to generate possible themes that would possibly explain the influences and impacts of the intervention on learning. Some primary themes on pupils’ explanatory framework were generated from our qualitative analysis.
Findings and Discussion

To recapitulate, the key research question is “are there changes in pupils’ conceptual understanding and explanatory framework on the topic of Light after going through knowledge building activity?” We used some of the principles of grounded approach to generate themes from the pupils’ answers in their pre and post tests.

Finding 1: From Specific to Generalised Statements

From the pretest, we observed that all 35 pupils gave specific descriptions of the objects stated in the question. For instance, one pupil wrote: “the sun has light and it travels to the tree” and another pupil also gave similar explanation: “the sun shines the tree, and the ground will have the shadow.” Similarly, one pupil explained: “The boy can see the tree when it’s dark.” No pupils were able to take a broader view in explaining his or her understanding on the reflection of light. It was apparent that our pupil participants tended to focus on providing specific descriptions of the sun, the tree, or the boy.

After the intervention, seven pupils attempted to generalize their explanation. However, only three of them were able to provide a more coherent and scientifically accepted response. In one instance, when one pupil wrote: “because anything reflects light” it was clear that he was trying to generalize his explanation, but such explanation was incomplete and failed to provide a more coherent understanding. In contrast, another pupil whose explanation was rather coherent wrote: “the sun travels in a straight line. After the sun hit the tree the light on the tree bounces to the boy’s eyes”

Finding 2: Attribution of agentive action in science phenomena

From both pre and post test, we believed that our pupils also tried to refine their initial explanatory framework by attempting to attribute the agentive action to particular objects. For instance, in one situation, a pupil initially said that: “because the sun shines everywhere.” He accurately drew the ray arrows, and he attempted to refine his explanations to: “The sun shines the tree than the tree shine the boy so that the boy can see.” Although one might argue that his explanation was still naïve and primitive as he gave agent to the tree, it was unquestionable that little steps were made to improve his understanding. Similarly, another pupil also improved his explanation from: “you said so I draw,” to “light traveled in a straight line. The sun gives light to the trees and it reflects to our eyes.” This improvement was closer to scientific explanation but he had given the agent to the sun. The improvements made by these pupils seemed to suggest to us that the knowledge building intervention had somehow perturbed the initial explanatory framework of your pupils and prompted them to modify their understanding.
Finding 3: The absence of scientific language

In our attempt to understand how children make sense of the natural phenomenon, we noticed that our pupils were unable to interpret the reflection of light using scientific language. Although a few pupils had tried to use scientific language to explain their understanding in the post test, most failed to use it appropriately. Majority of them consistently employed laymen terms to guide their formation of explanatory framework even when they were taught of scientific terms during the intervention and such terms were also used in their science textbook. Interestingly, during the pre test, we had observed that only five pupils used the word “travels” and the rest had used the word “shine” in their interpretation. For instance, one pupil said: “the sun has light and it travels to the tree.” Another pupil said: “the light travels toward the tree so that the boy can see.” In these two cases, “travels” was used, but it was not used appropriately to explain the reflection of light.

In the post test, more terms were used to describe the reflection of light, such as “travels,” “reflects,” “shines,” “bounces,” “lights,” and “hits.” The word “travels” was used in 7 occasions, “reflects” in 5 occasions, “Shines” in 6 occasions and “hits” in 4 occasions. An increase in the usage of non scientific terms such as “hits” and “bounces” might seem to hinder the process of understanding because they cannot accurately interpret the natural phenomenon, and this potentially increased chance of creating more misconceptions or naïve knowledge.

However, we observed that pupils had used non scientific terms to build better understanding in the post test. For instance, one pupil wrote: “the sun can shine anywhere” in his pre test, but he later refined it to: “it is because light falls into the object, it bounces off to the eyes.” Although the pupil did not use scientific term even in the post test, he had refined his initial understanding and formed a more logical explanation in his post test. Similarly, another pupil wrote: “the sun gives light to the boy and the tree so that the tree can be seen.” This pupil then refined his explanation to: “the light on the tree bounces off to his eyes.” Again, the explanation in the post test was relatively more appropriate but scientific term was not used. This was quite a prevalent phenomenon we observed in the post test. When we scrutinized the school science textbook we found no evidence of the usage of these terms and we had little evidence of our teacher participant using these terms as well. More research work would have to be devoted in this area to answer this query and substantiate our understanding.

An increase in the usage of scientific terms such as “reflects” and “travels” could imply that the pupils had achieved a better understanding of the natural phenomenon. This could be seen in one pupil’s responses. In the pre test, he mentioned: “the light has to shine to the tree so that the boy can see it (the tree).” His explanation was refined to: “the light reflects off the tree and travels into the boy’s eyes so that he is able to see the tree.” This pupil had apparently experienced the process of refining his explanatory framework by using scientific terms. In another similar situation, once pupil also wrote: “the sun is shining the boy” in his pre test and he later changed his explanation to: “the tree reflects light so that we can see the tree. Our eyes need light to see.” This pupil had replaced the term “shining” to “reflects” to form a more coherent understanding.

Findings 4: Inability to make distinction between relevant and irrelevant factors

There are evidences showing that pupils were unable to make distinction between relevant and irrelevant factors. For instance, in the pretest, a child wrote: “the tree had sunlight and the boy can see and grow.” Not only was the explanation inaccurate, the boy had also incorporated irrelevant evidence “the boy can grow” into his explanation. In the posttest, this pupil attempted to refine his understanding by writing: “the sun shines at the tree and the tree shine to the boy.” We preliminary concluded that this pupil had difficulty processing knowledge that seems to be abstract, and therefore he tried to make this process visible in order to assimilate the conflicting information that was presented to him in class into his initial understanding. Coincidently, another pupil also showed signs of inability to distinguish relevant and irrelevant factors. In the pretest, he wrote: “the sun is flashing at the tree and the boy is going there for a rest.” We believe that this pupil had attached irrelevant information to his explanation as a result of a lack
of capacity to explain the natural phenomenon. He had later refined his explanation to: “the sun shines at the tree and the tree shine to the boy.” Even when his ray diagram was accurately depicted, his explanation was insufficient to scientifically explain the abstract concept of reflection. Generally, pupils had attempted to remove irrelevant information from their initial explanation in the post test. In the post test, there was only one pupil who had irrelevant factor in his explanation.

Finding 5: Personification of concepts

There is a large literature evidently documenting children’s intentional explanations of human behavior at a young age (Wellman, 1990). From our analysis, personification of concepts was rather pervasive in the pretest. Personification of the source of light was most prevalent. That is, pupils tended to attribute human personalities and affections to the source of light. For instance, a pupil explained: “the light has to shine to the tree so the boy can see it.” The other wrote: “the sunlight can shine everywhere,” and another wrote: “the sun gives you the light to see.” It was apparent that our pupils had attempted to impose human actions and feelings to the objects they see in the natural world, forming their interpretation and understanding. Quite often, our pupils perceived the sun as the authority to “give” the tree light or enable the boy to see. Our pupils also interpreted the sun as one entity with high mobility as it could literally “travels” to anywhere it wanted to. This could be seen when pupils drew multiple rays protruding from the sun (figure 2). The sun was most widely portrayed as the active “sender” of light and the tree or the boy as the passive “receiver” of light. Interestingly, this phenomenon was very prominent in the pretest, but we had observed from the post test that when pupils were more inclined toward forming scientifically accepted explanations, they tended to move away from personification of concepts. For instance, one particular pupil changed his explanation from: “it (the sun) will make the boy not so hot” to: “the light travels to the tree so that the boy sees the tree.”

Figure 2. Pupil’s interpretation-personification of concept

Finding 6: Inappropriate usage of scientific concepts

Comparing pre and post tests results, we observed that a large number of pupils attempted to refine their explanatory framework by forming synthetic models (Vosniadou, 1992, 1994, 2000). For instance, a pupil wrote: “the sun will shine at the boy’s eyes and bounce to the tree in front of him.” His explanation was inaccurate and he did not use the term reflection appropriately. However, he had accurately drawn the ray diagram. Similarly, another pupil who had accurately drawn the ray diagram also provided a misinterpreted answer: “the sun travels to the tree so we could see the tree.” These evidences perhaps suggested that our pupils who were initially unable to interpret the concept of reflection, tried to incorporate accurate information to their initial conceptual framework in order to reach a coherent understanding. However, this led to the creation of synthetic models which is a combination of naïve understanding and scientific information. Our classification of pupils’ explanatory framework was perhaps
at an infancy stage and to develop a more robust system similar to Vosniadou (1992, 1994)'s categorization of conceptual models requires more research inquiry.

Conclusion

In this article, we presented preliminary findings from a pilot study that was designed to immerse pupils in a knowledge building environment for science learning. To accomplish the goal of helping our pupils constructively and collaboratively build knowledge in a culture that allows for the growth of personal and group cognition, we worked closely and co-designed classroom interventions with the school teachers. We sought to understand the characteristics and needs of the learners and geared towards developing a learning environment that enabled everyone in the community to perceive the value the contribution of ideas even when ideas are naive and are backed with little scientific interpretation. Although the explanatory framework of our pupils did not seem to have made tremendous improvement, it was encouraging to discover that majority of them had undergone active meaning making process during the intervention. From the pre and post test, it was obvious that all 35 pupils made attempts to modify their initial understanding. We believe that the knowledge building culture had created an impact on the way pupils construct their knowledge. Pupils’ ideas were valued and served as foundation for knowledge advancement. However, we acknowledge that how the social collaborative effort has contributed to the observed changes has not been established in this study. It will be an important part of our future investigation.

We had observed from the pre and post test that our pupils had struggled to grasp the concept of “reflection.” Most pupils believed that light brightens object so that we see them. Many of them had drawn accurate ray diagram in the posttest, but we were cautious about making conclusive judgment because most of their written justification could not substantially support the claim that they had indeed obtained or formed more sophisticated coherent explanatory framework. We documented some instances whereby our pupils had regurgitated and without internalizing information they received from the textbook. This prompted us to consider the indirect relationship of pupils’ background beliefs and scientific theories. Many researchers (Vosniadou & Brewer, 1992; Brewer, Chinn, & Samarapungavan, 1998) discussed the possibility of children applying plausibility as one of the most important criteria in forming their explanations on natural phenomena. If plausibility is one important criterion in pupils’ explanations, we then wonder whether traditional classroom practices or even our intervention adequately addresses this issue. To further exploit the usefulness of knowledge building, we will be dedicating more efforts study to explore the impact of knowledge building in the near future.

Based on our preliminary analysis, we believe that knowledge building culture has the potential of placing pupils in a community whereby they have every reason and motivation to co-construct new knowledge. Echoing the call from other researchers, we propose that the unit of analysis to be expanded beyond individual cognition to include peers and communities because the relationship between an individual and the society is inseparable, especially in the context of learning. People build or refine their knowledge structures on the basis of the information we shared, and the interactions we engaged. Evidently, children construct their mental model or form their explanatory framework based on their everyday experiences (Vosniadou, 1999) which comprises of personal observations or social interactions. If we could further analyze the dynamic interactions that take place during the knowledge building process, perhaps we could better develop effective and efficient instructional strategies that could facilitate this crucial process of meaning making.

References


