Examining the Real and Perceived Impacts of a Public Idea Repository on Literacy and Science Inquiry

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Abstract: Public idea repositories can facilitate beneficial interactions among students. They moreover offer contexts for developing inquiry and literacy skills, as they position students as writers, and not just reviewers of science. Access to peers' ideas can diversify students' thinking, but also reinforce existing understanding. We investigate the real and perceived impacts of different prompts for students' use of peers' ideas. 144 middle school students used an online tool to exchange ideas during a science inquiry unit. Students prompted to seek ideas different from their own perceived their peers as having greater impact on their thinking than students prompted to seek ideas that reinforced their own. Although students' revisions after exchanging ideas showed no actual change, students who diversified their ideas later showed significantly greater pre to post test gains. These findings suggest ways that technologies can be designed to best support students in taking advantage of peers as learning resources.

Keywords: public idea repositories, science inquiry, literacy, middle school, collaborative web-based curriculum tools, design experiment

Introduction

A principle in designing collaborative learning is to encourage exposure to others' ideas (Scardamalia, 2002). In comparing and contrasting different points of view, students strengthen their own understanding. Whereas it can be difficult for teachers to coordinate and track face-to-face interactions among their many students, technology can relieve some of this logistic burden, and promote students' exposure to others' ideas in ways that both improve and motivate science learning (e.g., Looki, Chen & Ng, 2009).

Public knowledge repositories, through which students can exchange ideas, offer authentic contexts for developing collaborative inquiry skills. Importantly, participating in the construction of a public knowledge repository positions students as writers, and not just reviewers of science (Scardamalia & Bereiter, 1993). It challenges them to articulate their understanding and as well as to select, evaluate, organize, synthesize, and interpret new ideas in relation to existing ones. This can help develop students' broader information literacy, which includes, among other things, an understanding of authority as constructed and contextual; of information as having value and of its creation as being a process; and of scholarship as being a conversation (ACRL, 2015).

Standards in information literacy emphasize the ability to use both divergent and convergent search strategies, but also to seek multiple perspectives when gathering and assessing information (ACRL, 2015). Whereas it is generally assumed that exposure to peers' ideas is valuable because it help diversify students' own ideas and expand their thinking, this exposure can also help refine and reinforce their existing understanding. For example, in a previous study, we examined the ideas students drew from their peers during a science inquiry unit, and the effects these had on their later written scientific explanations (Matuk & Linn, 2014). We found that students who sought peers' ideas that were redundant to their own were more likely to produce better quality explanations than students who sought ideas that diverged from their own. It was hypothesized that seeking redundant information amounted to refining one's own thinking, and imparted the benefit of learning by self-explanation (Roy & Chi, 2005). Meanwhile, other students may have sought diverse ideas because they were still exploring possibilities, and had not yet determined the key ideas necessary for a normative explanation. Thus, being drawn to divergent ideas may have been a red flag for students who required more conceptual guidance. These findings suggest there is more to know about which learners benefit from one strategy over the other, and when.

Two questions are pertinent, both for their relevance in designing and understanding the role of technology in supporting collaborative science inquiry, and in understanding the role of public knowledge repositories in general information literacy. One question is: What is the benefit of seeking divergent vs. convergent ideas on students' understanding? The impacts of each approach will gauge students' abilities to select and apply relevant information to a task. A second question is: What benefit do students perceive in exchanging ideas with peers? Their perceptions will gauge students' abilities to value others' ideas, as well as to recognize the need to evaluate others' contributions, which will vary in usefulness and relevance according to the task. Both questions address students’ awareness of their participation in an information-sharing community, and of the responsibilities this entails with respect to handling information.

Research questions

In this study, we ask what explicit instruction to seek contrasting vs. confirming points of view might reveal about the value of each approach. We investigate the impact on students’ understanding when they are prompted to draw upon their peers to either diversify or reinforce their own ideas. Specifically: (1) How do students view the impact of their peers’ ideas on their own understanding? (2) How do students revise their answers in response to their peers’ ideas? and (3) How does diversifying vs. reinforcing ideas impact students’ general conceptual understanding of a given topic?

WISE and the Idea Manager

We investigated these questions in the context of the Web-based Inquiry Science Environment (WISE). WISE is an open-source learning environment that offers a platform for authoring multimedia-rich units, and for monitoring, grading, and giving feedback on student work (Slotta & Linn, 2009). A library of adaptable classroom-tested middle and high school science inquiry units is available at wise.berkeley.edu.

This study uses the Idea Manager, a tool within WISE designed to promote the collaborative exchange of ideas during online science inquiry units (Matuk & Linn, 2014). Based upon the Knowledge Integration (KI) pattern of instruction, the Idea Manager guides students in integrating their prior fragmented ideas into a coherent understanding, first eliciting students’ existing ideas, and then iteratively guiding them in organizing, distinguishing, and reflecting upon those ideas (Linn & Eylon, 2011). The tool thus emphasizes the development of information literacy by encouraging students to meaningfully organize and synthesize information from various sources, to monitor gaps in understanding, and to draw conclusions based on the interpretation of information gathered (ARCL, 2015). The Idea Manager scaffolds this process by breaking it down into manageable steps, providing a persistent space within which students can document their prior and existing ideas (Figure 1, left), share them with their classmates (Figure 1, right), and organize them as they prepare to write an explanation (Figure 2). WISE meanwhile logs the content of students’ ideas; when these were added, shared, revised, or deleted; and with whom they were exchanged. Thus, in addition to scaffolding students’ collaborative inquiry, the tool also provides a record with which researchers can examine students’ developing understanding (Matuk & King Chen, 2011), including the role of peers.

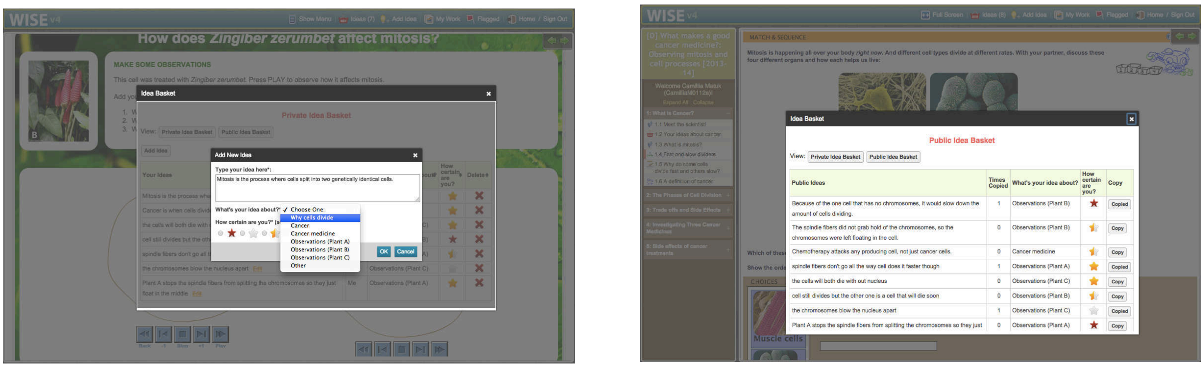

Figure 1. *Left:* Interface from *Mitosis* for adding ideas to the Private Basket. *Right:* Interface from *Mitosis* for selecting ideas from the Public Basket

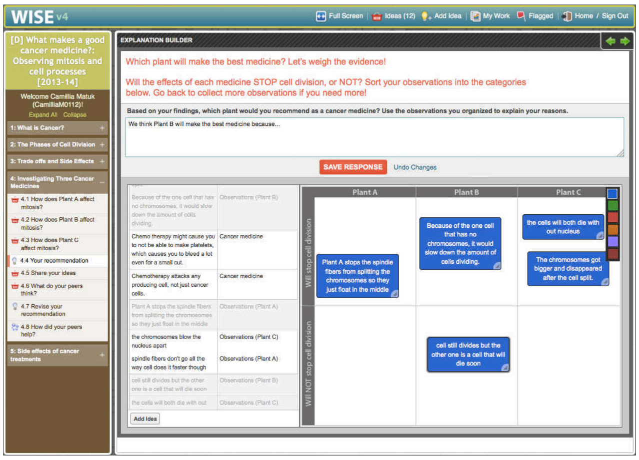

Figure 2. Interface from *Mitosis for* sorting ideas before recommending an effective cancer medicine

Methods

Participants
Participants were the 144 students across five class periods taught by one Grade 7 science teacher. The school was located on the west coast of the United States, and served a diverse but affluent student population. The teacher had more than 6 years of experience teaching with WISE, including previous versions of *Mitosis*.

The *Mitosis* unit
We integrated the Idea Manager into a middle school life sciences unit freely available at wise.berkeley.edu. In *What makes a good cancer medicine?: Observing mitosis and cell processes* (aka, *Mitosis*), students worked in pairs to explore videos, animations, and microscopic imagery of dividing cells as they learn about cancer and the phases of cell division. Throughout the unit, students used the Idea Manager to collect their observations, exchange ideas with peers, and sort ideas by dragging and dropping them into categories to prepare their written recommendations (Matuk & Linn, 2013). As a culminating activity, students examined separate animations of three dividing cells, each treated with a different plant-derived cancer treatment, and compared these to normal cell division. Students then refined an argument for the most effective cancer medicine based on their observations. For whichever option they chose (neither one being more or less correct), students were asked to write recommendations that integrated ideas about the roles of cell structures in the phases of cell division, the mechanism of cancer, and the action of an effective cancer medication (i.e., to stop cell division).

Study design
The study design is as follows (Figure 3). All students spent eight consecutive school days working in pairs to complete the *Mitosis* unit while their teacher and a researcher circulated the classroom to offer assistance as needed. The teacher also led whole class discussions each day to provide conceptual and logistic guidance.

Throughout *Mitosis*, all student pairs collected ideas in their *Private Baskets*, and organized and used these to support written recommendations for which of three plants would make the most effective cancer medicine. Students were then encouraged to contribute the ideas they used in their recommendations to a *Public Basket*, which was visible to their classmates. Students were then asked to visit the *Public Basket* and to select at least one of their peers' ideas to add to their *Private Baskets*.

Students were divided by class period into two groups. (Although this produced an uneven number of students in each group, we favored this approach because it made the job of grading students' work easier for the teacher.) Students in the *Diversify* group (Periods 2 and 5, N=59) were prompted to select ideas they did not already have. Students in the *Reinforce* group (Periods 1, 3, and 7, N=85) were prompted to select ideas that supported their existing ideas. All students were then encouraged to revise their initial recommendations based on these newly added ideas. Before advancing through the unit, students were asked to compare and contrast the new ideas with their existing ideas, to articulate what they modified on revising their recommendations, and to explain how their peers' ideas helped improve those recommendations.

Students spent an additional two days—one before and one after the unit—to individually complete a pre and posttest. Items on these tests were designed to measure conceptual understanding of the mechanisms of, and the relationship between cancer and cell division. Students were asked to order images and explain the importance of specific phases of the cell cycle, and to propose and explain the effect of an effective drug based on their understanding of cancer and mitosis. One item was designed to capture students' abilities to evaluate new vs. existing ideas when constructing scientific explanations. This item asked students to select from a range of given ideas, one that they would add to an existing repertoire of ideas that would help create a complete explanation for the role of spindle fibers in cell division.

In addition to the written responses to the embedded items and pre and posttest assessments, we also asked for students' impressions of the unit upon their completion of it. In an online survey, we specifically asked students what they liked best about the unit, and what they felt could be improved.

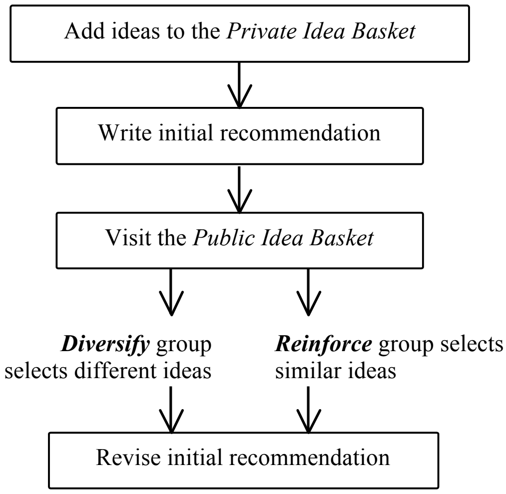

Figure 3. Study design, showing the sequence of activities throughout the *Mitosis* unit

Data and analyses

Measuring the perceived and actual impact of peers' ideas

To measure students' perceptions of the impact of their peers' ideas on their thinking, we scored the embedded items, in which students reported what they changed in their initial recommendations, and how they felt their peers' ideas helped improve their responses. Our scoring rubric had four levels, which ranged from reports of no effect of their peers' ideas, to a reinforcement of existing ideas, to reports that peers' ideas encouraged elaboration of existing ideas, to reports that peers' ideas entirely changed students' initial points of view (Table 1). We used a similar rubric to measure the actual impact of peers' ideas on students' understanding. Based on the differences between the initial and revised recommendations, scores ranged from peers ideas having no impact (i.e., students made no revisions to their recommendations), to having changed students' initial thinking (Table 2).

Table 1: Rubric for measuring the perceived impact of peers' ideas on students' revisions

Score	Description	Example
1	**No change.** Students report making no changes to the content and wording of their initial recommendation.	we did not change our recommendation it stayed the same
2	**Increased confidence in existing ideas.** Students report altering the wording without changing the content of their recommendation.	We didnt change our opinion about plant A being the best medicine but looking at the other ideas we grew more sure because it increased our knowledge of the plant.
3	**Detail added.** Students report including new information that elaborates without changing the content of their recommendation.	the thing that we changed about our recomendation based on the ideas we got from the public idea basket is that we got more information to explain what happened to the cell when it was treated with plant b
4	**Major changes.** Students report changing their initial point of view.	We changed our guess o(f) which plant to use. We saw others' ideas and thought that they made more sense. Plant B suddenly felt better than Plant A.

Table 2: Rubric for measuring the actual impact of peers' ideas on students' revisions

Score	Description	Example
1	**No change.** The revision maintains the content and wording of the initial recommendation. Some initial detail may be lost on revision.	***Initial:*** C-both of the cells die. We chose this one even though there is a chance of other cells dies. On the A plant, the cell become useless. On plant b, one cell dies, the other is still alive. ***Revised:*** We want plant C because it kills the cell, so it cant multiply any more
2	**Reworded.** The revision restates the content in different words but maintains the same level of detail in the content	***Initial:*** I think its B because having no chromosomes is not as bad as not reproducing, or chromosomes non stop growing. ***Revised:*** we still think that plant b is most effective because the cell still reproduces even though it has no chromosomes
3	**Detail added.** The revision elaborates without changing the content of the initial recommendation.	***Initial:*** We think that Plant A will solve cancer because it stops the spindle fibers from creating the two new cells. Therefore, mitosis is stopped and cells won't divide as much. Because of that cancer will slow down and might finally be cured. But, there is also a possibility that Plant A will stop cell division forever. Also, Plants B and C still let the cells divide, but the medicine still affects the cell. ***Revised:*** We think that Plant A will solve cancer because it stops the spindle fibers from creating the two new cells. Therefore, mitosis is stopped and cells won't divide as much. Because of that cancer will slow down and might finally be cured. But, there is also a possibility that Plant A will stop cell division forever. Also, Plant B still creates new cells although one of the cells doesn't have a chromosome. Plant C also creates more cells even though they both get their nuclei bigger.
4	**Major changes.** The revision reflects a different point of view from the initial recommendation.	***Initial:*** We would use the plant A because it stops mitosis earlier than the other, because it doesn't mess up the cell with its normal function. we would not chose plant B because it doesn't stop cell division it like mess the normal division and that can makes a worse problem. We didn't chose plant C because it stops mitosis to late, it mess around the process and it make's it worse and because they would be two different cells but without a nuclear membrane, and that is bad. ***Revised:*** We think that plant B is the best medical treatment because in Anaphase one of the cells will not have chromosomes and that will kill one of the cells because every cell needs chromosomes to survive. Another reason is that after that happens the cell that doesn't have the chromosomes will die and we will keep with only one cell, then that cell will divide and it is better that only one cell divides than if the two divide, because you will get less cells after cell division so that medicine will control the cancer. We didn't chose plant A because plant A stops cell division so then the cell will not do mitosis again. It stops the spindle fibers from lining up the chromosomes, and that stopped mitosis,and if the cell does mitosis the same each time it does it, that will make the cell never do mitosis again. That will be bad for the body to function, because will wouldn't have cells to function. We didn't chose plant C because it does it very slow and it mess up the cell. It doesn't make Telophase and that is important for the cell to work in order. It will make that one cell have a nuclear membrane and the other one not and that is not good for the cell. The one that doesn't have the nuclear membrane it expands through the cell, and then it will function messily. That is why we chose plant B, it will be more effective and will not damage the cell.

Measuring pre and posttest gains

We used unique Knowledge Integration rubrics to score each item of the pre and posttests. These 4-point rubrics credit responses that correctly link key ideas. One item, for example, asked students to "Explain the effect your drug would have on the different parts of the cell in that phase, and how this would help keep cancer growth under control." For complete normative responses, we sought at least three key ideas, including an understanding that an effective medicine would stop cell division, a mention of the organelles affected, and an explanation of how the medicine would disrupt the normal actions of those organelles. Responses that correctly linked these three ideas received full marks, while those that linked fewer ideas received fewer marks. We averaged the KI scores across all items to obtain overall pre and posttest scores for each student.

Findings and discussion

Perceived and actual impact of peers' ideas

There was an overall significant difference between conditions in the perceived impact of peers' ideas (t=2.794, df=60.485, p=.007) (Figure 4, left). Specifically, students prompted to choose ideas different from their own were more likely to report these ideas as having helped them add details or modify their thinking (M=3.17). Meanwhile, students prompted to choose ideas similar to their own were more likely to report these ideas as having merely increased their confidence in their existing ideas, or as having had no impact on their thinking at all (M=2.65).

In measuring the actual impact of peers' ideas on students' revisions, it appeared that students who sought to reinforce their ideas also tended to view their revisions as simple rewordings or additions of detail to their initial recommendations compared to students who sought to diversify their ideas (Figure 5, right). However, this trend was not significant. That is, in spite of their perceived impacts, there did not appear to be any real impact on students' revisions between the *Diversify* (M=3.22) and *Reinforce* (M=3.13) conditions (t=0.388, df=47.425, p=.700) (Figure 5).

Together, these results suggest that peers' ideas had a bigger perceived than actual impact on students' thinking.

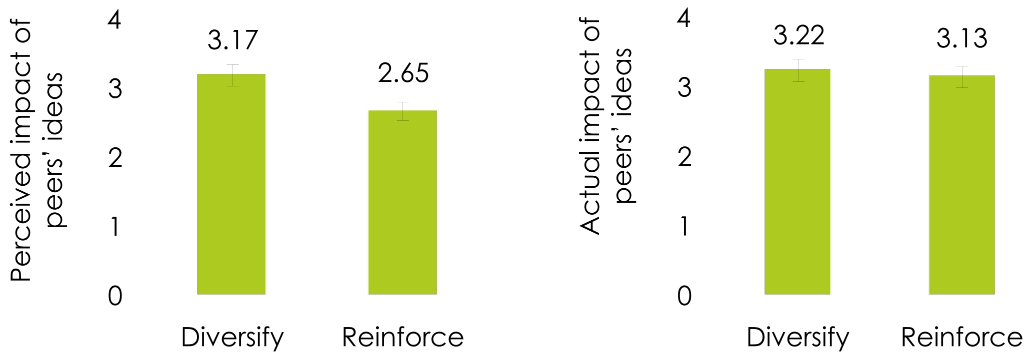

Figure 4. The perceived (*left*) and actual (*right*) impact of peers' ideas on students' written recommendations

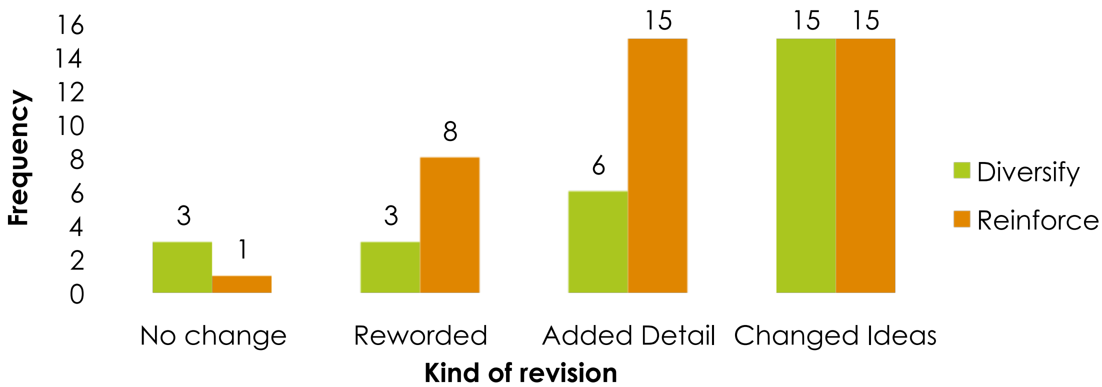

Figure 5. Frequencies of the kinds of revisions made by condition

Pre and post test gains

There were significant differences in pre to post test gains between conditions (t=2.136, df=122.948, p=0.03). Students who drew on their peers to diversify their ideas performed better on the posttest (M=1.19) than students who drew on their peers to reinforce their existing ideas (M=0.911). Thus, whereas the earlier results suggest there may not be any immediate or direct impact, prompting students to diversify as opposed to reinforce their ideas with those of their peers can ultimately promote more general conceptual understanding of the topic.

Other impacts of technology for sharing ideas

Collaborative tools such as the Idea Manager support a process of science inquiry that is more authentic than typical classroom science instruction. Such tools also have important motivational qualities. Indeed, students appeared to enjoy the ability to exchange ideas with their peers. As they commented in the survey at the end of the unit: "i liked how i could make an idea and share it with my class" and "I liked working together to combine our ideas."

For some students, the benefit of being able to access their peers' ideas appeared to extend beyond mere perception to actually encouraging revisiting and reconsideration of evidence in the unit, skills that are integral to science inquiry. As these students describe the impact of their peers: "they helped us see some mistakes , that the treated cells made, that we didnt see. Such as how in the plant C treated cell the chromosomes expanded and got bigger."

At the same time, access to a public repository of ideas also made it possible for students to be swayed by popular opinion. This student pair, who revised their response to recommend Plant B over Plant A, explains: "We saw more people that said the same thing about Plant B. They all were talking about one pair of chromosomes being killed. This felt better than A, which was the spindle fibers retracting. There were more Plant B than A explanations."

Conclusions and implications

This study investigated different ways of prompting the use of a collaborative tool to help students take advantage of their peers' ideas. In offering a public repository for ideas within an online science inquiry unit, we found that students perceived their peers as having greater impact on their thinking when encouraged to draw on their peers to diversify as opposed to reinforce their own ideas. In spite of students' perceptions, there were no impacts seen in students' actual revisions.

This finding may indicate an inability for students to realize the influence of new information on their understanding. Alternatively, it may be an artifact of the task design. Recall that an explicit prompt for students to either diversify or to reinforce their ideas was followed by a prompt to detail the impact of their actions. The formal context of this task may have led students to respond in a way that demonstrated that they followed the instructions, rather than to express recognition of real the impacts of their peers. Meanwhile, the fact that students who sought to diversify their ideas during the unit later showed greater pre to posttest gains than students who sought to reinforce their ideas, may indicate a real learning benefit in the diversification of ideas, at least among this group of students.

With more data, we might verify whether evening out the numbers of participants in each group would affect the significance of our findings. With more data, we might also quantify the observations made in the cases selected for our analysis. Nevertheless, our results suggest that explicit prompts to draw on a range of peers' ideas may encourage students to reconsider evidence and revise their own thinking. These are important practices to cultivate in developing science inquiry skills. Although these effects may not be immediate, they appear to have longer-term, and more general advantages. At the same time, there is evidence that some students are prone to be persuaded by the majority opinion rather than to objectively weigh peers' ideas. The implications of such behaviors over time, possibly in contributing to an increasingly homogenous public knowledge repository, deserve further investigation. What is clear is that the use of such repositories is thus not without caveats, and students may benefit from support in evaluating new information as they are exposed to their peers' ideas.

Further analyses will examine how the content of students' recommendations may have improved as a result of exposure to their peers' ideas, and what may have been the relative benefits of the kinds of revisions made as a result of diversifying vs. reinforcing ideas. Questions that remain for future investigation include: When in the inquiry process is it more helpful to diversify vs. reinforce one's ideas, and for which kinds of students (e.g., low vs. high prior knowledge)? How important is the perceived source of new information (e.g., classmates, teachers, or authoritative text)? Finally, what might be the teacher's role in moderating students' interactions within these public online spaces?

In all, this study reveals more about how tools such as the Idea Manager can help students draw on the knowledge of their peers to make sense of scientific ideas; improve literacy in general, as well as literacy in science; and help students recognize the responsibility associated with being part of a community of knowledge builders.

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Acknowledgments

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