

Using a Vicarious Learning Event to Create a Conceptual Change in Preservice Teachers' Understandings of the Seasons

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Abstract

Preservice teachers are entering science methods courses with misconceptions of topics they will likely teach; science methods educators need to find ways to help address their misconceptions. The purpose of this study was to discover whether a vicarious learning event, viewing a video of a discussion of students' misconceptions on the causes of the seasons, could create a conceptual change towards the misconceptions of preservice elementary teachers. Ten-weeks after viewing the video, half of the misconceptions initially identified in the preservice teachers had changed to the scientifically accepted explanation, suggesting that this may be one way to help change preservice teacher's misconceptions.

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Introduction

Misconceptions or naïve theories about many scientific phenomena exist for people of all ages. These misconceptions are “ways of construing events and phenomena which are coherent and fit with their domains of experience yet which may differ substantially from the scientific view” (Driver, Squires, Rushworth, & Wood-Robinson, 2000, p. 2). Preservice elementary teachers hold many of the same misconceptions about many scientific phenomena as children (Atwood & Atwood, 1996; Kikas, 2004); a problem if they are expected to teach these phenomena to students. Scholarship thus far has focused mainly on giving students of any age, including preservice teachers, activities and/or interactions to help successfully correct these misconceptions and create a conceptual change (Driver et al. 2000; Duit & Treagust 2003; Marion, Hewson, Tabachnick, & Blomker, 1998; Weaver, 1998). For science teacher educators, this process requires them to become aware of the preservice teachers' misconceptions, design a lesson that will provide a dissatisfaction with the misconception, and then a chance to process the information and develop the scientifically accepted understanding of the topic. While this direct experience method is preferred, a single elementary science methods course can only address a limited number of misconceptions in this way. In our

experience, science teacher educators often only have a semester with preservice elementary teachers, which is not enough time to both address all of the misconceptions with a hands-on approach described above and teach the preservice teachers about science teaching methods, theory, etc. Interestingly, what is rarely included in the discussion of changing misconceptions is the inclusion of the misconceptions directly in the lesson; that is, using the misconception as a means of creating a conceptual change has not been addressed in the research literature. When working with older learners, like preservice teachers, an inclusion of the misconception in a lesson might correct the misconception (Muller, Bewes, Sharma, & Reimann 2007). Inclusion of misconceptions, while not the ideal teaching method for creating conceptual change, might provide an efficient and effective way of altering preservice teachers' numerous misconceptions before they begin their teaching practice. We are committed to hands-on, inquiry-oriented approaches to teaching science and understand some may view the approach described in this study as a step backward. That is not our intent. We simply sought to address the realities of our classrooms where we are unable to address all of our students' misconceptions during our short time with them.

Statement of the Problem

If preservice elementary teachers enter science methods courses with misconceptions of topics they will likely teach, then science teacher educators need to find a way to help these students adopt scientifically accepted understandings of these topics within the short period of time allotted for the course while also addressing traditional topics, science methods, learning theory, etc., of such a course. For example, many preservice teachers cannot correctly explain the reasons for the seasons, which is a common topic in elementary school science (Atwood & Atwood, 1996; Kikas 2004). There are many activities, similar to those that could be used with elementary students, which could be included in methods courses to help preservice teachers adopt the scientifically accepted explanation for the causes of the seasons (e.g. Schneps & Sadler, n.d.), yet activities of this type require hours in a science methods course that is typically only one to two semesters in length. This study used a relatively short vicarious learning event to address preservice teachers' misconceptions on the topic of the seasons with the hope of providing a possible effective and efficient tool for changing teachers' misconceptions on this topic, and perhaps a variety of topics. For this research, a vicarious learning event is defined as watching the learning of another about a specific topic with no direct instruction or activities on the topic. The purpose of this quasi-experimental study was to discover whether a vicarious learning event, viewing a discussion of students' misconceptions on the causes of the seasons, could create a conceptual change towards the misconceptions of preservice elementary teachers at a large Midwestern university.

Relevant Literature

To date, there are no studies concerning the inclusion of a discussion of a misconception, like the misconceptions concerning the seasons, as the sole learning tool for correcting that misconception with students of any age. While articles have discussed activities and methods for creating conceptual changes to challenge misconceptions, only

a few have included a discussion of the misconception within the activity. Vicarious learning events largely have been examined in order to affect self-efficacy and computer learning (Chan & Lam, 2008; Gholson & Craig, 2006; Mayes, Dineen, McKendree, & Lee, 2001; McKendree, Stenning, Mayes, Lee, & Cox, 1998; Smith, 2001; Tang, Addison, LaSure-Bryant, Norman, O'Connell, & Stewart-Sicking, 2004; Wang & Ertmer, 2003), but they have not been examined in relationship to correcting a misconception.

In this section, literature relating to three main areas concerning this study will be reviewed. This first section presents research and theory about misconceptions or naïve theories, including specific research on the misconceptions about the causes of the seasons that have previously been found to be held by children and preservice elementary school teachers. The second section presents literature suggesting ways of correcting misconceptions and creating conceptual change. The final section examines vicarious learning and its uses in learning.

Misconceptions

From a very young age, children use their senses and their interactions with others to begin to make sense of the world around them (Driver et al., 2000). Constructivist learning theory explains that these observations and interactions allow children, or anyone, to construct or build their knowledge about the topic which they are interacting (Bodner, 1986; Lorschach & Tobin, 1992; Scott, Asoko, & Leach, 2007). The constructed knowledge and explanations for a phenomenon then “fit” with the persons experience but do not always agree with the scientifically accepted explanation for the phenomena (Bodner, 1986; Driver et. al, 2000; Michaels, Shouse, & Schweingruber, 2008). Explanations or conceptions which do not match the scientifically accepted explanations are often termed misconceptions or naïve theories (Bodner, 1986; Driver et al., 2000; Michaels, Shouse, & Schweingruber, 2008). For example, Michaels, Shouse, and Schweingruber (2008) and Driver et al. (2000) discuss children's misconceptions about the seasons. Children's experiences tell them that if they stand close to a heat source like a fire, then they will feel warm and as they get farther from the heat source they will not feel as much heat. Since students know it is warmer in the summer and colder in the winter and that the “heat source” for the earth is the sun, students might say that the Earth is closer to the sun in the summer and farther away in the winter. Based on their experiences, this explanation makes sense but it is not the scientifically accepted explanation for the causes of the seasons.

Misconceptions or naïve theories may be part of the natural learning process for children requiring little or no formal education in order for them to change (Michaels et al., 2008). Yet many misconceptions do not change with time and are even resistant to change with direct instruction, and thus children carry them with them into adulthood (Bodner, 1986; Driver et al., 2000; Weaver, 2009). Misconceptions or naïve theories are often resistant to change because of how they are developed, through experiences and interactions (Bodner, 1986; Driver et al., 2000). Students' misconceptions also develop when they infer similarities between situations which scientifically are very different, i.e. a heat source and the cause of the seasons (Driver et al., 2000; Michaels et al. 2008).

Also, some scientific explanations are counterintuitive or unlikely for children to encounter daily (e.g. atomic theory), thus occasionally some misconceptions can be constructed as students learn about the topic (Michaels et al., 2008). Part of the goal of science instruction is to help students understand and explain the scientifically accepted explanations for phenomena, which requires changing children's and even adults' misconceptions.

Relevant to this study are the specific misconceptions about the seasons which children and preservice teachers hold. Research has been conducted with both groups. According to Driver et al. (2000), there are three common misconceptions held by children. These misconceptions are that the seasons are caused by (1) the earth's changing distance from the sun (the most commonly held misconception), (2) changes in the plant life, and (3) the rotation of the earth.

Atwood and Atwood (1996) have shown that preservice elementary teachers hold the same misconceptions on seasons that Driver et al. reported for children. Atwood and Atwood found one additional misconception not clearly noted by Driver et al. They found that some preservice teachers described the Earth as changing the angle of its tilt and this caused the season.

Kikas (2004) expanded upon the research done by Atwood and Atwood (1996). She also showed that primary teachers and preservice teachers did not understand basic reasons for the seasons. She found that while they often identified the scientifically correct answer to a question they could not explain their choice with scientific accuracy. Their explanations showed the same misconceptions identified by Atwood and Atwood.

Conceptual Change

As the studies above have shown, preservice elementary teachers often hold misconceptions about the seasons, a topic they may well teach, which need to change. This requires creating a conceptual change. Chi, Slotta, and de Leeuw (1994) explained why conceptual change can sometimes be difficult. They argued that misconceptions that are difficult to change occur when the mind has knowledge categorized incorrectly. For example some knowledge may be in the students "matter" category when really it belongs in a "process" category. If the information is in the right category but the wrong subcategory, it can easily be corrected, and thus is not a strong misconception requiring conceptual change. "Conceptual change occurs when the category, to which the concept is assigned, changes" (Chi et al., 1994, p. 27-8).

To create this conceptual change, authors have pointed out the need to know the misconception first and then create lessons and activities for creating a conceptual change. Driver et al. (2000) explained that teachers first need to discover students' misconceptions through pretests, opening activities, questioning, or research about the topic they will be studying. Then teachers should analyze the misconceptions, exploring where the nature of the differences between the students' ideas and the scientific ones. Then activities should be planned that teach the subject but also give time and attention to exposing and correcting the students' misconceptions.

While Driver et al. (2000) wrote for secondary teachers, Modell, Michael, and Wenderoth (2005) promoted the same ideas for collegiate teachers as well. Uncovering misconceptions should be a diagnostic tool for instructors so that they can create activities that “help learners recognize errors in their mental models” (p. 26). They emphasized the fact that the activities created should guide students to see their own misconceptions and then correct them.

Weaver (1997) extended the discussion of the appearance of the activities. She looked at teaching strategies from teacher, student, and observer perspective in 4th, 8th, and 10th grade classes. She concluded that to achieve conceptual change and “encourage deep processing” as argued by Chinn and Brewer (1993) strategies need to include hands-on and relevant content to students' lives. She emphasized the need for strategies that “involve an integrated approach to laboratory instruction in which context, process and reflection with respect to content are used jointly” to create conceptual change (p. 471).

Duit and Treagust (2003) summarized the evolution of the practice for creating conceptual change, expanding on the previously mentioned studies. The best known model for conceptual change involves creating a dissatisfying moment for the students; something that does not fit with their ideas on the topic. Then students are presented with a reasonable replacement. Duit and Treagust explained that this basic model is evolving. Lesson designs for conceptual change are also placing an emphasis on “individual and social aspects of learning” (p. 675). This includes moments for discussion and reflection.

Finally, Marion, Hewson, Tabachnick, and Blomker (1998) described effective methods of teaching preservice teachers about conceptual change and how the teachers can create lessons for their future students that will cause a conceptual change. According to Marion et al. effective methods teach teachers how to create conceptual change by (1) modeling activities and giving teachers direct experiences with conceptual change activities, (2) providing the teachers with a chance for reflection, and (3) giving them practice planning and implementing lessons with feedback from colleagues and instructor.

All of the research discussed above emphasizes a need for activities or hands-on experiences. Several also emphasize the importance of verbal discussions and reflections to create conceptual change. None of the research suggests that an explicit discussion of misconceptions should be included in the lesson. Nor do any suggest that a conceptual change can be created from an event in which the student does not directly interact—a vicarious learning event.

Vicarious Learning

Gholson and Craig (2006) defined vicarious learning as knowledge acquired by a person who is not being directly addressed and is physically passive. They found that in a computer-based learning environment a good vicarious learning experience, which creates conceptual change, “request[s] learners to self-explain using content-free prompts” (p. 133). They also found that students learned more when watching a dialogue between a tutor and student than when watching a monologue.

McKendree, Stenning, Mayes, Lee, and Cox (1998) discussed the importance of dialogue in education. They affirmed that dialogue helps convey and create shared assumptions and interpretations. They also affirmed that viewing dialogue may help students learn because the students are not emotionally involved in conversation so there is less stress and better chances to evaluate and reflect.

In their research Mayes, Dineen, McKendree and Lee (2001) examined the connection between dialogue and computer-based vicarious learning experience. They provided an experimental group of students learning about *Models on Learning with Technology* with a chance to watch videos of “Task Directed Discussions” about the primary subject matter they were learning. They found that students who watched the videos modeled discussion techniques in a required discussion significantly better than the control group. There was not a significant difference in the amount of content-based knowledge achieved by the two groups. Mayes, Dineen, McKendree and Lee concluded that the vicarious learning experience in which a dialogue is involved can help students learn behaviors that will help them learn.

Many studies have been done to show the effects of vicarious learning on self-efficacy (Chan & Lam, 2008; Smith, 2001; Tang et al., 2004, Wang & Ertmer, 2003;). For example in research involving self-efficacy, vicarious learning, and science, Luzzo, Hasper, Albert, Bibby, and Martinelli Jr. (1999) exposed college freshman to a performance experience, a vicarious learning experience, both, or nothing in an attempt to change their self-efficacy with respect to math/science courses and career choices. They found the vicarious learning experience alone did not make a significant difference to math/science career self-efficacy, nor did performance alone, but when paired together they made a significant difference over the control group. This intervention was a one-time event for no more than thirty minutes and it was trying to change student self-efficacy that had been building for years; a difficult task for any type of learning experience in such a short time.

Finally, one piece of research has begun the process of combining the ideas of vicarious learning and creating a conceptual change to correct misconceptions in science. In their study, Muller, Bewes, Sharma, and Reimann (2008) randomly gave first-year college physics students four different ways of learning Newton’s first and second laws through a multimedia computer presentation. The first way was a traditional presentation of the material. The second was a traditional presentation with extensions and application to life included. The third way included a discussion of typical misconceptions in the mostly traditional presentation of the laws. The final method was a tutor-student dialogue (a vicarious learning experience) about the subject and common misconceptions. Students in these third and fourth groups showed significantly higher gains from pretest to post test than students in the first two groups with traditional and expanded traditional presentations. Muller et al. concluded that the inclusion of misconceptions was not problematic to learning. Also if the misconceptions were part of multimedia, it might free teachers to include them as it would reduce time constraints to the inclusion or any disconnect they might have in their own knowledge.

Methodology

The purpose of this quasi-experimental study was to discover whether a vicarious learning event, viewing a discussion of students' misconceptions on the causes of the seasons, could create a conceptual change in the misconceptions of preservice elementary teachers at a large Midwestern university. The research method sought to answer the following questions:

- What misconceptions about the seasons do these preservice teachers hold at the start of this study?
- How does viewing a discussion of students' misconceptions on the causes of the seasons change these preservice elementary teachers' explanations of the causes of the seasons?
- Did the preservice teachers' explanations remain 10 weeks after watching the discussion of misconceptions?

Participants

A convenience sample of eighty-one preservice elementary teachers (N=81) consented to participate in this study. The preservice teachers were enrolled in science methods courses at a large Midwestern university during the spring semester of 2009. The preservice teachers were in their third or fourth year of study. The participants did not receive any instruction in their science methods course or other methods course about the causes of the seasons other than the video used in this study.

Data Collection

The eighty-one preservice teachers were asked to answer the following on a piece of paper that was collected once they had finished answering it: "Please explain in as much detail as possible what causes the seasons (summer, winter, etc.). Feel free to draw pictures if that will help in providing as complete an explanation as you can." Then, following the submission of their initial responses to the question, as part of a lesson on misconceptions in science, the preservice teachers watched the 20-minute video *A Private Universe* produced by the Harvard-Smithsonian Center for Astrophysics (1987). The video includes Harvard graduates and three ninth-grade students explaining with words and pictures what they think causes the seasons. Then experts discuss the students' misconceptions and what this means for science educators. There is no direct instruction on the causes of the seasons. Like many who use this popular video series, this video was chosen because it was relevant to course objectives. The discussion of students' misconceptions, including the difficulties teachers often find in changing them, related directly to the topic of misconceptions and their use in lesson creation. It was hoped that in creating this connection to the course work, the participants would actually engage with the video. This video was also chosen because it addresses a misconception that preservice teachers commonly hold as well, but a topic that is not included in the content

of the methods course, so if a change in the participants' understanding of the seasons was observed, then the video, not the course, would likely be responsible.

During the next class period after watching the video, the preservice teachers were again asked to answer the question above, in writing, to see how their answers changed. Ten-weeks later the preservice teachers were again asked to write an answer to the same question to assess the lasting effects of the video.

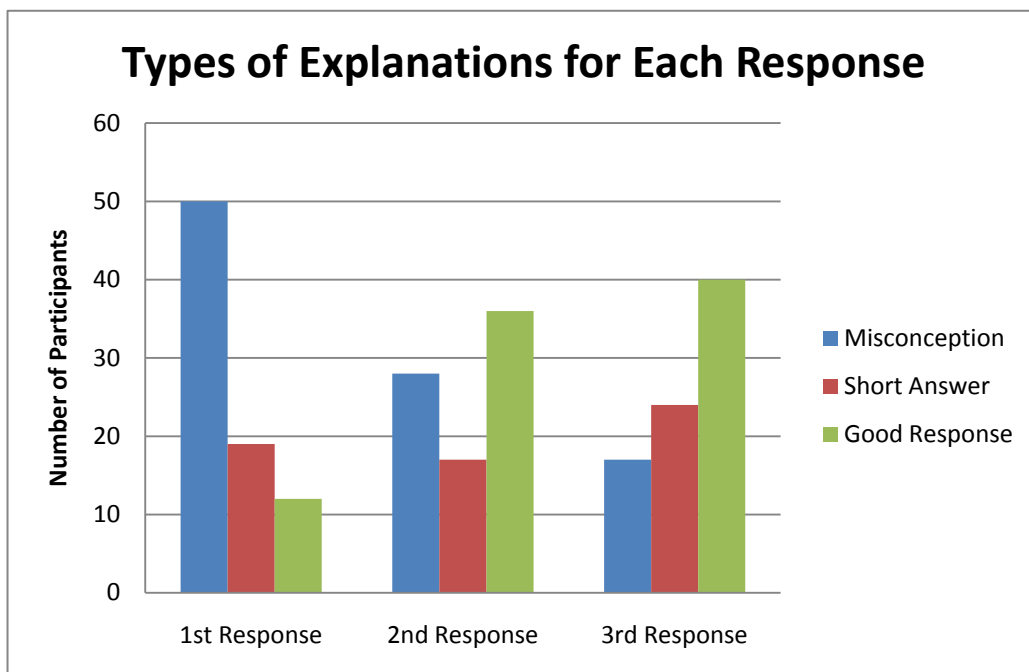
Data Analysis

A large sample of participants' responses were read by the first two authors with the intent of finding patterns or commonalities within the responses. Through a reiterative process of each researcher looking for patterns or commonalities and then checking with the other researcher, three groups were identified and agreed upon for further analysis. The next step of analysis was to categorize or code the responses into one of these three groups, (1) Contains a Misconception, (2) Too Short, or (3) Good Scientific Response. Each researcher then categorized another sample of responses and then met to discuss their level of agreement and any discrepancies, as they worked towards consensus on the categorization of each response. Each response was assigned a group number as a score. The researchers then read another sampling of responses and rated them in the same way. This reiterative process of cross-checking codes/categories was used to increase the inter-rater or inter-coder reliability (Miles & Huberman, 1994). An answer that demonstrated any sort of misconception (i.e. "the earth is closer to the sun in the summer" or "the seasons are caused by the tilt of the Earth which changes as it orbits the sun") was placed in group one. An answer that did not have enough information written to present a clear picture of the preservice teacher's understanding (i.e. "The seasons are caused by the tilt of the earth") was placed in group two. To be part of the Good Scientific Response group, the response must have mentioned, in writing or shown through their drawing, at least three items: (1) that the earth is tilted/angled, (2) that the tilt of the Earth does not change as it rotates about the sun, and (3) that tilting towards the sun results in summer while away results in winter. Good responses may have included ideas about direct and indirect sunlight and/or the difference between the two hemispheres but this was not required. During the reading and categorizing, misconceptions were also collected and listed. The scores (categories) from each of the three different responses for each preservice teacher were then recorded. A Chi square test was then performed to confirm that the results were different than the norm.

Results

For the initial response ($X^2 = 30.296$, $p < .0005$), 50 (62%) of the preservice teachers ($N=81$) provided an explanation for the causes of the seasons that contained a misconception, 19 (23%) provided answers that were too short, and 12 (15%) provided good scientific responses. The misconceptions demonstrated by the 50 (62%) preservice teachers were similar to those previously reported for children by Driver et al. (2000) and for preservice teachers by Atwood and Atwood (1996). For example, many of the preservice teachers indicted that "when it [Earth] is closer to the sun it is warmer," while others attributed the seasons to "the rotation of the earth on its axes[sic] and around the

sun.” “The seasons are caused by changing weather patterns” was also a popular response among the participants. During their second response ($\chi^2 = 6.741$, $p < .034$) to the question prompt following the viewing of the video, 28(35%) preservice teachers provided a response with a misconception, 17 (21%) provided answers that were too short, and 36 (44%) provided good scientific responses. Ten weeks later, for their third response ($\chi^2 = 10.296$, $p < .006$) to the question prompt, 17 (21%) preservice teachers provided a response with a misconception, 24 (30%) provided answers that were too short, 40 (49%) provided good scientific responses. [See figure below for a summary]. Thirty-one (38%) of the preservice teachers provided a good scientific answer on the third response when they initially provided an answer with a misconception. Only 2 (2.5%) of the preservice teachers provided a good response initially and an answer with a misconception for the third response.



Discussion

This study focused on trying to change preservice teachers' misconceptions about the causes of the seasons using a vicarious learning experience. A majority of the preservice teachers initially provided an explanation on the causes of the seasons that included a misconception; only 15% of the preservice teachers could provide a good scientific response to explain the causes of the season, but ten-weeks later with no direct instruction almost half (49%) could provide a good response, and the rate of misconceptions demonstrated went from 62% initially to 21% ten-weeks later. These results suggest that the preservice teacher's misconceptions about the seasons were changed to some extent without any direct instruction by the science methods instructor.

The results of this study provide some support the findings of Gholson and Craig (2006) in terms of what makes a good vicarious learning experience. Dialogue between a teacher and student, student and interviewer, or expert and interviewer was the majority

of the video, with the dialogue of the experts being the least of the three; this video was not a monologue or a collection of monologues. Since the preservice teachers' misconceptions were changed after watching the video, our results support Gholson and Craig's findings that a good vicarious learning experience requires students to observe dialogue, interaction between people.

While the exact cause of the change in misconceptions was not examined directly by the data collected in this small study, it is possible that asking the preservice teachers to write their understanding of the seasons and then showing them a video discussing younger students' misconceptions may have been enough of a discrepant event or disruptive occurrence to alter the preservice teachers' understandings. The fact that they had some of the same misunderstandings about the seasons that the students in the video did, a topic the video emphasizes as simple and taught in early levels of education, may have focused the preservice teachers' attentions to the correct explanation in the video or prompted them to investigate the correct answer on their own. There is some support in the responses themselves for this conclusion. Several good responses specifically addressed common misconceptions. For example, one preservice teacher wrote "Unlike many people believe, the summer is not caused by the earth being closer to the sun." The fact that the video and question prompt may have focused the preservice teachers to correct the misconception outside of class is also supported to some extent by the fact that more preservice teachers provided a good explanation on the third response (49%) than on the second (44%). Between the video and the asking of the question, they may have realized that this was a "simple" concept that they should know and understand. This inference is also supported by the improved responses between the second (44% provided good responses) and third (49% provided good responses) administration of the prompt. The preservice teachers may have needed some time with the content to process it and clarify it for themselves possibly through reflection on the topic or discussions with their classmates.

Important in our findings as well is the fact that misconceptions were not created by exposing the participants to the misconceptions. Only two participants went from having a good response initially to having a misconception, one of whom was classified as having a misconception at the end because her drawings looked opposite of what they should be, which could be an error in her artistic skills not her understanding. This suggests that the presentation of the misconceptions did not create misconceptions in participants who did not already have them. Without much effort, misconceptions dropped in about half of the participants and were not created in other students, showing this to be a possible way to change misconceptions without directly instructing on the topics. Viewing a discussion of a misconception or having a discussion of a misconception may lead to a change of the misconception in preservice teachers towards a more scientifically accepted explanation. The method may not be ideal but might hold promise for science teacher educators with little time to correct the numerous misconceptions students convey in a science methods course.

There are some limitations to this study and method for correcting misconceptions. First, while the number of misconceptions declined, they did not all disappear nor were a large number able to provide a good response, suggesting that this

vicarious event was not successful for all students. This could have occurred for several reasons. While the content in the video is not dated, the video itself is slightly dated. Also the main participants in the video are ninth-grade students, older than the students most of the preservice teachers are striving to teach. For these reasons, the preservice teachers may not engage with the video, either because they were distracted by the age of the video or did not think it was relevant to them because of the age of the students or age of the video. If the preservice teachers do not engage with the video, it has no opportunity to affect their misconceptions. This suggests the need for future research to find out what aspects of the video engaged the preservice teachers enough that it helped them correct their misconception.

Another important limitation to this study is that due to the nature of the data collection method, we do not know how rich the participants' understanding of the concept is. Since the preservice teachers merely wrote their answers and were not asked to expand or clarify what they wrote, we had to limit what we qualified as a good response. Participants may or may not understand the differences between the hemispheres or the difference between direct and indirect light, but as they were not asked about this specifically we cannot know. This also applies to the participants who provided a response that was "too short." It could be that they did not fully understand the topic, but it could also have been that they did not feel like taking the time to answer the question since it had no direct benefit for them.

Conclusions

As science teacher educators we are continually trying to find ways to improve teachers' pedagogical knowledge and their science content knowledge. If they have misconceptions about topics they are teaching, they may create lessons that are ineffective or actually pass on their misconceptions. We see this study as another tool to help preservice teachers change their misconceptions to more scientifically accepted explanations. More research is needed to find out if exposing preservice teachers to common misconceptions, not as just an abstract idea of misconceptions or as a list on a page, but through video discussions or small group discussions of the misconceptions could change the misconceptions. This may improve preservice teachers' ability to change their own misconceptions. In our experience, many science teacher educators bemoan how little science preservice teachers understand and how little time is available in preservice courses to prepare students to teach science. Perhaps videos similar to the one used in this study, along with online discussions, could be used as outside class assignments for preservice teachers.

We also suggest that this might be a useful tool to share with our colleagues in college science departments. Exposing students to the misconceptions does not appear to create misconceptions, perhaps if preservice teachers are exposed to the misconceptions through videos or discussions as they are learning about a science topic in their science courses, then the misconceptions could be changed without taking time from methods courses.

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