Cobern and Loving's Card Exchange Revisited: Using Literacy Strategies to Support and Enhance Teacher Candidates' Understanding of NOS

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Abstract

The nature of science (NOS) has long been an essential part of science methods courses for elementary and secondary teachers. Consensus has grown among science educators and organizations that developing teacher candidate's NOS knowledge should be one of the main objectives of science teaching and learning. Cobern and Loving's (1998) Card Exchange is a method of introducing science teacher candidates to the NOS. Both elementary and secondary teacher candidates have enjoyed the activity and found it useful in addressing NOS - a topic they tend to avoid. However, the word usage and dense phrasing of NOS statements were an issue that caused the Card Exchange to less effective than intended. This article describes the integration of constructivist cross-curricular literacy strategies in the form of a NOS statement review based on Cobern and Loving's Card Exchange statements. The use of literacy strategies transforms the Card Exchange into a more genuine, meaningful, student-centered activity to stimulate NOS discussions with teacher candidates.

Introduction

It is more important than ever that teacher candidates have a clear understanding of why scientists do what they do and what science is all about. Science methods courses are opportunities to help students develop tools and skills to engage with and deepen their understanding of the nature of science (NOS), a necessary skill set for teaching at the elementary and secondary grade levels. Dynamic activities, such as Cobern & Loving's (1998) Card Exchange encourage teacher candidates' inquiry, and critical thinking about NOS and the incorporation of cross-curricular literacy strategies promotes cooperative, collaborative interactions between students.

The consensus among science organizations is that developing an understanding of NOS should be one of the primary objectives of science teaching and learning. Organizations such as the American Association for the Advancement of Science (AAAS) (1993), National Research Council (NRC) (2013), National Science Foundation (NSF) (1996) and National Science Teachers Association (NSTA) (2012) recognize that understanding NOS is as essential to student success in science as scientific knowledge and skills. The National

Council for the Accreditation of Teacher Education (NCATE) (2008) has also called for the restructuring of teacher preparation programs to ensure science teachers are confident in both their science content knowledge and ability to engage students in the NOS.

Cobern and Loving's (1998) Card Exchange "works well," explains Cobern (1991), "because it begins with students getting up, moving around, and talking to each other, things almost all students like to do" (p. 45). The card exchange is an engaging and non-threatening method of introducing NOS to teacher candidates. It allows for students to reflect upon their conceptions of NOS that lead to both small group and class-wide discussion on NOS.

Teacher candidates have commented that the card exchange was not only fun but also gave them a better understanding of how and why we do science. Students comments on the card exchange noted the activity broadened their perception of science, enhanced their ideas about science, and increased their appreciation the role of philosophy in science. They have also reported increased confidence and science teacher self-efficacy. However, despite enjoying the overall experience and providing positive reviews about the card exchange, some teacher candidates have had difficulty with the vocabulary and card statements used during the exchange.

This article explores how integrating simple, constructivist cross-curricular vocabulary and literacy instructional strategies teacher candidates needed tools and skills to engage with Cobern and Loving's (1998) Card Exchange. It also describes the integration of simple, yet powerful, vocabulary and literacy instructional strategies. The incorporation of dynamic literacy strategies encouraged students' inquiry, critical thinking, and problem-solving skills and has transformed the card exchange into a broader and more impactful activity for teacher candidates.

Cobern and Loving's Card Exchange

The game is run as described by Cobern and Loving (1998) with some minor changes. While Cobern and Loving (1998) describe running the card exchange in classes of 30 to 40 students, I run it in classes of 15 to 25 students with each student receiving six cards. I have also taken to numbering the cards and card statement categories consecutively.

Cobern and Loving's (1998) process takes students from an internal dialogue on the card statements towards building group consensus (first in groups of two and then in groups of four) and finally a whole class discussion. The overall structure of the exchange allows students to debate the merits of some statements over others and share their thoughts on statements with others in the class.

1) Six to eight cards are distributed randomly to students. They have 5 minutes to read their cards and think about what the statements mean and rank their cards from their most to least favorite statement.

2) Stage I (10 minutes): Students trade cards (one-for-one) with each other to try to improve their hands. Their goal is to gain more cards with which they agree while discarding cards they do not like.

3) Stage II (10 minutes): Students pair up and compromise to reach eight cards on which both can agree. During this process, students must contribute at least three of their cards. Students return extra cards to the instructor.

4) Stage III (15 minutes): Students form groups of four, (two pairs) and compromise to reach a total of eight cards on which all four students can agree. During this process, each pair must contribute at least three of their cards. Students return extra cards to the instructor. Students then rank the cards in order of importance and write a paragraph statement answering the question "What is Science?" based on their cards.

At the conclusion of the game, groups share their statements aloud and other groups comment. What follows is a discussion as to why a group chose some cards and rejected others and cross-group discussion. Students debate the merits of some statements over others and share their thoughts on statements with which they agreed but were not chosen by the group and vice versa. Additionally, Clough (2011) suggests questions relating NOS and science education such as "how does the work of [insert scientist(s)] illustrate that data does not tell scientists what to think, but instead that creativity is part of making sense of data?" (p. 58) that can be used to create classroom discussion and debate.

Card categories and statements of their meanings are revealed at the conclusion of the activity as part of an overall group discussion on NOS. This revelation has led to exciting student insights into biases that exist concerning NOS and individual versus group preferences for statements during the card exchange activity. Finally, I allow time to address questions and comments students might have about the game or NOS in general.

Reflections on The Card Exchange

During the card exchange, teacher candidates often experienced difficulties with the vocabulary and the wording of card statements. The students' inability to unpack the meaning of the cards in the time allotted prevented the game from flowing the way it was supposed.

While not technical, the card statements can be confusing. Students found the concepts described in non-technical and procedural vocabulary on the cards to be abstract and lacking in contextual detail. The words and phrases "operate with expectations," "strive," "refined," "logical construct," "dogmatic," "pragmatic," "social negotiations," "Nature has nothing to say on its own behalf," and "infallible propositions" on cards 1, 2, 5, 12, 31, and 38 respectively were sources of confusion and frustration for some students. The dense wording on some

cards also proved to be a source of student frustration. On more than one occasion, after I explained a card statement, students responded “Well why doesn’t it just say that!” or “Why do they have to use all these big words? Why can’t they just say what they mean?”

One of the factors that make the card exchange work is the pace. Momentum builds throughout the game as students move from working individually to pairs to groups of four and finally to the broad class discussion. This pacing gets lost when the game is put on hold to address vocabulary and phrasing of the statements. These types of discussions are still teachable moments and can improve student literacy and can eventually lead to a better understanding of NOS. However, valuable class time was spent defining terms and unpacking the meanings of card statements instead of thinking about and discussing the statements to advance their understanding of NOS. What should be an exciting experience becomes frustrating to students and teachers and a tool that can help gain a better understanding of NOS is ignored and discarded.

Literacy Strategies for NOS Learning

The adoption of Next Generation Science Standards (NGSS) is changing the way teachers and students approach and engage in science content through crosscutting concepts that connect core ideas in different disciplines. It is also, to a certain extent, changing the language that teachers are using. Science already relies heavily on the use of specific vocabulary. Ardasheva and Tretter (2017) note “a pressing need for all students to master the academic language and vocabulary” (p. 252). This includes science-specific technical terminology (e.g., ‘photosynthesis’), non-technical vocabulary (e.g., ‘component’), procedural/signal vocabulary and general academic vocabulary (e.g., ‘the result of’) (Ardasheva & Tretter, 2017; Harmon, Hedrick, & Wood, 2005; Taboada, 2012).

Researchers such as Miller, Scott, and McTigue (2016), Shanahan and Shanahan (2012), and Vacca, Vacca, and Mraz (2016) believe literacy activities and strategies aid to encourage students’ interest, inquiry, critical thinking, and problem-solving in disciplines such as science. Reading and language ability has been shown to be factors that impact student achievement in science (Reed, Petscher, & Truckenmiller, 2016; Taboada, 2012). Like my students, Collier, Burston, and Rhodes (2016) have noted that science-specific vocabulary is akin to learning a second, or for some students a third, language.

Integration, repetition, meaningful use (Nagy, 1988; Nagy & Townsend, 2012) and scaffolding (Jung & Brown, 2016; Van Laere, Aesaert, & van Braak, 2014) can be applied to the Card Exchange to support student achievement in both literacy and NOS. Research by Harmon et al. (2005) describes independent reading, providing context, student self-selection of terms, and teaching targeted vocabulary words as strategies that support students struggling with the science-specific academic language.

The literacy strategies implemented in the NOS statement review for the Card Exchange promote cooperative, collaborative interactions among students. The idea is to generate a more authentic form of hands-on and student-centered instruction, along with the possibility for a more meaningful, genuine, and personal kind of learning. Additionally, integrating literacy strategies with science concepts demonstrates how to integrate seemingly content-specific learning strategies across the curriculum (Moje, 2008).

Both the expansion from a one to three-week activity and introduction of the statements prior the card exchange game uses the principle of repetition – providing multiple exposures to targeted terms. “While this practice may seem obvious, it is an essential one, especially for those readers who need more time and repetition to learn key vocabulary than other students” (Harmon et al., 2005, p. 276). Rather than pre-teaching the statements, this solution offers students the opportunity to highlight, draw attention to, and then discuss difficult terms.

The structure of NOS statement review also utilizes the principle of meaningful use. Students engage in individual reflective thought followed by small group and class-wide discussion of card statements. The students’ active involvement in this process, particularly their thinking about and discussing word meanings and using the new words meaningfully, leads to more learning and deeper processing of the underlying concepts of the card statements (Ardasheva & Tretter, 2017; Nagy, 1988). Talking about ideas and concepts in a text can improve vocabulary, academic language development, helps students make sense of their thinking, and can foster academic language development.

The long-term goal is for students to learn science-specific technical vocabulary and integrate new words into their vocabulary. However, before the integration of unfamiliar words and phrases, it is necessary to scaffold science-specific academic language by presenting targeted terms in a way that is more familiar and contextual to students (Ardasheva, Norton-Meier, & Hand, 2015; Jung & Brown, 2016; Shanahan & Shanahan, 2012; Vacca et al., 2016).

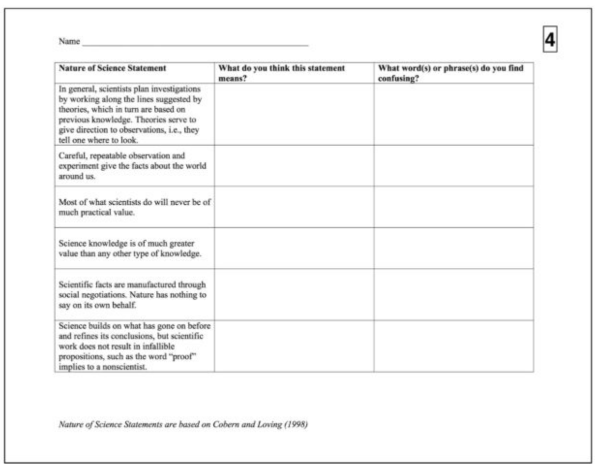
The NOS Statement Review

The NOS statement review gives students time to examine the statements individually, think about their meanings, self-identify words and phrases they find confusing, and discuss the statements in small groups and later as a class. Early introduction of the statements makes use of ‘powerful’ vocabulary instruction principles such repetition and meaningful (Nagy, 1988). Additionally, the transformation of the Card Exchange from a once-and-done activity to a multi-class exercise encourages both independent reading and learning by allowing students to self-select words and phrases (Harmon et al., 2005).

The overall goal of the NOS statement review is threefold: 1) to help students unpack the card statements and gain a better understanding of their meanings, 2) the come to class-wide understandings on the meanings of the different statements, which could include rephrasing, and 3) to prepare students to participate in the Card Exchange activity.

The review is run in four phases over two class periods and mirrors the structure of the Card Exchange, which is run during the next class following the review. During phase 1, students receive a graphic organizer (see Figure 1) with card statements from each of the card topic categories as a homework assignment at least two weeks ahead of the card exchange activity. The graphic organizer has the prompts “What do you think this statement means?” and “What word(s) or phrase(s) do you find confusing?” Assigning it as homework allows students to read and reflect on their particular statements at their own pace. As students read through the cards, they are encouraged to answer the prompts and to circle or underline parts of the card statements (see Figure 2).

Figure 1 (Click on image to enlarge). Graphic organizer for students with assortment of card statements and reflective prompts.

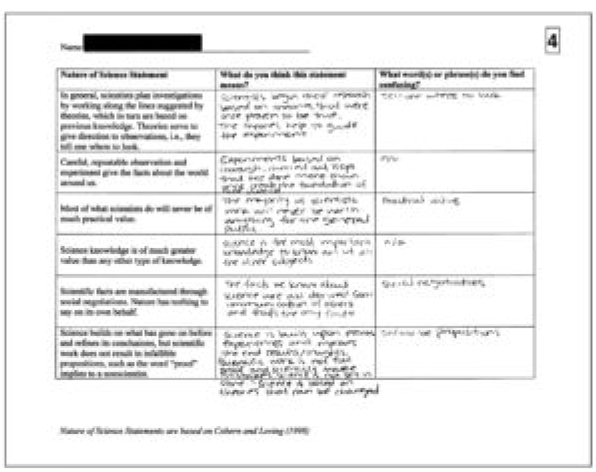

Name ______________

4

Nature of Science Statement	What do you think this statement means?	What word(s) or phrase(s) do you find confusing?
In general, scientists plan investigations by working along the lines suggested by theories, which in turn are based on previous knowledge. Theories serve to give direction to observations, i.e., they tell one where to look.		
Careful, repeatable observation and experiment give the facts about the world around us.		
Most of what scientists do will never be of much practical value.		
Science knowledge is of much greater value than any other type of knowledge.		
Scientific facts are manufactured through social negotiations. Nature has nothing to say on its own behalf.		
Science builds on what has gone on before and refines its conclusions, but scientific work does not result in infallible propositions, such as the word “proof” implies to a nonscientist.		

Nature of Science Statements are based on Cobern and Loving (1998)

Figure 2 (Click on image to enlarge). Student work sample.


Name [redacted]

4

Nature of Science Statement	What do you think this statement means?	What word(s) or phrase(s) do you find confusing?
In general, scientists plan investigations by working along the lines suggested by theories, which in turn are based on previous knowledge. Theories serve to give direction to observations, i.e., they tell one where to look.		
Careful, repeatable observation and experiment give the facts about the world around us.		
Most of what scientists do will never be of much practical value.		
Science knowledge is of much greater value than any other type of knowledge.		
Scientific facts are manufactured through social negotiations. Nature has nothing to say on its own behalf.		
Science builds on what has gone on before and refines its conclusions, but scientific work does not result in infallible propositions, such as the word “proof” implies to a nonscientist.		

Nature of Science Statements are based on Cobern and Loving (1998)

Phases two through four occur during the following class. During phase two, students use their completed graphic organizers and are given ten to fifteen minutes to have several small group discussions. First, they are grouped (two to three students) based on the number in the upper right-hand corner of their worksheets. This ensures that students with the same card statements have the opportunity to share their thoughts and comments with classmates that read and reflected on the same statements.

Phase three involves students moving around and meeting with classmates who were assigned different card statements. Students have ten to fifteen minutes and can meet one-on-one or in small groups of no more than four students. The groups must consist of students with different card statements, and each member of the group must have the opportunity to share.

As the instructor, both phases two and three are opportunities to circulate work with students individually or within the small groups. It is a time to listen to student conversations, ask guiding questions, address individual concerns and questions.

During the fourth phase of the NOS statement review, all of the students come together to engage in a class review and discussion. Students receive a second worksheet (see Appendix) with all of the card statements and students are invited to share their respective statements with the entire class. Cross-group discussion is encouraged with the instructor as moderator.

At the conclusion of the NOS statement review, we try to come to some understandings about specific terms used in the card statements and what they mean in and out of science. Sometimes the discussion involves the rewording of a statement. For example, in one class statement 12 (see Appendix) was reworded to read “Science is never opinionated; it is practical and open-minded – always subject to adjustment in the light of solid, new observations.” In another class, statement 32 (see Appendix) was reworded to say “When scientists work together they can be influenced by each other. Therefore, it can be hard to identify alternative ways of thinking.” Finally, students are then encouraged, but not mandated, to look over all the statements before the card exchange activity during the next class (week 3).

Discussion

Introducing and discussing NOS is still tricky and finding active methods to engage students in NOS discussion can be a challenge. Herman, Clough, and Olson (2013) lament that “much is understood about effective NOS teaching and learning, but while the phrase *nature of science* is widely recognized by science teachers, accurate and effective NOS instruction is still not widespread” (p. 2). Since language ability is quickly being recognized by both NRC’s *Framework for K-12 Science Education* (2012) and NGSS (2013) as a critical component of student success in science, technology, engineering, and mathematics

(STEM) the integration of literacy strategies can help address both NOS and literacy skills for students of all ages. Integrating simple, yet effective, literacy strategies in the form of a NOS statement review before Cobern and Loving's (1998) Card Exchange transforms the activity into one that emphasizes both NOS and literacy skills.

Early Introduction: A Double-Edged Sword?

The introduction and repetition of the card statements benefit students by providing them with time to reflect upon and discuss the meanings of the NOS statements. However, there was a fear that a review could take away from the trading aspect of the game. By reading, reflecting, and discussing the statements, students could have already made up their minds about the statements before the actual activity.

Since implementing the NOS statement review, I have asked students to provide feedback on whether the review enhanced or took away from the Card Exchange. Students (n = 64) were asked to fill out a short online survey at the conclusion of the card exchange that asked them to rate two statements about the NOS statement review and card exchange on a four-point Likert-like scale (1 = strongly disagree:4 = strongly agree). The voluntary survey has an average response rate of 87.7%. In response to the statement "Reading, reviewing, and discussing the card statements ahead of the card exchange enhanced the card exchange game" 81.8% responded that they "strongly agree." Conversely, 78.2% "strongly disagreed" that reading, reviewing, and discussing the card statements "took away" from the card exchange game.

One of the more difficult aspects of the NOS statement review, mainly during phases three and four, was keeping students focused. During both small group and class-wide discussion, students kept veering away from focusing on the meanings of the statements instead wanting to debate the merits of the statements. While appreciating their enthusiasm, they were reminded throughout these phases that they would have the opportunity to debate the merits of the statements and whether they agreed or disagreed with them, during the Card Exchange.

Conclusion

The importance of understanding NOS is important to the science and science education community. However, there is still a need to find interesting and exciting methods of engaging teacher candidates as well as elementary and secondary students in discussions about NOS. Cobern (1991) concluded his original article stressing the card exchange activity's effectiveness at hooking his students into discussing and considering NOS – a subject, according to him, they had previously avoided. Speaking about science teacher candidates, he noted that the card exchange "capitalizes on the innate gregariousness of students and the diversity of opinion among students" (p. 46) and stressed the need for "creative instructional strategies" for NOS instruction to be effective.

Despite the issues cited earlier with vocabulary and phrasing, the Card Exchange is still a creative and effective introductory NOS activity for both elementary and secondary teacher candidates. Integrating cross-curricular literacy strategies, such as a NOS statement review, enhances the Card Exchange without taking away from the initial focus of the Card Exchange activity. Instead, it creates a deeper more meaningful learning experience for students.

Supplemental Files

NOS-Appendix.pdf

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