A Progression of Discourse in the Science Classroom

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Abstract: The framework of the NGSS requires the development of skills central to the field of science. Scientific discourse is necessary for developing these skills, but the use of discourse is absent from many science classrooms. Possible reasons for this could be that teachers do not know how to incorporate methods into their classroom. This manuscript addresses methods that can be used to develop the discursive skills necessary for students to participate in activities central to science. Methods are described in a progression from introductory vocabulary use and explanation of ideas, discussion skills, and finally, the integration of skills to perform complex tasks such as inquiry and argumentation.

Introduction

The introduction of more rigorous science standards has placed a greater emphasis on improving student language use in science classrooms. Many students are not familiar with this form of language use, and associate speaking and writing requirements with language arts classes. The use of scientific discourse in the classroom is a skill that must be taught to ensure students are successful when using higher level skills (e.g., inquiry and argumentation) necessary for successfully meeting current standards. This manuscript discusses a framework, or progression of discourse, for teaching students foundational science language skills and guiding them to more advanced language skills in the science classroom.

What is Discourse?

It can be a struggle at times to fully understand what is meant when referring to the word discourse. It involves language, but if discourse was just language, we would call it simply that: language. Discourse is more than just spoken language; it makes up who a person is. Gee (1996) defines discourses as, "ways of being in the world, or forms of life which integrate words, acts, values, beliefs, attitudes, social identities, as well as gestures, glances, body positions and clothes" (p. 142). Thus the use of discourse depends on the context of how one lives such as one's culture, occupation, education, and religion. According to Gee, there are different forms of discourse. Big "D" Discourse reflects one's identity in society and little "d" discourse is language use in general (p. 142). Little "d" discourse is simply the use of language, and is included in big "D" discourse. Big "D" Discourse, as stated before, consists of one's identity, which determines the ways in one uses language. For example, a scientist will speak and write differently than a historian because the language of each field differs. A student may speak and write at home in a manner different compared to how they speak or write in school. Through education students can develop different Discourses. Some may be social or cultural, while others may be educational.

Discourse in Science

Engaging scientific discourse requires the use of language specific to the science community. Language use can include reading publications, analyzing data, presenting results, collaborating with colleagues, etc. The use of language in science is unique because it is the language of observation, discovery, and explanation of the natural world. To truly understand science, one must become fluent in its language, just as to truly understand a conversation with a person from Venice, one must become fluent in Italian. When learning any new language, there is a progression. First one focuses on learning the basic terminology, followed by applying basic language to make simple statements, then, finally, fully integrating use of the language. To teach students the language of science, a similar progression can be applied. First, vocabulary and terminology are learned, followed by practice with speaking the language, with the end goal being full incorporation of language use in the context of science.

Progression of Discourse in the Science Classroom

There are many methods for increasing the use of student discourse in the science classroom. Students do not necessarily enter the classroom with the appropriate skills to participate in an inquiry or argumentation activity; these skills must be taught and students must be provided with scaffolding to help them successfully reach that point. Figure 1 illustrates the progression needed for students to reach higher level skills such as inquiry and argumentation. Development of these skills depends on a student's ability to understand the language of the subject matter and use language to participate in meaningful discussions related to subject matter. In science education, language use can take many forms: stating hypotheses, describing measurement and collecting data, analyzing data, and collaborating with peers to name a few. How are students to be led on the path to these different forms of scientific discourse? As depicted in Figure 1, the path begins with a solid foundation constructed with the teacher's careful guidance. The various methods for assisting students with developing scientific discourse will be examined as a progression; discussion of these methods will follow.

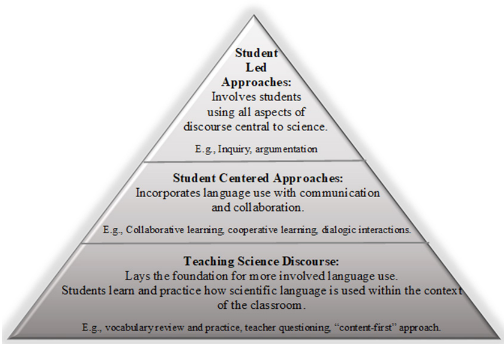

Figure 1: Explanation and methods for the progression of teaching scientific discourse in the science classroom.

Teaching Science Discourse

Teachers shape the path students will travel to successfully communicate in the science classroom; they structure and model the language use expected. To begin students on their journey of learning the use of scientific discourse, knowledge of background vocabulary is essential. Teaching vocabulary is often thought of requiring the memorization of words and definitions. When placed in the context of developing student discourse, students should be using vocabulary words within the context of the concept being mastered, in order to develop more complex modes of communication like language use and presentation of data (Dawes, 2015). The significance of teaching vocabulary in this manner is illustrated by a study of middle school students conducted by Crosson, Lawrence, Pare´-Blagoev, & Snow (2015). A limited number of vocabulary words were selected each week for students to learn. Given a topic, students read, talked, and wrote about the topic using the vocabulary words for the week. The results showed an increase in the quality of classroom discussion. This method of vocabulary instruction involves students using new vocabulary in an appropriate context and illustrates for students how the word is used within the subject. Using this method helps students make connections between vocabulary and its usage.

Another method for vocabulary incorporation, as described by Brown and Ryoo (2008), is the "content-first" approach to teaching science. This vocabulary teaching strategy involves teaching students a scientific concept using everyday language before introducing scientific vocabulary. To illustrate, students initially learn about photosynthesis through statements like, "This is the inside of an energy pouch where plants make their own food. There are many green pigments inside of an energy pouch" (p. 540). After the concept is introduced, students are presented with the statement again but with appropriate scientific language, "This is the inside of a chloroplast where plants make glucose. There are many chlorophylls (green pigments) inside of a chloroplast" (p. 540). This method is useful because it supports students in making connections between everyday language and scientific language. Another benefit to this method is it improves student's ability to use scientific language when communicating in the classroom.

While both of the above methods focus on the use of vocabulary, they both impact the quality of discussion. Thinking of discourse as a framework or progression, classroom discussions are aimed at building skills that will lead students to an endpoint where they will acquire critical thinking and analysis skills. For students to reach this endpoint and build a solid foundation, the types of discussion questions to be posed must be carefully planned by the teacher. When students are asked higher-order questions they are given the opportunity to explain and justify their opinion (Smart & Marshall, 2013). Higher-order questions are open-ended and do not have one right answer, so they allow students to think and communicate, and respond to their peers. Typically, when first introducing this method of questioning, a scaffold is needed. Referred to as the "cognitive ladder," as described by Chin (as cited in Smart & Marshal, 2013, p. 251), questions progress from lower-order to higher-order as students become more confident with the material. For example, a lower-order question is "What is density?" and a higher-order question is "How would you find the density of this nail?" The first question involves a simple definition, where the second question requires understanding of the definition but, more importantly, creates the opportunity for discussion. This method of discussion and questioning helps students develop a deep conceptual understanding of scientific concepts.

The teacher-led methods discussed above assist students in developing their conceptual understanding and skills necessary to explain and justify their opinions; they lay the foundation depicted in Figure 1. Students must obtain these skills before progressing to the next level of scientific discourse; collaboration and communication with peers.

Student-Centered Approaches

Collaboration and communication with peers is a use of discourse central to science and the scientific community. Therefore the next phase in the progression of science discourse is to promote interactions between students. A way to introduce communication that is student-centered is through dialogic teaching. Dialogic teaching is a type a teacher-led discussion. The teacher poses a meaningful question followed by a rotation that allows students to explain what they know or do not know, while the teacher connects the students' responses together in a meaningful way (Dawes, 2015). Although it is teacher-led, dialogic teaching conducted in this way can be considered student-centered because it is most successful when students participate in interactions with peers while preparing their thoughts about the proposed question (Aguiar, 2015). Dialogic interactions involve the production of student ideas, not the teachers. The teacher may mediate the discussions and provide background information when necessary but it is the students that create the dialogue. This method is successful for increasing communication between students while also introducing argumentation skills that may be used for future purposes (Reznitskaya, 2009).

Dialogic interactions assist students in becoming familiar with communicating in the classroom. Students begin by simply stating what they know or think. Collaboration is the next step in this progression. Collaborative learning involves discussion between students to solve a problem posed by the teacher. Discussion guides the learning. When students are given the opportunity to discuss a question or problem, they increase their conceptual knowledge. A study by Barth-Cohen et al. (2015), illustrates the success of collaborative learning. Students were asked questions and responded using a clicker system. After their initial answer, students collaborated with their peers. Together, they answered the same question again followed by a separate question that was different but covering the same concept. The results showed that more students answered correctly on their second attempt answering the first question. More importantly, the number of correct responses on the follow-up question were much higher compared to responses on the first before the students had collaborated. The increased scores were a result of better conceptual understanding gained from the discussion rather than simply being told the correct answer. This is the basis of collaborative learning: students discuss problems to gain conceptual knowledge.

Cooperative learning is similar to collaborative learning, but cooperative learning involves more student communication because it requires students to work together toward a common goal (Murphy, 2015). According to Murphy, there are five elements essential to cooperative learning; groups should be interdependent, there should be face-to face interaction between students, all students are accountable, social skills are necessary, and the group should self-evaluate. Cooperative learning opportunities usually involve the production of a product (model, presentation, etc.) and require student communication using scientific discourse combined with adequate content knowledge.

The methods discussed in this phase of progression involve giving students opportunities to become comfortable communicating with their peers while promoting deeper conceptual understanding. The skills gained by students from the first two phases of progression can now be transferred to more complex activities that immerse students in scientific discourse like inquiry activities and argumentation.

Student-Led Approaches

The final step in the progression of science discourse is for students to participate in activities that resemble the work of scientists in the field. Inquiry-based learning is a method where students explore the answer to a question that is of interest to them. Skills necessary to perform inquiry have become the framework for many present science standards. The National Research Council has outlined the processes critical to science as:

1. Asking questions
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information (as cited in Melville, 2015, p. 507)

The processes listed above require the use of scientific discourse. Students cannot successfully participate in inquiry activities if they do not have sufficient content knowledge and communication skills. The progression of scientific discourse that has been laid out supports and prepares students for introduction into inquiry-based learning. Even with such preparation, inquiry activities can be intimidating for students. To ease the intimidating nature of inquiry activities, skills such as formulating hypotheses, observing, measuring, collecting data, and interpreting data can be broken down and taught in manageable pieces until students become more comfortable with the processes (Russel, 2015).

Inquiry-based learning is, as it seems, the future of science education. Inquiry develops critical thinking skills and independence by integrating science discourse in the classroom within the context of the scientific community. Hand in hand with inquiry goes argumentation. Argumentation is another important skill in the scientific community. While argumentation is related to inquiry, the focus in argumentation follows "a claim, evidence, reasoning, and rebuttal framework" (Krajcik, 2015, p. 286). The argumentation framework, like inquiry, requires various uses of scientific discourse. Students are required to make clear statements, to analyze text or data for evidence, to discuss and explain their viewpoints, and to listen to and take into consideration the viewpoints of others. The topics used in argumentation should be relevant and meaningful issues that are related to scientific concepts. Like inquiry, argumentation can seem intimidating to students, so breaking down the process and guiding students through the steps will be beneficial when first introducing this method.

Inquiry and argumentation involve the use of skills and processes that are central to science. At the center of these processes lies the one thing that supports the whole structure: Discourse. The language and the processes involving the use of language are what creates the field of science. Science education is not only about the content or the facts, but also about the process of science: giving students the skills they need to observe and understand the world around them.

Conclusion

Understanding science means understanding the corresponding discourse associated with it. Practice and guidance in using scientific discourse assists students along their journey to understanding science as a way of knowing. This progression takes into consideration the fact that many students do not have experience with the discourse skills needed for inquiry and argumentation. It involves creating a gradual path that introduces students to the various methods that constitute scientific discourse. Beginning with vocabulary, students become familiar with terminology, enabling them to explain scientific phenomena. Students then begin to incorporate their explanations into the group setting where they communicate ideas to their peers. Both the vocabulary and communication phases deepen student conceptual understanding of topics which is necessary for the final step of the progression: inquiry and argumentation. Inquiry-based learning and argumentation build on previously learned skills like providing explanations, communicating ideas, and collaboration with peers and incorporates them into the larger context of science.

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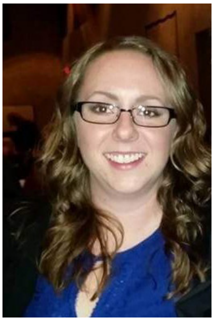

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Jennifer Wiesen received a Bachelor of Science in Education from Youngstown State University in 2015. She recently obtained a Master of Science and Education degree from the University of Toledo. Jennifer is currently in her third year of teaching at Crooksville High School where she teaches physical and environmental sciences.