Characterizing Teachers' Support of Modeling Practices in Science Classrooms

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Abstract: Modeling used, as an inquiry tool is critical to the development of understandings in science. Teacher knowledge of this use of models impacts their development of learning experiences for students. This study focuses on teacher modeling practices and relates them to student performance on assessment items requiring interpretations of multiple representations. This characterization of teacher practices will provide insight into the learning experiences needed for students to engage in authentic scientific modeling.

The practice of building, refining and redesigning models based on evidence lies at the core of scientific practice. It drives scientific discoveries as scientists use models to guide experimental design, test variables, and generate hypotheses. (Windschitl, 2006) According to the *Framework for K-12 Science Education* (NRC, 2012) and the *College Board Standards for Success in College* (CB, 2009) these ideas play a critical role in the development of scientific ideas and understanding in students. While in the classroom, models are traditionally used by teachers to present "correct" information to students, the power of modeling as a tool for inquiry and exploration is not often employed. (Justi, 2002)

In order to foster the scientific practice of modeling in students we must better understand how teachers currently use modeling in the classroom. In this study, we will be to characterize teacher practice with regard to modeling and explore the relationship to student performance on science assessment items that require modeling skills including the interpretation, evaluation and critique of models and representations.

Framework

Developing a learning environment that supports students in creating and using models requires a complex set of knowledge and skills. Teachers make instructional decisions based on their pedagogical content knowledge (PCK). When teachers lack sufficient knowledge about scientific modeling they are unable to make the type of instructional decisions necessary to support students' understanding. In the classroom, the educative power of models and modeling is commonly underestimated. Traditionally, the teacher uses models to present information to students. For example, in their study of the beliefs of experienced secondary science teachers, van Driel and Verloop (2002) found that many teachers generally focused only on the descriptive function of models and ignored the predictive power of models and the use of modeling as a scientific practice.

Teachers' orientation toward teaching science can also influence their instructional choices around modeling. This orientation reflects the pedagogical knowledge teachers' use to manage and organize classroom activities. These general principles are another important aspect of PCK (Shulman, 1986). van Driel and Verloop (2002) found some teachers chose a teacher directed approach using models as a tool to focus on the content. Other teachers used a more constructivist approach, encouraging students to design and build models to form explanations**.** The latter is more consistent with by the national standards (NRC, 2012; CB, 2009).

Methods

This study is a part of a larger project focused on measuring students' progress along a hypothetical learning progression related to transformations in matter. Our study included 13 middle school science teachers from 5 different schools. The schools included public, private and charter schools in urban and suburban settings. The approximately 1600 students varied in race, ethnicity, and SES (15%-52% free and reduced lunch).

Students from each school were tested at the beginning (Fall 2010) and end (Spring 2011) of the school year. We estimated students' latent ability parameter based on item response theory (IRT, Wilson, 2005) analysis and calculated the change in student mean ability levels for each teacher. For this study we also compared students' gains on items that required students to use modeling skills with disciplinary knowledge.

Data related to individual teacher enactment was collected through classroom observations and surveys. We electronically collected surveys from teachers using Survey Monkey. Survey questions related to teachers' backgrounds and their teaching practices, which included use of modeling and inquiry strategies. We conducted multiple classroom observations to characterize teacher practice and the instructional experiences of students. We used an ethnographic approach that focused on creating detailed descriptions of classroom activities using a running record. Running records were coded using a coding matrix that focused on types and purposes of modeling activities in the classroom (Peek-Brown, 2013). For inter-rater reliability, two team members independently scored at least 10% of the data and reached 90% or greater agreement with 100% agreement after discussion.

Results and Discussion

In order to characterize teacher practices that might be related to student performance on assessment items related to modeling preliminary analysis of data was limited to two teachers (Creed and Dorsey) from the same school that teach the same grade. Their curriculum materials emphasize engaging students in the practice of modeling and support students in relating observed phenomena to the unseen processes that occur at the molecular level (development of a particulate model of matter).

Despite similarities in population and curriculum materials, differences in student performance were observed. Dorsey's students performed better on more complex items that require applying disciplinary knowledge and interpreting, evaluating or critiquing representations. For five of eight items focusing on interpreting molecular level representations, Dorsey's students performed better than Creed's students.

Preliminary analysis of teacher data provides insight into the source of the observed differences in student performance. In the survey Dorsey reported regularly using modeling strategies during instruction, while Creed reported rarely using modeling even though modeling practices are an integral part of the curriculum.

Observational data was consistent with the survey data. Dorsey had 19% more instances of modeling-related activities than Creed. The majority of observed modeling activities in Creed's class were student driven (88% of coded references). A more balanced approach was observed in Dorsey's class with 46% of the coded references being teacher driven, 38% student driven and 16% collaborations between the teacher and students. Although these results would seem to indicate that Creed's students spent more time engaged in actively building their own models, a closer look at their modeling experiences suggests differently. For example, both classes were observed engaging in a modeling activity where students built molecules from gumdrops. Both teachers used the same lessons from the curriculum however the focus of their lessons was very different. Creed gave students directions as to how to build their models, but gave very little explanation as to why they were building them. In contrast, Dorsey engaged students in relating the model and the actual object in order to help students understand the limitations and the purpose of building different models.

Although both teachers participated in identical professional development activities around these lessons Creed did not seem to recognize the development of modeling skills as an important aspect of the lesson. This lack of understanding may have contributed to the instructional decisions that she made. Further supporting data from student assessments and data for other teachers in the study will be included in the poster.

Implications

As the field moves toward the goal of supporting students in coherently developing understanding of core science concepts blended with scientific practices, learning research is needed to gain insight into how to effectively support teachers in meeting these goals. By characterizing teachers' practice related to modeling and linking it to student progress along a learning progression performance, this study contributes to that effort.

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