Examining the Influence of Teacher's Framing of Modeling Practices on Elementary Students' Engagement in Modeling

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Abstract: Scientific modeling is one of the core scientific practices that are critical to learner's knowledge-building. Despite the increasing emphasis on scientific modeling in the community of science education, more information/research is needed to better inform teachers as to how they can support epistemically-rich, non-procedural engagement in modeling. In this study, we use *Epistemologies in Practice* as our theoretical framework to examine students' engagement in modeling practice. We used a comparison approach to analyze 26 classroom video recordings in order to understand how two teachers framed modeling practices in the same modeling-based unit. In doing so, we analyzed what support teachers provided students as they engaged in modeling and how that might have led to students' engagement in several epistemic aspects of modeling practices. Our findings suggest that how teachers framed the purpose and goals of modeling appeared to have a great influence on how students engaged in the modeling practice.

Introduction

Within the past two decades, reform efforts in science education (National Research Council, 1996) have increasingly called for engaging students in authentic scientific practices such as scientific modeling, argumentation, and scientific explanation that resemble the intellectual work of scientists. This "practice turn" with respect to K-12 reform efforts (Ford & Forman, 2006) recognizes the importance of engaging students in communities of practices (Wenger, 1998) where they become active participants in generating knowledge and figuring out how the natural world work the way they do. Therefore, it is critical for students to engage in scientific practices in a scientifically meaningful rather than a procedural way. Among scientific practices, scientific modeling has been considered particularly important since constructing, testing, and revising models lies at the heart of scientific endeavor (Lehrer & Schauble, 2006). In the recent release of the Next General Science Standards (NGSS; NGSS Lead States, 2013), scientific modeling is highlighted as one of the eight core scientific practices in which students should engage in order to make sense of the world. However, little is known about how teachers can support students' scientifically meaningful engagement in scientific practices in general, and scientific modeling in particular, as required by the NGSS.

In this study, we addressed this critical need by examining how teacher's overall framing of scientific modeling might influence students' engagement in the modeling practices. We focus on teachers' framing because teacher's values and goals of the practice, as well as the way they frame it can influence how the practice unfolds in classroom (Berland & Hammer, 2012). By comparing and contrasting two teachers' framing of modeling practices in the same modeling-based unit, we seek to understand what support teachers might provide with students while engaging in modeling and how it might, or might not lead to students' engagement in various aspects of modeling practices. In particular, we ask the following two research questions,

1. How do the teachers frame the purposes or goals of modeling practices over the course of a model-based unit?
2. How might teachers' framing of modeling practices influence students' engagement of scientific modeling?

In this paper, we use Epistemologies-in-Practice framework (in press) developed by our larger research group as our theoretical framework to examine students' engagement in modeling practice. We argue that in order to make students' engagement in modeling scientifically meaningful, students must be guided by the epistemic considerations that characterize some of the norms and values of science. By epistemic considerations, we refer to the purposes and goals of the work students are engaged in. For example, developing and revising models that address the mechanism of phenomena lies at the core of the scientific endeavor; therefore, considering the degree to which an explanation is mechanistic should guide learners who are engaged in modeling practice. We termed these epistemic considerations that frame and guide practices "epistemologies in practice" (EIP). The term Epistemologies *in practice* refers to both the practice-based perspective of student learning and the emphasis on students' epistemological ideas *in use*. This EIP framework is helpful for this study because not only can we capture the nature of students' engagement in modeling practices, we could also use this framework to see how teachers support students' development in epistemic considerations of modeling in classroom community.

The EIP framework focuses on four epistemic considerations (ECs), Nature, Generality, Justification, and Audience. The Nature EC refers to students' ideas about the nature of the model or the kind of answer the model should provide, which could range from describing *what* happens in details, to identifying key factors of the phenomena, to explaining *how and why* something happens. The Generality EC relates to how specific phenomena or experiences relate to one another and to more general scientific ideas. A student who is viewing his/her model as connecting a range of phenomena could apply the model to a specific phenomenon or explain how multiple phenomena are accounted for in the model. The Justification EC focuses on students' thought about why their ideas in the model are correct. A student could include the information that others told him/her to include without justification or he/she could use empirical evidence or theoretical information to justify his/her model. The Audience EC reflects how students identify and orient their model for a particular audience and their understanding of how that audience will use their model. A more detailed description of the four epistemic considerations will be included in the full paper.

Methods

Contexts and participants

To investigate our research questions, this paper reports on the analysis of two 5th grade classrooms taught by two teachers (Mrs. M and Mr. H) in a Midwest suburban elementary school during the 2012-2013 academic year who have worked with our research group for 7 years on how to engage upper elementary students in scientific modeling. As a result, we have a long history and extended involvement and interactions with both teachers. Both teachers taught a 6 to 8-week model-based unit about evaporation and condensation; for both, it was their 4th time teaching the unit. In the unit, students are asked to address a driving question whether or not they would drink the liquid from a solar still. To answer this driving question, students constructed an initial diagrammatic model to explain the phenomenon, and continuously evaluated and revised their models using evidence from their empirical investigations and scientific information. The evaluation and revision process involves discussions within small groups and whole class. In each teacher's classroom, we focused on one group of students (called "focus students") and video recorded them while they are constructing their consensus models. Each group consisted of four students selected by the teacher.

Data collection

The primary data for this paper include video-recordings of every lesson each teacher taught except those in which students were expected to do investigations or explore computer simulations of molecular movement. In those modeling lessons we video-recorded, students were expected to construct, revise and evaluate their models of evaporation and condensation. These lessons were critical for showing us how the teachers framed modeling at different stages of the curriculum as well as how students were engaged in the practice of modeling, both in whole-class and small group settings. Each recording was transcribed and analyzed. In total, we analyzed about 12 hours of classroom-recorded lessons from the unit for each teacher. Each 45-minute class period for the unit usually consisted of both whole class discussion led by the teacher and small group discussions among students.

Data analysis

In order to answer the first research question, we analyzed what the teacher said to students in each lesson. First, we summarized how the teacher talked about the purposes or goals of modeling in each lesson. The unit of analysis was an utterance, which we define as bound by a clear pause or silence. Next we used a modification of grounded analysis (Glaser & Strauss, 1967) to identify patterns across the summaries of teachers' goals. This was iteratively conducted for each teacher. By comparing and contrasting those summaries, we collapsed them into a more general theme that represents the teachers' overall framing of modeling practices over time.

In order to answer the second research question, we analyzed the small group discussions among focus students when they constructed consensus models of evaporation and condensation. Similar to the analysis of the teachers' talk, the unit of analysis was an utterance. Since we were interested in whether students are engaged in the modeling practices in a scientifically meaningful—rather than procedural—way, we used two codes to analyze group discussions: epistemic and task-oriented. While epistemic utterances convey students' ideas about the purposes or goals of modeling practices as our EIP framework suggests, task-oriented utterances focused on how to finish the tasks. Therefore, task-oriented utterances often involved questions or suggestions about what to include in the group model specifically without explicitly stating the rationale for doing so. We also used the four epistemic considerations to identify which epistemic considerations students' considered and how that might have been influenced by the teachers' framing.

Findings

Teachers' framing of modeling practices

Analysis of video-recorded data indicates that Mrs. M emphasized the notion that "use models to explain different phenomena" consistently throughout the unit. This framing of modeling highlights the utility of models and incorporates both the Generality and Nature epistemic considerations. The following excerpt exemplifies what Mrs. M's framing looked like in the classroom and can be seen in 33 other utterances throughout her instruction. At the beginning of that particular class period, Mrs. M explicitly stated the goal of what they would be doing as a class, "today is evaluating our consensus models and come up with ways that we can use our consensus model to apply to other phenomena." The conversation happened in the middle of that class period when students were presenting their group consensus model of evaporation in front of the class.

Mrs. M:	Your group used open cup-closed up as your phenomenon of your model. Selina, *I'd like you to use this model to explain what happens to the dew on the ground in the morning and why it's not there when you get out.* [Framing of modeling: Explain different phenomena]
Selina:	So like the water would be the dew. The water molecules in contact with air molecules and they evaporated.
Mrs. M:	What happens to those water molecules when they meet the air?
Selina:	When the air molecules hit the [water] molecules, it depends on the temperature at the time, it's gonna turn into water vapor and go out.

In this excerpt, Mrs. M asked Selina to use their consensus model to explain a new phenomenon, dew disappearing from the grass, which reflects Mrs. M's overall framing of modeling, "use models to explain different phenomena." In other words, Mrs. M focused on the explanatory nature of models and how it can be applied to different phenomena.

In comparison, Mr. H often highlighted the idea of "scientifically correct information should be put into models." This framing of modeling highlights the role of the model as an end product rather than an explanatory tool. For example, when his students were to revise their initial models of evaporation after some investigations of phenomena of evaporation, he said, "All this information we've been gathering, should be in our model somewhere." Throughout the unit, Mr. H had similar utterances about this 'model as container of correct information' notion of modeling and focused on the correctness of information that students put into their models. In addition, later in the unit, Mr. H started to worry about the amount of time his students spend constructing the consensus models within the small group. Therefore, one of the goals of the modeling practice became "finish in time." Mr. H explicitly told his students "the goal today is trying to finish this up", and also made "majority rule" the criteria to solve disagreement among group members instead of other scientific criteria such as how the model is supported by empirical evidence in order to speed up the consensus modeling process.

Teachers' influence on students' practices

Analysis of small group conversations when students' were constructing consensus models of evaporation and condensation, mirrors the framing teachers' shared with students above and indicates that students in Mrs. M's class tend to focus on the epistemic aspect of modeling practices. For example, during a 20-minute group discussion when Mrs. M's focus group were constructing their consensus model of evaporation, we recorded 16 utterances of Nature EC talk, 6 utterances of Generality EC talk, 8 utterances of Justification EC talk, 5 utterances of Audience EC talk and 9 utterances of task-oriented talk from the focus group. Below we present an excerpt from that discussion that is representative of how Mrs. M's focus group engaged in the practice of the constructing consensus model.

Sue:	We have to explain it didn't seep through the cup, if someone asked that. [Justification] Our model cannot explain that. [Nature]
Jack:	Well does this explain how paint dries? [Generality]
Sue:	Yes. The water molecules are leaving. This explains how nail polish dries. It also explains how you can smell stuff because molecules go away carrying scent. [Generality]

Emilia: How about label? Did you label it? Like an open cup. [Task-oriented]

Ben: We know it's an open cup. If you shaded it in, it's obviously a closed cup. I bet if you show it to somebody, they would know this is uncovered and this is covered. [Audience]

Emilia: I'm just saying, it's good to label, just, just saying.

As the transcript indicates, at the beginning of the conversation, Sue thought about an alternative idea about why water disappeared over time (water seeping through the cup instead of going to the air) and she proposed to justify in the consensus model why water molecules going to the air is correct, which relates to the Justification epistemic consideration. Then Jack asked the question, "Well, does this explain how paint dries?" Jack's question was very important for answering our second research question because it reflected Mrs. M's framing of modeling, "using models to explain different phenomena." In the previous excerpt, Mrs. M asked one student to apply their model to explain why dew on the grass disappeared. Here, Jack was echoing Mrs. H's questions, asking his peer if their consensus model is general enough to explain other phenomena such as paint drying. Multiple instances of the group work indicate that Mrs. M's framing of modeling may influence the kind of question Jack posed to the rest of the group.

Compared to students in Mrs. M's class, students in Mr. H's class tended to be more task-oriented or procedural while engaging in modeling practices. The nature of the focus group conversation is task-oriented most of the time and occasionally they attended to Nature EC as they were trying to figure out the mechanism of evaporation or condensation. For example, compared to 21 utterances of task-oriented talk, we only observed 5 utterances of Nature EC talk when the focus students were constructing the consensus model of evaporation during a 20-minute discussion. Also, the group did not attend to any other epistemic considerations during that period of time. We hypothesized that the procedural nature of the conversation might result from how Mr. H framed the purpose and goals of modeling overall, seeing models an end product.

Conclusions and implications

The analysis indicates that Mrs. M and Mr. H framed scientific modeling differently – Mrs. M framed the modeling process as a tool to explain multiple phenomena, while Mr. H framed model as an end product filled with scientifically correct information. We can also see how the framings were echoed in their students' small group work respectively. As shown above, the small group work from Mrs. M's class focused on multiple epistemic considerations of modeling practices while Mr. H's mostly focused on procedural aspects of modeling practices such as labeling components.

The findings suggest that how teachers frame the purpose and goals of modeling might have a great influence on how students engage in the practice of modeling. Students will engage in a more scientifically meaningful way if the teacher supports them in thinking about the epistemic considerations. In addition, the findings indicate that it is important to consider modeling practices in school settings where other goals of instruction co-exist. In order to make the practice scientifically meaningful for students, teachers should balance those goals and provide a learning environment that prioritizes the epistemic considerations of modeling practice.

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