

Which Knowledge Helps Science Teacher Students in Scientific Modeling?

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OVERVIEW: Our examination of teacher students' thinking processes in modeling shows that different modeling practices require different kinds of knowledge. Teaching these practices more separately may help educators better scaffold the specific knowledge each one requires.

KEYWORDS: inquiry learning | modeling | metaknowledge | content knowledge | teacher education

AUDIENCE: Curriculum Developers | Teacher Educators | Teachers.

KEY POINTS

- Scientific modeling involves different scientific practices, such as constructing or testing models.
- An interplay between domain-general meta-knowledge about modeling and subject-specific knowledge of the modeled phenomenon helps teacher students engage in these practices.
- However, the specific interplay between these two types of knowledge differs across practices.
- We suggest teaching modeling practices in a more isolated manner.

INTRODUCTION Scientific modeling involves key scientific practices such as constructing or revising models based on evidence, using them to make predictions, and testing models. Before teachers can implement modeling practices in science classrooms, they need to be able to engage in scientific modeling practices themselves, a skill they often struggle with. Prior research suggests that scientific modeling requires the application of two knowledge types: meta-knowledge, which is general knowledge about what models are and how modeling works, and content knowledge, which is topic-specific knowledge about science concepts and phenomena. However, it remains unclear how each knowledge type supports particular modeling practices and how they interact. This study addresses these questions.

FINDINGS Our analysis of 17 science teacher students' thinking processes in modeling practices revealed two key results:

First, predicting with models and testing models were more difficult than constructing and revising models based on evidence.

Second, the examined teacher students applied general meta-knowledge *and* specific science content knowledge to engage in scientific modeling practices. However, different modeling practices had different knowledge requirements: constructing models predominantly required the application of content knowledge, whereas testing models primarily required meta-knowledge. Revising models required an interplay of meta-knowledge *and* content knowledge.

For predicting with models, we hypothesize a similar interplay of knowledge types, but due to this practice's high difficulty, our results are unclear.

TAKEAWAYS These findings strengthen previous teaching strategies for scientific modeling that involve fostering meta-knowledge and content knowledge to develop modeling practice abilities. Commonly, these teaching strategies suggest a comprehensive sequence that involves multiple modeling practices for one phenomenon. For instance, students should develop an evidence-based model to explain the phenomenon of delayed-onset muscle soreness, then derive a prediction from their model, test the model, and eventually revise it. Based on our results, however, it might be more beneficial for science educators to focus on a single isolated practice and practice it repeatedly for similar phenomena that share a common content knowledge base. This could mean that after constructing models for delayed-onset muscle soreness, students continue to construct evidence-based models for similar phenomena (e.g., muscle adaptation or muscle injuries) before moving to another modeling practice. This approach would allow science educators to better foster the focused practice's specific knowledge requirements and enable their science students to master one modeling practice before progressing to another. Due to the varying difficulty of the modeling practices we examined, we suggest introducing modeling with the easier practices of constructing or revising models before teaching the more difficult practices of predicting with models and testing models.