

Models as a means for implementing interdisciplinarity and vice versa

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What problem is to be addressed?

In Danish upper secondary school, the subjects are highly compartmentalized and seldom interrelate. This is partly due to the structure of the “gymnasium,” where scheduling and organization do not support interdisciplinarity, and partly due to teachers’ backgrounds, as they typically hold a master’s degree in one (sometimes two) subject. As a result, teachers are not trained in interdisciplinarity as a didactical tool and often perceive subject contributions as separate rather than integrated. Yet, interdisciplinarity holds potential for strengthening students’ understanding of both the individual subjects and their connections. This potential is also emphasized in the curriculum, which explicitly encourages interdisciplinary teaching.

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Østergaard, M. K., Pedersen, M. K., Jankvist, U. T., & Misfeldt, M. (2026). Models as a means for implementing interdisciplinarity and vice versa. In M. S. Aguilar & M. Misfeldt (Eds.), *Proceedings of the First Implementation and Replication Studies in Mathematics Education Conference: IRMEC 2025* (pp. 93–97). Editorial SOMIDEM. <https://doi.org/10.24844/SOMIDEM/S3/2026/03-09>

A promising entry point is the concept of models. Models are central across the sciences, providing access to studying and explaining phenomena, but are rarely made the explicit target of teaching. They are mainly employed for illustration, without paying attention to their nature, purposes, or limitations. Moreover, the notion of what counts as a model differs: in biology, models are often descriptive, in chemistry they may be structural representations, and in physics they are closely tied to mathematical formalism. Bringing these perspectives together can give students a richer understanding of both the disciplines and the cross-cutting role of models in science. In this project, we explore how interdisciplinarity may foster students' understanding of models, and how models may serve as a basis for implementing interdisciplinarity.

How is it to be addressed?

Our approach combines a didactical view of interdisciplinarity with a metatheoretical view of models. From the first, we draw on Jensen and Jankvist's (2018) argument that a discipline's nature—and its potential for interdisciplinarity—becomes clearer when contrasted with others. From the second, we rely on work emphasizing reflection on the nature, purposes, and limitations of models (Gouvea & Passmore, 2017; Niss & Blum, 2020). Focusing explicitly on modelling provides a shared foundation across disciplines.

Methodologically, we use a design-based approach in which interdisciplinary activities are co-designed and implemented with teachers. Each activity centers on a scientific phenomenon explored from two disciplinary perspectives, enabling students to compare and reflect on models across boundaries. Across nine iterations, we define, test, and refine design principles for interdisciplinary model-oriented activities, which may later inform broader implementation principles (Bach et al., 2025) aimed at depth, sustainability, and teacher ownership (Coburn, 2003). In line with implementation research (Century & Cassata, 2016), we attend not only to the designed activities but also to their enactment, teacher adaptations, and contextual influences. Following Koichu et al. (2021), we consider four subprocesses teachers may experience during implementation: constructing agency, shifting communication, adapting practice, and tailoring the innovation to their needs.

What is to be implemented?

The project implements a series of interdisciplinary activities in Danish upper secondary school that place models at the center of instruction. Each activity is designed around a scientific phenomenon that can be explored from two disciplinary perspectives, such as biology and physics, or

chemistry and biology. In this way, students encounter and compare different types of models, while teachers are provided with designs that support collaboration across subject boundaries. According to Gilbert (2004) and Schwarz and White (2005), a sophisticated understanding of models requires both insight into the nature of models as well as experiences with actively constructing models. Hence, the principles for designing model-oriented activities build on theories concerning both a metaknowledge perspective on scientific models (model *reflections*) and active modelling (model *practices*).

To develop the students' model reflections, the activities address six core properties of models (Grosslight et al., 1991; Treagust et al., 2002): A) There are different types of models. They are not only visual and concrete but can also be abstract and symbolic. B) Models can have different purposes. C) Models are changeable. D) Models may be "wrong" in relation to the real phenomenon, but can help explain structures, processes, and properties. E) Models are human-made and are therefore not objective. F) Models are not exact representations; they show selected parts of a phenomenon. The model practices activities follow a progression going from using models over revising and reconstructing existing models to constructing models de novo (Gilbert, 2004).

For example, in an activity involving chemistry and physics, students explored phase transitions through multiple types of models with different purposes, showing selected parts of this phenomenon. They began with a chemistry experiment distilling ethanol from water, using their different boiling points. Next, they worked with an interactive physics simulator showing molecular motion at various temperatures, completing tasks related both to content and to comparing the simulator with textbook models as well as reflecting on the simulator's influence on their understanding of the distillation experiment. Students then drew water and ethanol molecules at different stages of the distillation, thereby constructing their own model of the process. Finally, they compared the different models used during the activity and reflected on how these supported their understanding.

What might be the potential importance and significance?

The project has the potential to contribute both to students' learning and to interdisciplinary teaching practice. For students, the activities create opportunities to deepen their understanding of models by engaging with their different functions and limitations across subjects. For teachers, the design offers a structured way to collaborate and integrate interdisciplinarity into the subject framework. The project also aligns with insights from implementation research (Century & Cassata, 2016) by

emphasizing not only the design of activities but also their enactment in classrooms, as well as the process of shifting the ownership of an innovation during an implementation process. A further didactical potential lies in recognizing that the activities can be understood both as a means to strengthen students' understanding of models and as a means to realize interdisciplinarity. Holding these perspectives together highlights a dialectical relationship between models and interdisciplinarity that may enrich the way science teaching is conceived and implemented.

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