Phenomenon-based learning and model-based teaching: Do they match?

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Abstract. The goal of physics teaching is to guide students from their everyday conceptions and activities to scientific models and practices. In essence, there are two different ways toward that goal: Phenomenon-based instruction and model-based instruction. Phenomenon-based instruction has been characterised by subjectivity, affectivity, mediation, exploration, and restrained model use. By definition, model-based instruction must be described by diametrically opposed characteristics: objectivity, rationality, confrontation, hypothesis testing, and extensive model use. Thus, the physics teacher may wonder whether the two methods of teaching and learning are mutually exclusive, or whether they can be combined to guide students stepwise from phenomena to models.

1 Introduction

Physics involves a continual transition between the world of phenomena and the world of models [1]. In the physics classroom, students need to have an opportunity to experience this interplay themselves. According to science education standards in various countries, students should be able to explore phenomena and to apply models [2-4].

However, the standards do not imply a specific teaching method. Thus, it is up to the teacher to decide how to fulfill the standards. Broadly speaking, the physics teacher may choose between **phenomenon-based physics instruction** [5,6] and **model-based physics instruction** [7,8].

Phenomenon-based physics instruction is based on the *phenomenological method*, which can be described as a sequence of four steps: 1) Describe instances of an every-day phenomenon. 2) Explore the phenomenon in experiments. 3) Create a systematic overview of the various ways in which the phenomenon has occurred. 4) Formalise relationships between selected aspects of the phenomenon [9].

Model-based physics instruction is based on the *modelling method*, which can also be described as a sequence of four steps: 1) Pose a question about a phenomenon. 2) Create a model representing the relevant aspects of the phenomenon. 3) Apply the model to answer the question. 4) Discuss the model and the modelling process that has been used [10].

Apparently, the two methods of instruction follow a similar sequence: First, students observe a phenomenon, then, they model certain aspects of the phenomenon. By definition, however, phenomenon-based instruction can be clearly distinguished from model-based instruction, according to *concrete*, *normative*, and *testable* criteria [5,11].

Thus, a fundamental question arises: **Is model-based physics instruction compatible with phenomenon-based physics instruction?**

To answer this question, we will first review the criteria for phenomenon-based instruction [5,11] to infer a corresponding set of criteria for model-based instruction (Section 2). Then, we will discuss whether it is possible to devise a method of instruction that can fulfill both sets of criteria, or not (Section 3).

2 Criteria for the two instruction methods

Table 1 Phenomenon-based instruction versus model-based instruction

Subjectivity Students rely on their own senses to explore a phenomenon	**Objectivity** Students use technical devices to measure physical quantities
Affectivity Teacher promotes emotional and social competences	**Rationality** Teacher promotes scientific knowledge and skills
Mediation Teacher uses phenomena as a bridge toward scientific understanding	**Confrontation** Teacher uses phenomena to induce a crisis of understanding in students
Exploration Students observe and describe the conditions under which a phenomenon occurs	**Hypothesis Testing** Students construct and test hypotheses about causes underlying the phenomenon
Restrained Model Use Students understand phenomena by relating observable facts to each other	**Extensive Model Use** Students explain phenomena by relating them to imaginary entities

3 Compatibility of the two instruction methods

By definition, the criteria for phenomenon-based learning are diametrically opposed to those for model-based teaching (Table 1). At first sight, the two instruction methods seem to be incompatible. Upon closer examination, the diametrically opposed criteria turn out to define two ends of a continuum. Over time, the teacher can move along that continuum, guiding students from exploratory to more theory-laden experiments, from inductive to deductive reasoning, and from their everyday world to the world of physics.

4 Conclusion

Phenomenon-based and model-based instruction are contradictory but complementary.

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