Chapter 4
"Can Modelling Be Taught and Learnt?" – A Commentary

Marcelo C. Borba

1 Introduction

The questions, whether mathematical modelling can be learnt and what we know from empirical research, are highly relevant not only for the current research on modelling, but they are as well essential for curricular changes introducing modelling into schools. Werner Blum tackles these questions in his paper from several perspectives and shows important research regarding the possibilities of students and teachers learning and teaching modelling, respectively. Blum dedicates his research to cognitive analysis of students who are involved in developing modelling tasks with the help of teachers.

Building on some of the important research developed in the area, he sets the stage for his argument defining *modelling competency*

> as the ability to construct and to use mathematical models by carrying out those various modelling steps appropriately as well as to analyse or to compare given models. It is a natural hypothesis that these modelling steps correspond to *sub-competencies* (Kaiser 2007; Maaß 2006) of modelling. The main goal of teaching is that students develop modelling competency with – using the notions of Niss et al. (see Blomhøj and Jensen 2007; Jensen 2007; Niss 2003) – a degree of coverage, a radius of action under a technical level as extensive as possible.

Blum claims that these sub-competencies are related to the steps students take to solve modelling tasks: constructing, simplifying, mathematizing, intra-mathematical tasks, interpreting, validating. He uses two problems to help the readers understand his ideas, the Giant problem and Fuel problem. The first one is more of an open problem and the second more related to the optimization problems that can be found in textbooks. He also refers to other problems in order to make his ideas clearer.

M.C. Borba (✉)
UNESP-Universidade Estadual Paulista Júlio de Mesquita Filho, São Paulo, Brazil
e-mail: mborba@rc.unesp.br

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He then presents the difficulties faced by teachers to orchestrate the classroom that is involved in solving modelling problems and discusses the steps that students use to solve problems. His chapter is anchored on strong reference to research developed in the field. My comments should then be understood as a means of expanding the very important ideas presented by Blum in the preceding chapter.

2 View of Modelling

The very first idea that the reader may want to consider is what view of modelling is embedded in Blum's chapter. Blum's view is one in which the problem is presented to students by the teacher as a story that is connected to other realms of the students' experiences. It is similar to problem solving in the sense that the teacher maintains the role of presenting a problem and the student responds to the teacher's input. As we know there are different views of modelling when we consider the role of teacher and students. One possibility is to have students choosing the theme to be studied as is done in some of the Danish and Brazilian traditions (see Borba and Villarreal 2005). We propose to enrich the modelling approach by such a competency designing a problem within a chosen theme, because it seems to be essential in order to promote autonomous learning processes. Alternatively, in some cases, the students may decide not to design a problem or a "research" question and opt instead to study and discuss the theme of their choice using mathematics and other established fields of knowledge. There is extensive research in Brazil illustrating this. In one study, for example, students enrolled in a first-year biology course chose mad cow disease as their topic of study and ended up merging biology and mathematics. Others chose photosynthesis and came up with topics, such as the logistic curve, which was not included in the syllabus of the calculus discipline they were enrolled in, as Fig. 4.1 illustrates.

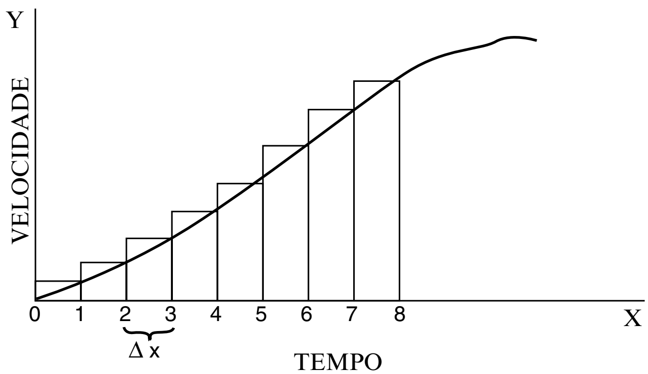

Fig. 4.1 Speed of photosynthesis increases as pollution increases over time

On the other hand, some students chose themes that did not develop into a problem. It is the case of the students who chose Nietzsche as a theme. They studied the life of the philosopher and elaborated a project, with the help of the teacher that included the view of mathematics expressed by the famous thinker. This never became a problem in any usual sense of the word. Is this problematic for schooling? Must students be solving problems or demonstrating in mathematics classes?

Answers to these questions are beyond the scope of both this commentary and Blum's chapter, but it does help to show that there are other possibilities of modelling to be investigated using Blum's analysis of students' cognition and teachers' competencies. On the other hand, little of the kind of research conducted by Blum has been done in classrooms where modelling is seen as a practice that emphasize students' choice of the theme. Both kinds of research could benefit from one another.

In the Brazilian tradition, recently Herminio and Borba (2010) studied what drives students' interests and how this drive changes over time as a group chooses a theme to study. Anchored on the discussion carried out by Dewey (1978), we make a critical analysis of the Brazilian tradition of modelling in which much importance is given to the students' choice of theme of interest. It would be interesting if cognitive analysis like the one proposed by Blum was incorporated into Brazilian studies to consider aspects such as goal orientation and motives of the ones involved in modelling projects.

3 Technology and Modelling

The research presented in this book by different authors and studies described in Borba and Villarreal (2005) show many examples of problems and modelling activities that were designed to be solved using software or the Internet. It seems to be necessary in the future to include technology in modelling activities. The examples by Blum mostly do not make use of technology. It would be interesting to find out what happen if studies like Werner Blum's were developed within a modelling approach in which problems were designed to be explored using information and communication technology (ICT). Not much has been done in terms of cognitive analysis in this kind of modelling project.

4 Critical Perspective and Cognition

In Brazil, a perspective on modelling is prominent, which is described by many authors, such as Kaiser and Sriraman (2006), as the social-critical perspective. In this perspective, learning of mathematics is connected to a critical reading of society as well. In this sense, it is fairly reasonable to say that connecting learning mathematics to a critical reading of the world (Freire 1976) may demand new "cognitive activities," a terminology used by Blum. In this regard, it may not be fruitful, as is the case in some areas of mathematical education, to see critical education and cognitive perspectives as a dichotomy. It would be interesting to see the design of the study developed by Blum and others incorporated into a task that engages students in a critical perspective as well.

5 Teachers and Modelling

Last, but definitely not least, Blum's paper pointed to competencies that teachers should have to teach modelling. He suggests that orchestrating a class with different groups developing different solutions at different paces is something that may bring uneasiness to teachers who engage in modelling activities.

Werner Blum claims that for teaching modelling you may have in mind some principles:

> The criteria for quality teaching (see Sect. 3) have to be considered also for teaching modelling; teachers ought to realise a permanent balance between students' independence and their guidance, in particular by their flexible and adaptive interventions …. In order to reach the goals associated with modelling, a broad spectrum of tasks ought to be used for teaching and for assessment, covering various topics, contexts, (sub-)competencies, and cognitive levels …. Teachers ought to support students individual modelling routes and encourage multiple solution …. Teachers ought to foster adequate student strategies for solving modelling tasks and stimulate various meta-cognitive activities, especially reflections on solution processes and on similarities between different situations and contexts.

There is much to be unpacked in the principles brought by Blum for those who would like to be involved in teaching modelling. This unpacking is a task for the community, and I would encourage them to consider the following questions, as well: How would one consider these principles if other perspectives of modelling are considered as well? How about if we consider technology in the classroom? Or if we consider it part of our task to teach students to be critical of the world they live in as they learn mathematics? These questions may contribute to making an already important agenda outlined by Blum regarding the teaching of modelling even more complex. I hope we can tackle some of these issues in the next ICTMA.

6 Final Considerations

Werner Blum's work connects cognitive analysis and modelling. By presenting a careful analysis of cognitive processes of teachers and students involved in modelling activities, he invites researchers who are focusing on other domains of modelling, or other conceptions to do the same. It also invites researchers to consider other cognitive approaches to analyze students' and teachers' actions. For instance, one could use, as was done in previous ICTMA proceedings, activity theory, a perspective that focuses on students' motives as they are involved in a task.

In summary, I believe that Blum’s chapter brings new ideas to the field and inspires new research as we try to change curriculum structure in school through our research on modelling.

References

Blomhøj, M., & Jensen, T. H. (2007). What’s all the fuss about competencies? In W. Blum et al. (Eds.), *Modelling and applications in mathematics education* (pp. 45–56). New York: Springer.

Borba, M. C., & Villarreal, M. E. (2005). *Humans-with-media and the reorganization of mathematical thinking: Information and communication technologies, modelling, experimentation and visualization*. New York: Springer.

Dewey, J. (1978). *Vida e Educação.* São Paulo: Melhoramentos; [Rio de Janeiro]: Fundação Nacional de Material Escolar. Tradução de TEIXEIRA, A.

Freire, P. (1976). *Education: The practice of freedom*. London: Writers and Readers.

Herminio, M. H. G. B., & Borba, M. C. (2010). A noção de Interesse em Projetos de Modelagem Matemática. *Educação Matemática Pesquisa, 12*(1), 111–127.

Jensen, T. H. (2007). Assessing mathematical modelling competencies. In C. Haines et al. (Eds.), *Mathematical modelling: Education, engineering and economics* (pp. 141–148). Chichester: Horwood.

Kaiser, G. (2007). Modelling and modelling competencies in school. In C. Haines et al. (Eds.), *Mathematical modelling: Education, engineering and economics* (pp. 110–119). Chichester: Horwood.

Kaiser, G., & Sriraman, B. (2006). A global survey of international perspectives on modelling in mathematics education. *Zentralblatt für Didaktik der Mathematik, 38*(3), 302–310.

Maaß, K. (2006). What are modelling competencies? *Zentralblatt für Didaktik der Mathematik 38*(2), 113–142.

Niss, M. (2003). Mathematical competencies and the learning of mathematics: The Danish KOM Project. In A. Gagatsis & S. Papastavridis (Eds.), *3rd Mediterranean conference on mathematical education* (pp. 115–124). Athens: The Helleniic Mathematical Society.