Mathematical Modeling: a new approach for mathematics teaching in different levels

Aslan Doosti ¹ & Alireza M. Ashtiani ²,³

Abstract

The term model has a different meaning in mathematics teaching. In fact the mathematical modeling is linked to the notion of project work. The goal of this work is to provide a comprehensive overview of mathematical modeling and its applications in mathematics education, and characterize how a student's modeling competency can be characterized. This work presents some new ideas and developments of major importance to practitioners working in the field of mathematical education, seeks to improve the education of mathematics teachers, tries to develop teaching methods and shows the role of modeling and applications in everyday mathematics teaching.

Keywords - Mathematical modeling. Mathematics education. Project work. Student's modeling. Open active approaches.

1 INTRODUCTION

Education is something that someone gets familiar with a culture and nor with the formal study. So education is a cultural activity that has been shaped over time and has a strong and lasting relationship with the beliefs that are parts of the culture. Currently, the image of mathematics in the community; in fact, is an image with non-human things. From the point of view of ordinary people, mathematics is for suffering and mathematics is a kind of mental torture! Often it is thought that only people which is highly intelligent has the ability to understand mathematics concepts. In the culture of the United State teachers, modern tools such as overhead projectors, presentation

¹ Islamic Azad University - Omidiyeh Branch, Omidiyeh, Iran. Email: aslan_doosti@yahoo.com
² Universidade Estadual de Campinas - UNICAMP, Barão Geraldo, 13083-852 Campinas, São Paulo, Brazil. Email(s): armashtiani@gmail.com (or ashtiani@dt.fee.unicamp.br) .
³ Corresponding author.
must be used to provide the content and draw attention of the students in mathematics learning, and they believe that mathematics learning is possible in every moment (Weissglass, 1992).

Weissglass (1992):

“The culture is the attitudes, beliefs, values and practices shared by a community of people which they often do not question, are often unstated and which they may not be consciously aware of.”

The cultural activities are very stable over time and are not easily changed, since the activities, particularly such as complex education system are very hard to change. As well as cultural activities are rooted in a widespread culture and for most members of such culture is not very apparent. To improve the education system, both the systematic and the cultural aspects must be recognized and considered. During the last decades, the researchers have been discussed and introduced a number of different approaches to teaching and learning mathematics, which an alternative approach to learning and teaching mathematics includes changes in the pedagogical practices of the mathematics classroom, such as “active learning approaches”. Within the activity learning approaches, the learner activity constructs her understanding of mathematical concepts. The components of the “teaching in the classroom” process, in an activity learning approach, are identified as “entities”, teacher, student and contents, and “ restrictions”, place and time, which these two components together represent the “traditional teaching” – Figure 1.

![Figure 1. Traditional teaching](image-url)
In fact, the “learner” is the “key-person” in this strategy, that is, the mathematics teaching should be learner-centered. This means, the learner’s need to active mentally, socially and physically in this education learning system. In this approach, the role of teachers is seen as that of a manager of the learning environment, and it also is notable that this process is open-ended learning. The learner and the teacher are two important actors in this environments. Teaching and learning is influenced by the context where it takes place, and learners and teachers bring their characteristics to the learning environment and as such interact with the learning and cultural context. One of these active learning approaches is the “mathematical modeling”.

2 MATHEMATICAL MODELING IN MATHEMATICS EDUCATIONS

In the last few decades, technology usability has evolved and spread to all sectors of daily life activities at lightning speed. Education is no different. The ease and diversity technology offer to enhance the teaching and learning experience for both the educator and the student is unparalleled. Firstly, people often think about educational technology as a limited tools, only to use of computer at school activities. This view excludes other important educational technologies, such as mathematical modeling, games, maps, etc. The teacher has a wide range of methodological options, opportunities to organize their communication with students, to introduce a theme to work with students. For example, it is no surprise, then, that technology used in academic institutions is giving rise to more cases of cheating.

The idea of using mathematics modeling in mathematics education began in the mid-'70's at PUC-RJ, by Aristides C. Barreto after he had started teaching at this institution. The mathematical modeling deals with the process of creating a model that should then be applied in solving the mathematical problems. From a conceptual point of view, it can be said that there is no unique definition of what is mathematical modeling. The mathematical model is obtained when we translate the problems from the hypotheses language into the formal symbolic language, in other words, when we extract the essence of the problem situation and turn it into systematic mathematical language. In mathematics learning, mathematical modeling deals with modeling and applications in mathematics teaching, characterizes how a student's modeling
competency can be characterized and how modeling and applications activities can contribute toward building up these competencies.

In fact, the mathematical modeling is linked to the notion of project work. Dividing the students into small groups into with a specified time to discuss a particular aspect of the topic or to work on a particular problem, which the topics of interest must be chosen to be investigated by means of mathematics, with the accompanying teachers, Bassanezi (1994) and Biembengut (1999). However, several techniques are suggested in the literature on teacher education. For example, Franchi (1993) used a problem situation related to the concepts of Differential and Integral Calculus.

There is a large number of researches conducted dealing with the teaching and learning of mathematics at different educational levels. The mathematical modeling is characterized as a learning environment in which students are invited to inquire or investigate, through mathematics, situations from other areas. Thus, the importance of integration of situations from everyday life and other areas of knowledge in the classroom, with the purpose to enable students to intervene in this reality, is emphasized in this environment. In this work we try to show the advantages of mathematical modeling activities in scholar education.

With the help of mathematics, one uses representations that are able to explain and interpret phenomena under study, which these representations are called models. A mathematical model can be understood as a set of symbols and mathematical relationships that represents a situation, a real phenomenon or an object to be studied. Mathematical models can be expressed through graphs, tables, equations, systems of equations. Modeling (in general) can be defined in terms of the purposes and interests underlying its implementation, leading to conceptual and curricular implication. For example, Kaiser-Messmer (1991) suggests two general views that prevail in international discussions on modeling, the pragmatic and the scientific views. Mathematical modeling is used in understanding and resolving problems of reality, as a strategy for teaching and learning. It enabled us to use the chosen themes, knowing the problems that are exist within it and try to solve them with the help of mathematics.

In view of Barbosa (2002), modeling as a learning environment conducive to investigate other areas of knowledge through mathematical:
“Modeling is a learning environment where students are invited to inquire and/or investigate, by means of mathematics, situations arising in other areas of knowledge. If we take a mode of socio-critical, the question goes beyond the formulation or understanding of a problem, integrating the knowledge of mathematics, modeling and reflective.”

3 THE MODELING PROCESS

What do “modeling” and “mathematical modeling” mean in mathematics education? We try to answer these questions and others. In general, there is no unique definition of the term mathematical modeling and this makes confusion about modeling, because, different people has different definitions. Modeling can be understood in more specific terms. This is an opportunity for students inquiring situations through mathematical procedures without previously established procedures and with different routing possibilities. However, some cases may be more amenable to some mathematical concepts, for example, situations that involve variation but nothing guarantees that students are inclined to them. Skovsmose (1994) introduced the concept of learning environment to refer to conditions in which students are encouraged to develop certain activities.

The term environment refers to a place or space that surrounds it. Mathematical modeling encourages students to investigate cases of other areas than mathematics through mathematics. We can now talk in the active learning environment modeling. The process of modeling consists of steps. Before to begin the mathematical modeling, first step is try to divide the students into small groups. Then, the process of modeling may be considered as follows:

**Pass 1.** The professor need to define and identify an suitable problem to be investigated;

**Pass 2.** The profesor tries to determine the important factors for his student. For example if the professor wants to teach the concept of velocity, he need to determine the factors distance, time, and in the potential energy case, the important factor is the
gravity and its effect, velocity, and the initial velocity, and finally the concept of the height of the object at time $t$;

**Pass 3.** Then, the professor needs to represent those factors one by one and interplay them mathematically and write the mathematics relations and analyze them in sequence;

**Pass 4.** The professor needs to interpret the mathematical results in the context of real world phenomenon;

**Passe 5.** Evaluate how applicable the results are to the real world situations.

The advantages and disadvantages of mathematical modeling process in the classroom can be summarized as follows.

Advantages:

- The students are more interested in an activity such as mathematical modeling than learning the context, solving some problems, and learn how to solve an equation, without knowing how the problem can be applied in real world, since in general, the mathematics problems have no meaning for students, not even for teachers;

- The students learn how to make a connections to other situations, especially to the physical situations; in fact, the student will feel more prepared to the use of mathematics in other areas;

- The learning will have a real meaning; in other words, it becomes easy to make connections to other situations and problems;

- It is much easier for most students to remember a modeling problem that spent much time on than a mathematical equation;

- It can happen in any level of education, *primary* and *secondary* education;

- In addition, the mathematical modeling process is more flexible and controllable for a professor that the traditional mathematics learning methods, and etc.
Disadvantages:

- The choosing of good problem to discuss in the classroom is not very simple, in general, and in fact is the art of the professor!
- The mathematical modeling process (or any active learning approach) take more time than the traditional approaches;
- The students do not like to test a new approach, in general. So, the chose of a good problem or situation is very essential.

The following models have been tested in two classes of total 49 students (all boys, in the age of 14 – 18 years olds):

1- The problema of the location of a hospital in a small city, with no traffic;
2- The problema of finding the root of the quadratic functions;
3- The problem of the minimum distance, between the students’ homes and the school;
4- The time serie of the queue of the milk.

All 49 students participated in the all tests above, and the results were as follows: 81% of the students (approximately 40 students) answered “yes” to the mathematical modeling approach, in fact, this group was very interested in the activities. 11% of the students (approximately 5 students) were with no idea about the process, and 8% answered “No”; in fact, 47% of "this group" (which answered NO) did not like the activities! The second question was: In your opinion what is the desadvantage of this approach? Almost all, approximately 95% said the approach can not be generalized to all examples, and 5% said the approach is very time-consuming! As an advantages of the modeling approach, approximately 76% of the students said the approach is very exciting, but 24% of them believed that the activities are boring, due to the fact that they require individual activity! Almost all studets (96%) liked the fourth activity; the students believed that the fourth activity is very applicable in real life!
When the professor asked: “mathematical modeling class or sport activity class?” The answer of about 89% of the students was “sport activity class” (as it was expected), but the interesting thing was when we asked “mathematical modeling activity class or theoretical sport class?” The answer of more than 67% of the students was “mathematical modeling!”...

4 CONCLUSIONS

In this work we have studied the mathematical modeling approach as an alternative strategy in the mathematics education. Mathematical modeling approach can be considered in the class of the active learning approaches, since the approach is a learner-centered approach. In fact, the process of mathematical modeling in mathematics classes is through taking a real world modeling approach to the teaching of mathematics. In this education approach, students can develop and sharpen their skills, deepen their understanding of mathematical concepts. The mathematical modeling, in fact, tries to connect students to a variety of ideas and skills, and in this education process, students can learn how to make a connection to other situations, feel more prepared to the use of mathematics in other areas. From our own experience in teaching mathematics, we can tell that the mathematical modeling approach, as a new alternative in learning, makes a remarkable changes available to students and professors, and these changes together suggest that the mathematical modeling improves the learning process, since this method works on three criteria - observing, retaining and replicating and the students learn more by observing the things and acquire it by imitating it time and again. In other words, it is much easier for most students to remember a modeling problem that spent much time on than an mathematical equation.

ACKNOWLEDGMENT

This work of the first author (Aslan Doosti) was supported by “Islamic Azad University, Omidiyeh Branch”, Iran.
REFERENCES


