Evaluation of the new secondary school curriculum in Turkey from the point of mathematical models and mathematical modeling

Alper Çıltaş*, Büşra Çelik, Nizamettin Bilen, Kübra Yılmaz, Muhammet Doruk, Ferhat Öztürk

*Atatürk University, Faculty of Education, 25240, “Erzurum”, Turkey

Abstract

This study aims to evaluate the secondary school mathematics curriculum renewed in 2013-2014 education year in Turkey from the point of mathematical models and mathematical modeling. The old and new mathematics curriculum were compared for all class levels by researches and discussed the changes within the group. The report of researchers shows that the following is stated in the 2009 curriculum vision: “Mathematical concepts are abstract in nature. Given the developmental level of children, these concepts are hard to conceive directly. Hence, mathematical concepts are addressed using concrete and finite life models.” Whereas in the general purposes section of the new curriculum, it’s emphasized that information and communication technologies should be effectively used in mathematics education, such technologies should be implemented to create the environment for children to improve their skills such as problem solving by modeling, communicating, and reasoning. Moreover, the addition of improvement of problem solving skills by modeling into the program objectives shows that the new curriculum considers modeling important. Considered in general, the new curriculum is found to be simplified, subjects and gains are reduced, and course hours are increased. As it stands, this curriculum is more beneficial and flexible both for students and teachers.

© 2013 The Authors. Published by Elsevier Ltd. Open access under CC BY-NC-ND license.
Selection and peer-review under responsibility of The Association of Science, Education and Technology-TASET, Sakarya Universitesi, Turkey.

Keywords: model, mathematics, mathematical modeling, education and training

* Corresponding author: Assist Prof. Alper ÇİLTAŞ, is currently an Assistant Professor at the Department of Elementary Education. Address; Atatürk University, Kazım Karabekir Education Faculty, 25240, Erzurum/Turkey. E-mail: alperciltas@atauni.edu.tr, Tel 0442 231 4220, Fax: +90 442 236 0955.
1. INTRODUCTION

Mathematics is an important part of our daily lives just like it plays a great role in the scientific world, and it constitutes the basis for various fields such as physics, chemistry, astronomy and engineering. Therefore, in modern life, as science and science-related technology changes rapidly to the point of being re-shaped, the value of mathematics has become an unquestionable subject. In today’s world, it will not be hard to say that the rapidly changing technology transforms the whole living style of society from culture to economy, and also influences learning habits. We discover many unknown events as we continue to make researches, and we move towards different horizons as we share our knowledge. So, educational institutions are also obliged to change their conditions in order to adapt to the ongoing knowledge revolution. The aim is to teach students knowledge, skills and behaviors they may need throughout the rest of their lives. One of the most significant changes in mathematics education has been on curriculums.

Curriculums foster students’ conceptual learning, fluency in operations and communication through their mathematical knowledge stressing the development of their problem solving skills and orienting them to value mathematics. Moreover, curriculums also consider it important that students generate mathematical meanings by means of concrete experiences, and perform abstraction and association. That’s why it is a requirement to create learning environments enabling students to consider mathematics as “perceivable, functional, and a field worth the effort” and helping them to study “with diligence and perseverance”. On the other hand, learning mathematics also covers mathematical thinking, apprehension of problem solving strategies, and recognition that mathematics is an important tool in real life along with acquiring basic concepts and skills. (Ministry of National Education, [MEB] 2013). Within this context, mathematical models and mathematical modeling play a significant role in creating such environments.

In mathematics courses, delivering a concept directly makes it hard for students to learn and internalize the concept (Van de Walle, 1998). Concepts should be taught to students with mathematical models instead. According to Blum and Niss (1989), mathematical model is a type of real model created by means of mathematics. Which means, mathematical model is an act of transforming real world events into mathematical objects or operations, and real objects are included in this process. According to a study by Lesh, Carmona, Hjalmarson and Mason (2006), models are conceptual and visual tools helping students, teachers, researchers and instructors to learn, explain and grasp subjects better in applications related to mathematical concepts (Lesh and Doerr, 2003; Lesh, Doerr, Carmona and Hjalmarson, 2003). According to Olkun and Ucar (2007), mathematical concept model is an image, a drawing, a symbol or a concrete tool containing the relation within the concept. Modeling is defined as the whole of actions to clarify a target by use of current sources, and resulting products are known as models (Harrison, 2001; Treagust, 2002).

Van Driel and Verloop (1999) have described the common characteristics of models as follows:

• A model is always related to the target or targets represented by itself. The target can be a system, an object, a phenomenon or a process.

• A model is a research tool used to obtain information about a target that is not directly observable or measurable. Hence, a different scale copy of an object (such as house, and bridge models) is not accepted as a scientific model.

• A model does not directly interact with the target it represents. Therefore, a photograph or a spectrum cannot be considered as a model.

• A model always shows distinct characteristics compared to the target. Generally, models are simplified as much as possible.

• While creating a model, similarities and differences between the target and the model should help researchers in making predictions about things represented by the model.
A model is developed as a result of interactive processes. Mathematical modeling is the process of dealing with daily life problems (Keskin, 2008). In general terms, problems related to every part of mathematics under daily life conditions can be called as daily life problems (Blum and Niss, 1989). According to Kapur (1998), mathematical modeling covers models that act as an interpreter to daily life problems, and turn mathematical problems to real life problems. Which means, expressing a situation with a mathematical form such as a formula, an equation, a graph, a table or a figure is called a mathematical model, and the process applied to develop this model and the process of interpreting the problem solution are known as mathematical modeling.

Models can help us in recognizing how an object is structured or how a process occurs. A model is not a real thing and it can change (Harrison, 2001). It can be used to facilitate greater understanding of the subject in the learning environment and to test concepts. Harrison (2001) emphasizes that use of models in learning environments facilitate envisioning complex abstract concepts, objects and processes, and make it easier to understand complicated abstract subjects with a deeper grasp. According to Yildiz (2006), models are not real and they don’t reflect reality. However, they are guiding in development of ideas and transfer of knowledge to a higher step. It should be kept in mind that no model represent a target hundred percent accurately. Otherwise, the model becomes the target itself, and there would be no need for a model (Sagirli, 2010).

As stated by Blum and Kaiser (1997), different sub-skills are important for mathematical modeling studies. According to Maab (2004), modeling skills consist of the following:

- Ability to understand daily life problems and create models according with reality.
- Ability to create mathematical models out of real models.
- Ability to solve mathematical problems featured in the mathematical model.
- Ability to interpret mathematical results in line with daily life.
- Ability to confirm the solution.

Given the general objectives of education, mathematics plays a significant role in helping students to develop themselves under the light of their skills, acquire knowledge and skills in their fields, and contributes to their creative thinking (Ciltas 2012). Mathematics education aims to train individuals who could generate effective solutions to real problems, use mathematical effectively in their daily lives, recognize the close relation between mathematics and the real world, and therefore love and enjoy mathematics rather than being afraid of it (Doruk and Umay, 2011). In the secondary school mathematics curriculum developed and revised by the Ministry of National Education in 2013, the aim is to teach mathematical thinking system, and develop basic mathematical skills and abilities related to such skills. The program was reviewed and updated in order to realize this aim. This study aims to analyze the secondary school mathematics curriculum renewed in the 2013-2014 academic year in terms of mathematical models and mathematical modeling. Moreover, the old and the new mathematics curriculums are separately compared among different class levels by researchers and the changes are discussed within the group.

2. Method

2.1. Research group

The research group consists of three teachers and three academicians totaling six people.
2.2. Data collection

Research data consists of reports written after reviewing the secondary school curriculum updated in the 2013-2014 academic year.

2.3. Data analysis

Qualitative descriptive analysis method is employed to analyze the research data.

3. Findings

The updated secondary school mathematics curriculum is evaluated under two stages. First, the curriculum was subjected to a general assessment. Another assessment was performed to evaluate the curriculum on class-basis. Upon performing a general assessment on the curriculum, the following findings are found as a result of the reports of researchers. The 2009 curriculum vision reads: “Mathematical concepts are abstract in nature. Given the development levels of children, it is hard for them to apprehend these concepts directly. Therefore, mathematical concepts are discussed using concrete and finite life models. In the general objectives of the new curriculum, there is an emphasis on effective use of information and communication technologies in mathematics education, it is stated that proper environment should be created to develop the problem solving, communicating, and reasoning skills of students through modeling. Moreover, addition of developing the problem solving skills by means of modeling to the program objectives shows that the new curriculum prizes modeling. 6 items are taken from the general objectives list in the new curriculum. The study-related “Can develop models, and associate models with verbal and mathematical expressions” item draws the attention. Besides, about the mathematical process skills, the new curriculum states: “Along with abstract symbolic expressions, verbal expressions, written and visual expressions and if necessary, models are important in mathematical communication.” The old curriculum also states the following in relation to communication skills: “Verbal and written expressions, images, graphs and concrete models should be used throughout mathematical efforts and also following this process.” The new curriculum addresses the association skill from among the mathematical process skills as follows: “Environment should be created to facilitate association between concrete and abstract representation modes (tables, graphs, equations, figures, concrete models, real life situations etc.). Virtually the same expression is uttered in the old curriculum.

Upon evaluation of the curriculum on class basis, the following findings are found as a result of the reports of researchers. It is stated that models should be used in arranging fractions, and converting mixed fractions to compound fractions and vice versa. The old curriculum also shows that such subjects are handled with models. Comparison of natural numbers and compound fractions, abbreviation, expansion, equivalent fractions, arranging fractions with equal or solid denominators, finding the proper fraction of a quantity are among the subjects taught using models in the old curriculum, but not expressed in the new curriculum. While the old curriculum suggests teaching the subject of fractional operations with models, the new curriculum doesn’t separately state that models should be utilized. While the old curriculum taught the subject of fractional multiplication by means of modeling, the new curriculum omitted this from the fifth grade subjects. Decimal notation of fractions, a subject of fourth grade, is given as a subject of fifth grade, and it is recommended to teach the subject using models. In addition, both curriculums suggest teaching certain concepts such as finding the specified percentage of a quantity and decimal fractions using models.

It is also recommended to teach the distributive property of natural numbers, a subject of sixth grade, using models, and the old curriculum teaches the same subject with decimal base blocks. Moreover, while four operations with natural numbers is a subject suitable for modeling, and while the old curriculum uses tables for addition and multiplication with natural numbers and shows different models to students about the properties of
these operations, the new curriculum doesn’t involve anything about how this subject should be taught. On the other hand, while the old curriculum teaches multipliers, prime numbers and prime multipliers using models, the new curriculum makes no mention of this subject. Fractions and fractional operations are recommended to be taught using models in both the old and the new curriculum, yet decimal notations are handled with models in the old curriculum, but again, the new curriculum makes no mention of this subject.

Analysis of the updated secondary school mathematics curriculum on class basis yielded the following data: While the old curriculum taught multiplication and division of natural numbers by using number pieces, patterns, and numerical axis, the new curriculum suggests using models for the subject. The old curriculum teaches the subject of rational numbers using fraction cards, while the new curriculum makes no mention of this subject. However, the subject of rational numbers, and particularly four operations in rational numbers is a subject suitable for the modeling method. Besides, the old curriculum uses polygon models for the subject of interior and exterior angles of polygons, while the new curriculum gives no data about this subject.

Lastly, analysis on eight grade shows that both the old and the new curriculums suggest using square models to define the relation between perfect squares, natural numbers and their roots. In multiplying algebraic expressions, and explaining identities, both curriculums suggest the use of models. But while the new curriculum doesn’t mention it, the old curriculum uses models for factoring algebraic expressions. Slope models are suggested in both curriculum for the subject of slope of a line. Both curriculums suggest using models to explain equality-similarity, prism, pyramid and cone.

4. Conclusion and discussion

As a whole, the new curriculum is simplified, the number of subjects is reduced, and course hours are increased. The new curriculum is more practical and flexible for both students and teachers. Moreover, subjects are divided among grades with a certain order, while the old curriculum had some difficulties with this issue. For example, while the subject of prisms was taught in the fifth grade, the subject of angles was instructed in sixth grade. The curriculum has no big changes in terms of modeling. The new mathematics curriculum also suggests teaching certain subjects using models just like the old curriculum. Tough problem solving with mathematical modeling is situated among the objectives of the new curriculum, the subject was not elaborated while describing attainments. Generally, use of concrete models was referred, however modeling and modeling skills of students were not mentioned. It is particularly emphasized that students should develop their problem solving, communicating, and reasoning skills with the use of technologies. Therefore, only a minor difference can be found between two curriculums in terms of modeling.

While the old curriculum teaches fractional operations in fifth grade using models, the new curriculum does not particularly state the need for models. The old curriculum teaches multipliers, prime numbers and prime multipliers in sixth grade using models, but the new curriculum doesn’t mention about it again. In seventh grade, multiplication and division of whole numbers is taught using number pieces, patterns and numerical axis. And the new curriculum also emphasizes employment of models. Lastly, in eighth grade, both curriculums suggest using models to multiply algebraic expressions, and explain identities. While the new curriculum denotes nothing about it, the old curriculum employs models to facilitate understanding of factoring algebraic expressions. In the old curriculum, Pythagorean relation is taught using right triangles, but there is no such method given in the new curriculum.

Today, scientists express everything with mathematical terms in order to get a better grasp of the world around us, and to find solutions to technical problems. Thus, it is important for mathematics education that math teachers use real life problems and perform mathematical modeling in their courses. It is necessary to develop the modeling skills of students, helping them to think creatively, performing cognitive activities, and adopting an effective and student-based approach to improve the mathematics-oriented conceptual understanding of students, and to present the relation between mathematics and real life situations. Formulating, analyzing and interpreting a
daily life problem means solving the problem in half. It is possible to consider mathematical modeling as a complex mathematical activity, and mathematical thinking, teaching, learning and many aspects of life can be found in mathematical modeling.

The new mathematics curriculum also encourages effective use of information and communication technologies in mathematics education. A special emphasis is put on information and communication technologies that make it possible to find out different representation methods for concepts and relations between them, and also help students in discovering mathematical relations. Environments, where students can develop their problem solving, communicating, and reasoning skills using the method of modeling, should be designed with the help of such technologies (MEB, 2013).

5. References