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Modelling and Applications in Iran School Mathematics Curriculum: Voices of Math Teachers

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Abstract: *In this paper, six mathematics curriculum changes in Iran are reviewed, spanning from 1900 to 2021. Change of forces, barriers, and the main features of each reform are represented. Specifically, the first five curriculum changes are described briefly and the sixth and most recent one is elaborated upon, with more detail as contemporary school mathematics curriculum change. This recent curriculum reform will be then analyzed using an application and modeling approach, followed by reflections from five teachers of mathematics' voices about how they implemented recent curriculum reform after passing modelling course in their master's program. These teachers shared their professional beliefs about the role of the modelling course in shaping their classroom practices. We believe that the practical aspects of this paper can have enormous implications for other mathematics teachers in developing countries.*

INTRODUCTION

Iran has a centralized educational system, so the mathematics curriculum and textbooks are designed at the national level and distributed around the country by the Ministry of Education. All schools, teachers, and students have to use the same mathematics textbook for teaching and learning mathematics. Also, the main resource in all sorts of exams (like classroom assessment and national external exams) is the same math textbook to which all students have access. According to TIMSS math teachers' questionnaire, most Iranian math teachers in grades 4 and 8 reveal that they use mathematics textbooks as the main source for their teaching in classrooms (Mullis, et. al., 2008 and Mullis, Martin, Foy, & Arora, 2012). So, in a centralized educational system, textbooks have an important role. The first and only Iranian National Curriculum was prepared and published by 2010 (Supreme Council of Education, 2010). Therefore, in this paper will illustrate the Iranian mathematics curriculum reforms traced through Iranian mathematics textbook changes. Indeed, mathematics textbook changes show the reflection of new aims, scopes, and direction of the mathematics curriculum.

Iranian mathematics curriculum has experienced six reforms from 1900 until now. Five of them occurred before launching the National Curriculum in Iran and one of them occurred subsequently and upon the direction of the National Curriculum. Indeed, the Iranian national curriculum was prepared and announced by the Ministry of Education in 2010. After launching the Iranian national curriculum, recent reforms in all mathematics textbooks began, and gradually all of the math textbooks at primary and secondary levels changed in a new direction. In this paper, the recent reform (post-2009) will be presented as the contemporary mathematics curriculum reform.

Despite that the main focus of this paper is an analysis of the contemporary reform in the Iranian mathematics curriculum using an application and modeling point of view, the past reforms dating from 1900 to 2009 shall also be reviewed. This will allow a better understanding and a more comprehensive picture to be gleaned of historic Iranian mathematics curriculum reform. Therefore, the specific research question which lead this study are as below.

1. What are the mathematics teachers' voices about recent curriculum reform in Iranian school mathematics toward modelling and application?
2. What are the key ideas which guide the changes in Iranian school mathematics over time?

Even if this study discusses curriculum changes in the Iranian context there are at least two international contributions that include scholars from different backgrounds and countries around the world. Firstly, the Iranian context as a developing country is discussed so the emerging ideas can help other scholars from developing countries learn how they can integrate their globalization effect into their official curriculum. Secondly, the discussion about how the Iranian school mathematics curriculum provides an in-depth insight into mathematical content and the process in which Iranian emigrant students learned during their study in Iran (Farsani, 2016). At this time, there is an estimate of 6 million people of an Iranian heritage living outside of Iran (Cohen & Yefet, 2019). The findings of this study can therefore help mathematics teachers and curriculum developers in developing countries to devise better programs for emigrant students.

Past Mathematics Curriculum Reforms

In this section all educational changes and mathematics curriculum reforms from 1900-2009 will be briefly reviewed and the change of forces and barriers of past reforms will be discussed. Some of these reforms were previously distinguished and explained in national journals and magazines by other Iranian scholars in Persian (Farsi) language which is the official language in Iran (e.g. Jalili, 2010; Rezaie, 2016).

The first mathematics curriculum reform started after establishing a new type of school in Iran to resemble a European school style. In 1851, the first Iranian school (namely 'Dar Ul-Funun') was established in Tehran (Capital city of Iran from 1788). In this school, foreign teachers were employed to teach modern knowledge to Iranian students. Gradually, this school published some textbooks on various subjects. These textbooks continued to be used until 1938 where the Ministry of Education tried to unify them (including mathematics textbooks) by 1938. As a result of that, the second mathematics curriculum reform started from 1938 and continued until 1962, during which time all mathematics textbooks orchestrated uniformity in the entire country (Rezaie, 2016).

In 1962, the third reform in the mathematics curriculum started after the White Revolution (Revolution of Shah and People). This curriculum change as the third reform stimulated the educational system changes by 1967 and the educational system was divided into three sections: Primary school (5 years), Intermediate or guidance school (3 years), and Secondary school (4 years). All textbooks including mathematics textbooks changed during this reform (Rostami, 1978 and Orton, 1981).

The fourth reform started in 1975 and continued until 1992. At this time "New Math" was introduced to the Iranian school mathematics curriculum. Traces of "New Math" could be seen all over the mathematics textbooks during this period from primary to secondary level. At that time, after grade 8 students were divided into two types of school: theoretical and vocational. In theoretical school, students have divided again into three different groups: Mathematics and Physics, Experimental Science, and Human Science. As a result of integrating "New Math" into the math textbooks, mathematics became meaningless for students. So, only small numbers of students (about 9%) chose math and physics for their future studies (Parvaneh & Rejali, 2019). This created in the future a shortage of candidates in math and science-related roles. As a reaction to this social phenomenon, the High Commission of Fundamental Changes in Educational System decided to launch new reform.

The fifth reform started from 1992 until 2009, as a reaction to new math and this curriculum reform influenced just the secondary level (grade 9-12). This reform also coincided with educational system changes. The educational system is divided into four sections: Primary (5 years), Intermediate (3 years), Secondary (3 years), and Pre-University (1 year). Another change in this reform has been that the school year starts from September to June, which is divided into two parts (as a semester) instead of three parts (as before). There is special attention to vocational education at the secondary level during this reform. In this reform, all mathematics textbooks in grades 9-12 were changed. During this reform research finding in the mathematics education domain was used widely and in some of the mathematics textbooks at the time, there are some features of constructivism and problem solving which would draw upon new findings in the field of mathematics education. Mathematics changes included the subject "discrete mathematics", which was added to grade 12 as a separate mathematics textbook for students studying mathematics and physics.

Contemporary Mathematics Curriculum Changes

The Iran National Curriculum project started in 2006 in the High Commission of Fundamental Changes in Educational System (under the Supreme Commission of Cultural Revolution) and the first edition of this document was published in 2009. After approval of this national curriculum in 2010, the sixth and most recent mathematics curriculum reform started and continues until now. In this national curriculum document (Supreme Council of Education, 2010) there are eleven learning domains which Iranian students have to study during their formal education. Mathematics is one of these learning domains which is defined as a science of pattern, symmetry, art, and finally a precise language. In the Iranian national curriculum document, several roles for the necessity and function of mathematics are considered, as below:

- Understanding the laws of nature (anticipating and controlling different natural situation)
- Solving real-world problems
- Developing a method of thinking in other natural and human science enhances rational reasoning.

There are four content topics (Number and Operation, Algebra and Symbolic Representation, Geometry and Measurement, Data and Statistics and Probability), and seven process topics (Problem Solving, Modelling Real Data, Reasoning, Visual Thinking, Creative Thinking, Connection, Communication) in the Iranian national curriculum document.

In this document, there is an emphasis to express the role of Iranian mathematicians in developing mathematics in the Golden Islamic Age (Europe's Dark Ages). In some of the mathematics textbooks which were published after the approval of the Iran national curriculum, there are some historical points about Iranian mathematician and scientists in the Golden Islamic Age which have a major impact on Muslim culture and civilization. Some of the Islamic Golden Ages examples are still present today through the work of arts, paintings, and relics. The role of symmetry, ratio, and geometry is pertinent in such historical relics. Nowadays, the Iranian ethnomathematical community manifested the crucial role of Iranian mathematics not only within the Islamic Golden Age but also in the entire world.

Integrating the use of technology in education (Farsani et al., 2020), in mathematics lessons (Rosa, Farsani, & Silva, 2020), and particularly in the didactics of mathematics has been emphasized (Breda et al., 2021). In Iran's national curriculum, there is also an emphasis on the use of technology (such as calculators and computers) in mathematics. However, this is not seen in the new mathematics textbooks!

After the enactment of the Iranian National Curriculum, contemporary mathematics curriculum reform started in Iran and two mathematics textbooks (one from the primary level and another from the secondary level) were changed in each school year. Now, almost all school textbooks were changed or modified upon the national curriculum.

The sixth curriculum reform is also stimulated by educational system changes. The educational system is divided into four sections: Junior Primary (3 years), Senior Primary (3 years), Junior Secondary (3 years), and Senior Secondary (3 years).

Analysis of Contemporary Mathematics Curriculum Changes

It seems that new contemporary mathematics curriculum changes have small influences on the process of teaching and learning mathematics in Iran. Several studies show that there is still plenty of work to do. As an example, TIMSS 2015 reveals that Iranian students' performance in mathematics in both grades 4 and 8 increased, but this result shows that Iranian students' performance is still below the international average and still unsufficient (Mullis, Martin, Foy, & Hooper, 2016). There is a public opinion among Iranian people about Iranian students' performance in mathematics. Most Iranians think Iranian students had or must have good performance in mathematics because of their good record in the mathematics Olympiad contest where they have finished in the top 10. However, when the first results of TIMSS were published around 2000, Iranians were shocked and after that, the poor performance of Iranian students became one of the researchers' and policy-makers' main concerns. Although at this time we know that TIMSS and Olympiad results are not dependent statistically, but at that time, there was a general impression which tried to connect TIMSS and Olympiad results. Indeed, TIMSS data shows the situation of general education of Iranian, But Olympiad revealed a special type of education which nurtured elites in mathematical knowledge.

After analysis of some new mathematics textbooks published during recent, contemporary curriculum reforms, Gholam-Azad (2015) mentioned some of the challenges of new textbooks. It could be observed/remarked upon that the importance of these challenges is an instrumental understanding of recent research findings, instead of a rational and deep understanding of them.

Gholam-Azad (2015) said instrumental (superficial) understanding of recent research findings cause to reverse outcome. To clarify superficial understanding of research findings, we will focus on application and modeling (which is one of the mathematics processes in the Iranian National Curriculum). This will allow for a discussion through the systematic literature review of research studies related to mathematics textbooks and investigations of teacher education programs.

Modeling in Mathematics Textbooks

The modeling approach means that teaching starts with a problem situated in the real world. The modeling process continues with formulating real-world problems in mathematical terms. When this part is complete, the mathematical problem can be solved by the application of mathematical concepts. Finally, the mathematical solution must be interpreted to provide an answer to the real-world problem and checked for its adequacy in answering the original question. A new cycle of the formulation may then begin for improving the model. In Figure 1, a simple diagram of the modeling cycle is presented.

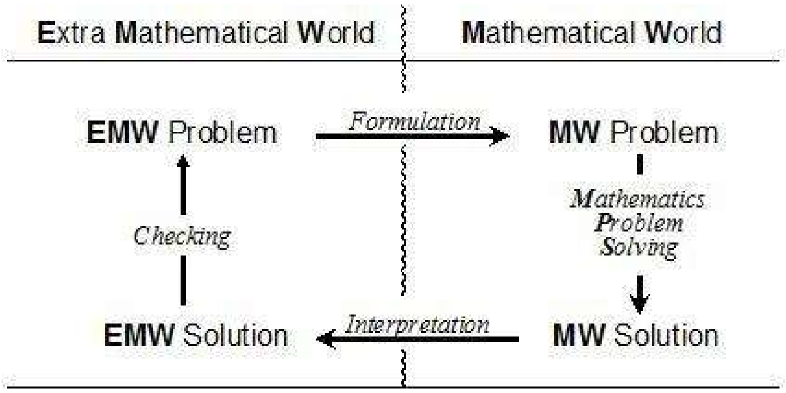

Figure 1: A model of the modeling cycle (Verschaffel, 2002)

Some other related expressions are similar to modeling but are different. For example, Standard Application problems refer to a real-world problem, in which the mathematical model of the solution already exists in the hands of students (Niss, Blum, Galbraith, 2007). Another proximity term is Word Problem or Story Problems which are some sort of mathematical problems that are covered in language form (See Figure 2). Although Standard Application problems and Word Problems have some overlap with modeling, they are different.

A take-away food shop sells hamburgers, sausages, and pizzas. On one day the number of hamburgers sold was three times the number of pizzas, and the number of sausages sold was five times the number of pizzas. The number of hamburgers and pizzas sold was in total 176.

How many of each type of food was sold? (Galbraith, 2007)

Figure 2: An example for story problem

All authors of the new mathematics textbooks, written after a re-enactment of the national curriculum, mention in the preface their loyalty to the national curriculum. Even if some parts of these mathematics textbooks contain application of mathematics in the real world (Gooya, 2007), almost all of them are not of real modeling but of a superficial usage. Moreover, a study of Rafiepour, Stacey & Gooya (2012) shows that modeling activities are absent in the new mathematics textbook in grade 9, while there are some standard application tasks included. Research studies show that in new Iranian mathematics textbooks series, at the primary and secondary level, there are no actual modeling activities (e.g. Rafiepour, 2012; Rafiepour, 2014; Khani, Rafiepour, 2015).

Modeling in the Teacher Education Program

Consequently, in a centralized educational system in Iran, there is a centralized system for educating teachers. Recently, a new program designed for a pre-service mathematics teachers which has a mission for teacher training for the entire country (Ministry of Science, Technology, and Innovation, 2015). Even if this new program does not contain courses about modeling, there is a small emphasis on applications in other courses such as problem-solving. Therefore, there is some support for mathematics teachers in the pre-service program in Iran to implement modeling approaches in their future teaching.

Now, what happened in the in-service program for mathematics teachers in Iran? After the textbooks change, the Ministry of Education devised some short courses for mathematics teachers to provide familiarity with the new changes of the textbooks. In a small number of these courses, application and modeling were introduced to Iranian mathematics teachers.

Mathematics Teachers Voices about Modelling and Application

There is another sign of supporting Iranian math teachers regarding using modeling and application in their classroom. In the master’s program of mathematics education, most students are teachers of mathematics. Usually, they are teaching mathematics simultaneously whilst studying in the program. Thus, we can consider this master’s program to be an in-service teacher training. In the curriculum of a master’s degree in mathematics education, there is an optional course about modeling and application. Table 1 illustrates the responses of teacher A to the following question: “what is the application of taking modelling course in your teaching practice?”

Mathematical Modelling activities can improve students' motivation in learning mathematics and enhance students' understanding of mathematical concepts. When a student is confronted with a real-world problem and with real data, in addition to the mathematical knowledge used in the problem, s/he is also confronted with some concept which related to her/ his real life. It seems that the experience of solving modelling problems can show the connection between mathematical concepts, so students will enjoy when solving such problems. So, I will use modelling activities in my future teaching practices.
Teacher A continues by saying when he introduce a new mathematical modelling problem in his classroom, students appear to find mathematics which is related to their real life and pursue it eagerly. Because the results of mathematical modelling problem can improve their daily life practices. • In your point of view which pizza is cost effective? A pizza with 30cm diameter by 5 USD or pizza with 40cm diameter by 8 USD?
Indeed, when students encounter with above modelling problem which related to their real-world experience, they try to use mathematics to 'earn more pizza'. They calculate area of each of the two pizzas and then compare the price of pizza with respect to its given area.

Table 1: response of teacher A after modelling course in master program

Teacher B in responding to the following question: "what is the application of taking modelling course in your teaching practice?" explains his experience as changing mindset toward mathematics (see Table 2).

As a mathematics teacher, passing modelling course changed my mindset toward mathematics. So, at this time I know many applications of mathematics in the real-world that we deal with on a daily basis. From now on, I try to solve many of the problems which I encounter in real life by using mathematics ideas. I try to introduce this important capacity to other teachers and persuade them to use modelling activates in their teaching practice.
Teacher B formulate a real-world problem from his real-life experience which is familiar with his student's experiences. In the area which teacher B lives, the farmer of walnut hire people for picking fruit. After finishing, one-third of walnut goes to workers and two-third of walnuts goes to farmer. If 3 workers hired for picking fruit in walnut farm which had 10 trees that each one had 5000 walnuts in average, then how many walnuts goes to each worker and farmer?

Table 2: response of teacher B after modelling course in master program and his modelling activity with familiar context

Table 3 illustrates the responses of teacher C to the following question: "what is the application of taking modelling course in your teaching practice?" which shows his modelling example in technology-based context for teacher and their students.

Using modelling activities in the mathematics classroom can motivate students to learn mathematics as an interesting domain of knowledge. Many students say "math" is hard for them and they are not interesting to read and do the math. If math teachers start their teaching with real-world problems and gradually bringing out mathematics from real context, students start to enjoy math and they become interested to do more math. So, in my opinion, this is the best way to introduce math lessons in the classroom, because it consequently makes math meaningful and understandable for students and motivates them for continuing to study more mathematics in the future. For example, when math classroom starts from a real world situation such as selecting best mobile phone operator with data comes from reality, students start to use mathematics to find best solution for their conversation habits.

Table 3: response of teacher C after modelling course in master program and her (his) modelling activity with technology-based context

Teacher D in responding to the following question: "what is the application of taking modelling course in your teaching practice?" Reveals that his knowledge improve about word (story) problem. Indeed, teacher D mentioned that he understand differences between problematic word problem versus standard word problem and this distinction help him for enhancing students' capability for encountering modelling activities. Standard word problem was constructed such that they asked for the straightforward application of an arithmetic operation on the given numbers. Problematic word problems, were constructed such that real-life knowledge should be taken into account to come to an appropriate reaction (Greer, 1993 and Verschaffel, De Corte and Lasure, 1994). See table 4 for example about standard word problem and problematic word problem.

standard word problem	A man cuts a piece of rope 12 meters long into pieces 1.5 meters long. How many pieces does he get?
problematic word problem	A man wants to have a rope long enough to stretch between two poles I2 meters apart. But he has only pieces of rope 1.5 meters long. How many of these pieces would he need to tie together to stretch between the poles?

Table 4: Example for problematic word problem versus standard word problem

Teacher E in responding to the following question: “what is the application of taking modelling course in your teaching practice?” mentions that he encourages designing authentic mathematical modelling activities in his classroom. For example, he used a map of a city that students live and determine two different points as origin and destination. Then ask students to find the best route in terms of minimum time, minimum price, and so on. These sorts of problems can continue in terms of finding the best route which compatible with sustainable development.

Key Ideas for Curriculum Changes over Time

Several curriculum changes can be distinguished as an effect of globalization in Iranian mathematics curriculum history. In this section, these curriculum changes will be reviewed in the chronological order. The Iranian national curriculum document (2010), explicitly does not mention globalization and its position in the national curriculum, with just a definition of globalization expressed in the appendix of the national curriculum document. However, investigation of Iranian mathematics textbooks shows that recent research findings in the fields of mathematics and mathematics education were to be used as first impact of globalization for shaping new changes in math textbooks during that time. For example, during ‘Dar Ul-Funun’ time (1851-1938), European teachers jointly with Iranian partners, tried to develop new textbooks for updating Iranian students with new knowledge. As another example, during the fourth reform (1975-1992), *“New Math”* was introduced to the Iranian school mathematics curriculum. In more recent reforms in the Iranian mathematics school curriculum, writers of textbooks try to use the recent findings of mathematics education. For example, in the fifth Iranian mathematics textbooks reform (1992-2009), there is an emphasis on constructivism and problem-solving in some of the math textbooks. In contemporary and sixth Iranian mathematics textbooks reforms, writers continue to emphasize problem-solving skills and cover some application of math through the math textbooks in all grades.

Second context for the effect of globalization on changing the Iranian mathematics curriculum related to Trend International Mathematics and Science Study (TIMSS) data will follow. Iranian students participated in the TIMSS study from 1995 until the present day, in different grades. Iranian students’ performance in mathematics was not good and in all TIMSS studies (1995, 1999, 2003, 2007, 2011, and 2015) was below the international average (TIMSS, 2016). Although in grade 4, Iranian students’ performance increased from 387 in TIMSS1995 to 431 in TIMSS 2015, and in grade 8, Iranian students’ performance increased from 418 in TIMSS1995 to 436 in TIMSS 2015; but this situation is still not desirable. Educational policy-makers frequently ask researchers and curriculum developers to reform the Iranian school mathematics curriculum toward enhancing Iranian students' performance in the TIMSS study. In contemporary school mathematics textbooks reform, writers of textbooks try to direct change in such a way as to focus on problem-solving in all mathematics textbooks and to respond to educational policy-makers' concerns concerning Iranian students' performance in TIMSS.

The third idea which affects Iran mathematics curriculum was Programme for International Students Assessment (PISA) organized by OECD. PISA as a large-scale international assessment influence the mathematics curriculum in many countries (De Lange, 2017) so Iranian mathematics curriculum was not an exception. Although Iran did not participate in PISA until now, PISA has had an implicit effect on Iranian school mathematics (Stacey, et al. 2015). PISA was introduced to the Iranian community through mathematics educators' research, at first. Following this, several teachers of mathematics who had started their master's degree researched mathematical modeling and applications, which is one of the focal points of PISA. The results of this research were displayed in national and international conferences and journals. Through this sharing, other mathematics teachers familiar with PISA can benefit and improve their practice of teaching and learning mathematics in Iran. Aforementioned, there is some sort of application of mathematics in all-new versions of mathematics textbooks to reflect the passion of the community.

DISCUSSION AND CONCLUSIONS

A review of mathematics curriculum reforms in Iran shows that every 15-20 years, Iranian mathematics textbooks were changed. In all of these reforms, some barriers hinder progression. It seems one of the important barriers is related to the teacher education program. For example, Gooya's (2007) research shows that traditional mathematics teachers did not believe in the constructivist point of view and they are opposed to geometry curriculum change in direction to constructivism. In contemporary curriculum change, lack of adequate knowledge of teachers of mathematics resulted in disappointing results (e.g. in TIMSS 2015 Iranian students' performance in mathematics was below the international average). Indeed, teachers of mathematics had not access to good resources to improve their knowledge and skills in line with the direction of new educational reforms. They did not receive suitable content and pedagogical knowledge during their pre-service and in-service program concerning new curriculum changes. In such a situation, teachers stand alone with their problems and they do not receive suitable and adequate support. It is more and more important to support the mathematics teachers for future mathematics curriculum reform, especially in the 21st century where changes occur quickly, and the school mathematics curriculum must reflect these new changes in new reforms. Teachers are the most important and smallest loop in the curriculum chain. If teachers are properly supported through pre-service and in-service programs, then we can expect improved results after any educational reform.

A review of the history of education reforms in Iran reveals that there were several different reasons for different educational changes such as:

- Varying goals, perspectives, and educational expectations upon social changes
- Assessment of implemented curriculum
- New research finding in the field of mathematics and mathematics education
- Widespread usage and pervasiveness of technology such as a computer, Internet, smart boards, calculators, and so on.

This paper also shed light on another equally important aspect which was on teachers' voices. The notion of curriculum change and teachers' voices are often one-directional. Students often experience curriculum as fragmented and unrelated. This paper showed instances from teachers' voices wherewith real-world problem solving, the curriculum becomes integrated and relevant as students construct meaning and make connections to their world. We would hope that future curriculum changes integrate both policy and practice (including teachers' voices and students' reflection) into consideration.

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