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The mathematical values in the Turkish Middle School Mathematics Applications Course Curriculum

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The present study aimed at investigating the mathematical values embedded in the Turkish Middle School Mathematics Applications Course Curriculum (MACC). For this purpose, MACC was carefully analyzed by considering main components of the curriculum. The findings indicated that all of the mathematical values, namely objectism, rationalism, control, progress, openness and mystery, were embedded in MACC. Although the balance among the embedded mathematical values in MACC was not equal, the findings clearly proved that the mathematical values were taken into consideration by curriculum developers, and thus it might be expected to raise awareness among mathematics teachers, students as well as textbook writers about the values in mathematics education.

Keywords: Mathematical values, mathematics applications course, curriculum analysis.

Background of the study

In almost all field of human endeavor, astounding developments and advancements are indebted to mathematics to a great extent. Among the other disciplines, "... mathematics was considered the Queen of the sciences." (Gregorian, 2009, p. ii). Mathematical literacy has always been at the heart of nations' capacity for economic growth and social welfare. In other words, there is no doubt that mathematics is not only vital to economic prosperity; but also a fundamental skill for life. Thus, it is essential for all societies to provide learning opportunities in which students will possess and use the understanding of mathematics purposively and interactively. Although mathematics is considered as one of the crucial subjects of school, it is a well-known fact that "...many students leave school with negative attitudes towards mathematics; some dislike the subject, others feel inadequate about it, still others feel it is irrelevant in their lives. This is an unacceptable outcome of school mathematics." (Education Department of Western Australia, 1998, p.9). In many classrooms, mathematics has delivered in a way that follows a textbook under the guidance of a teacher with little emphasis on affective side of mathematics. Thus, most of the students perceive mathematics as a non-creative, mechanical, value-free and teacher- or textbook writer-invented subject (Diamond, 2001). Seah, Andersson, Bishop, and Clarkson (2016) argued that such negative perceptions held by many students are not due to the nature of mathematics itself. It is most likely as a result of developing and implementing a mathematics curriculum which is full of concepts, skills, and procedures but not explicitly include the values of mathematics and the values of mathematics education. Indeed, values are powerful tools for promoting cognitive and affective development in mathematics education since they lead teachers' and students' interests, thoughts, decisions, preferences and behaviors about mathematics (Bishop, 2008; Corrigan, Gunstone, Bishop, & Clarke, 2004). The values expressed by teacher either intentionally or unintentionally in the context of the mathematics classroom may root in his/her personality, pedagogical approach and instructional materials preferred to use, etc. However, the important point is here that "what kinds

of values are embedded in the intended mathematics curriculum?” Because as a teacher, it is his or her responsibility to implement the curriculum as intended. Therefore, analysis of curriculum regarding mathematical values will shed lights on what kind of values that a teacher is expected to convey into instruction as well as what kind of an image of mathematics is going to be presented for students.

Affective issues in mathematics learning and teaching have been a prolonged and persistent interest among researchers. McLeod (1992), attributed to as the pioneer in work on the affective dimension of mathematics education (Gil, Blanco, & Guerrero, 2006), identified three main constructs of affect as beliefs, attitudes and emotions “...representing increased levels of affective involvement, decreased levels of cognitive involvement...” (p. 579). The scope of the mathematics-related affect has broadened with the addition of a fourth construct – values (sometimes including morals /ethics) – by such leading works of Bishop (2001); De Bellis and Goldin (2006); Leder and Grootenboer (2005). Considering the studies on the affective constructs such as beliefs, motivation, anxiety and attitudes, research on values in mathematics education is still insufficient (Zan, Brown, Evans, & Hannula, 2006). Leder and Grootenboer (2005) stated that the field of affective domain has been dominated by the studies on beliefs and attitudes, yet there has been a few number of study concerned with values. Although different conceptualizations of values in mathematics education have been described in the literature, the Bishop’s (1988) classification of the mathematical values provides a widely-used framework while analyzing mathematical values (Hannula, 2012; Seah, 1999). Besides, there is no doubt that mathematics is the sum of the human activities, and thus the Bishop’s framework (1988) not only gives room for discussing the values from the socio-cultural perspective but also corresponds to White’s (1959) three components of culture – ideology, sentiment, sociology. In this respect, the present study is primarily concerned with “mathematical values” and thus the Bishop’s framework was chosen to analyze the mathematical values. According to Bishop (1988), Rationalism-Objectism (the ideological component of mathematical values), Control-Progress (the sentimental component of mathematical values), and Openness/Mystery (the sociological component of mathematical values) are the mathematical values grouped as three pairs of complementary values. Table 1 summarizes each pair of mathematical values.

During the past decade, there have been the bulk of theoretical and research-based arguments on values in mathematics education (e.g. Values in mathematics and science education by Bishop, 2008; Identification of a learner’s value orientations in mathematics learning by Seah, Zhang, Barkatsas, Law, & Leu, 2014), yet the number of the studies on mathematical values embedded in math curricula is still very limited. In this respect, the present study aimed to is to explore the mathematical values embedded in the Turkish Mathematics Applications Course Curriculum (MACC) by addressing the following research questions: (1) What are the mathematical values embedded in the MACC? (2) Where are the mathematical values located in the components of the MACC?

<i>Three Pairs of Mathematical Values</i>	
<i>Rationalism</i>	<i>Objectism</i>
Focuses on the development of students' mathematical reasoning through discussions, explanations, evaluating their way of solutions etc. (Bishop, 1988, p. 62).	Focuses on concretizing abstract ideas through the use of symbols and objects, promoting to use different kind of representations (Corrigan, et al., 2004)
<i>Control</i>	<i>Progress</i>
Focuses on control ensured by the nature of mathematics for the problems related to both natural phenomenon and social environment through application of mathematical knowledge and favors stability (Seah & Bishop, 2000).	Puts emphasis on change and progress in society by means of mathematical knowledge (Seah & Bishop, 2000).
<i>Openness</i>	<i>Mystery</i>
Focuses on transparency/verification aspects of mathematical ideas and conclusions through proofs (Corrigan, et al., 2004)	Focuses on mystique and unclear origins of mathematics and puts emphasis on dehumanized knowledge, intuition, wonder (Corrigan, et al., 2004)

Table 1: Three Complementary Pairs of Mathematical Values

In 2012, a comprehensive change took in the Turkish educational system. The length of compulsory education was increased from 8 to 12 years and redefined the system into three levels (12-years compulsory education covering 4-years elementary, 4-years middle and 4-years high school) and this structural reform required for the curricular revision as well. One of the results of the curricular revision was the inclusion of more than twenty elective courses offered for the Turkish middle school students who can able to choose max.6 hours in a week. Along with the fact that mathematics is one of the core subjects of the curriculum, “Mathematics Applications Course” (MAC) is one of the elective courses for middle school students since 2013-2014 academic year. According to statistics, MAC is the most popular elective course among 5th-7th graders in 2014-2015 academic year (Ministry of National Education [MONE], 2015). The main purpose of MAC is not only to improve students' mathematical knowledge and skills but also to like mathematics and develop positive attitudes towards mathematics through the learning opportunities that allow students to practice mathematics (MONE, 2013).

Keeping in mind that the concept of a value is associated with “what is desirable, preferable, worthy, important, right, or beneficial” (Bishop, Seah, & Chin, 2003, p. 723) by different scholars and they, as cultural products, depend on personal choices, preferences and decisions, the focus of the present study is on the mathematical values of the mostly chosen elective math course by the Turkish middle school students. In this respect, the present study might shed lights on what kind of values about mathematical knowledge and discipline that a teacher is expected to convey into instruction as well as what kind of an image of mathematics is going to be presented for students. Further, the results of the study might raise the awareness of curriculum developers, mathematics teachers, and textbook writers about the values in mathematics education. It is also expected that the results of this study may contribute to the math-related affect studies by giving an example from the values of mathematics in the Turkish Mathematics Applications Course Curriculum.

Method

This study was designed to explore the mathematical values in the MACC (5th-8th grade). For this purpose, data were collected through document analysis. The main data collection source of this study was MACC published by the MONE. In this respect, the focus of the present study is on the intended curriculum and limited to the MACC which is available on the MONE's official website.

Before the data analysis process, the framework for curriculum analysis was developed by considering the literature on the mathematical values and the structure of MACC as well as the research questions. In order to portray the mathematical values, namely “Rationalism-Objectism; Control-Progress and Openness-Mystery”, Seah’s outline of the major signals for the mathematical values was adapted (Seah, 1999, pp.110-111). Afterwards, MACC was examined carefully to find out what type of mathematical values embedded in which part of the curriculum. MACC consists of 8 main chapters as (1) Introduction part; (2) Aims of MAC; (3) The developmental characteristics of middle school students; (4) The structure of core mathematics curriculum; (5) Explanations about the implementation process of MACC; (6) Basic principles of MAC; (7) Assessment and evaluation process and (8) Learning objectives of MACC. While locating and analyzing the data, the researchers independently read all chapters line by line and coded all instances of the mathematical value statements in MACC according to the framework. To establish internal consistency, inter-coder reliability was carried out using the formula ($\text{Reliability} = \frac{\text{Number of agreements}}{\text{Total number of agreements} + \text{Disagreements}}$) proposed by Miles and Huberman (1994). A high agreement score (0.92) between the two coders (the researchers) was obtained. Then, the basic descriptive statistics including frequencies and percentages were carried out by means of IBM SPSS.23.

Results

The mathematical values in the Turkish Mathematics Applications Course Curriculum

The major focus of the content analysis here was to identify all instances of the mathematical values in the written curriculum, namely MACC. The findings indicated that totally 39 value signals of the mathematics embedded in MACC. As given in table 2, it is obvious that objectism ($f = 10$) was emphasized more than rationalism ($f = 6$); progress ($f = 8$) was emphasized more than control ($f = 2$) and openness ($f = 12$) was emphasized more than mystery ($f = 1$). According to the results, while “openness” ($f = 12$) was the most-emphasized value; there is only one reference to the value of “mystery” ($f = 1$) in MACC.

<i>Mathematical Values</i>	<i>Number of value signals (f)</i>	<i>Proportion (%)</i>
Rationalism	6	15.4
Objectism	10	25.6
Control	2	5.1
Progress	8	20.5
Openness	12	30.8
Mystery	1	2.6
<i>Total</i>	<i>39</i>	<i>100</i>

Table 2: The proportional distribution of mathematical value embedded in MACC

The place of the mathematical values in MACC

The last research question of the study aimed to portray the parts of MACC in which the mathematical values are embedded. As given in Table 3, the results indicated that the mathematical values mostly located in the learning objectives ($f = 14$). However, both in the introduction part and assessment part of MACC, only three statements referring to the mathematical values were found.

Mathematical values	<i>Introduction</i>	<i>Aims & Principles</i>	<i>Objectives</i>	<i>Teaching & Learning</i>	<i>Assessment</i>
Rationalism	1	2	1	1	1
Objectism	0	2	6	1	1
Control	0	0	1	1	0
Progress	1	3	3	1	0
Openness	1	4	3	3	1
Mystery	0	0	0	1	0
<i>Total</i>	<i>3</i>	<i>11</i>	<i>14</i>	<i>8</i>	<i>3</i>

Table 3: Frequencies of the mathematical values embedded in the parts of MACC

Considering the *Introduction part*, it was found that the value of rationalism was embedded in the statements explaining the importance of providing the learning opportunities to develop students' mathematical thinking as well as finding reasonable, rational and logical solutions/answers for problems. It was also found that the value of openness was conveyed in the expressions about the importance of cooperative learning. In addition to rationalism and openness, the value of progress was highlighted in the introduction part through the statements putting emphasis on making connections with mathematics and daily life. Further, the value of rationalism, objectism, openness, and progress were included in part of *the Aims and Principles* of MACC. More specifically, the value of rationalism was embedded in such statements that underline the use of mathematical reasoning; focusing on symbolization and modelling portrayed the value of objectism; putting emphasis on group working, sharing/discussing ideas addressed to the value of openness; and the statements signifying the relationships between mathematics and the other disciplines as well as daily life were found as the indicators of the value of progress. It's also noting worth that in the following statement, the attention aimed to draw on the mathematical values “...it is important for students to develop true values about mathematics” (p. 1). However, there was no explanation related to what are the true values about mathematics provided in this part of MACC. In order to portray the mathematical values, all learning objectives (totally 21) were analyzed in line with the framework. As given in Table 3, the mathematical values embedded in MACC were mostly located in the part of the *Learning Objectives*. The objectives putting emphasis on the use of appropriate mathematical symbols while solving problems were found as the indicators of objectism; asking students to discuss their solutions process through mathematical reasoning were the indicators of rationalism. Additionally, the learning objectives that put emphasis on the development of students' problem solving abilities through daily life math problems were considered as the indicators of progress, and the objectives aimed to promote students' procedural fluency through the tasks asking to test or evaluate the way of solution process were the signs of control. Further, the learning objectives aimed to improve students' problem solving skills through sharing/discussing ideas and pose questions/problems were found as the indicators of openness. Considering the part of *Teaching and Learning Approach*, it was found that while the value of objectism was fostered through the statements suggesting the use of different kinds of representations in problem solving process, the value of rationalism was embedded in the explanations related to the characteristics of problems that should promote students' mathematical reasoning. The indicators of control were found in the sample problem that required using of mathematical knowledge in an attempt to change the environment. The sample problem also indicated the value of progress by means of addressing the relationship between mathematics and daily life. The statements emphasizing the idea of sharing information and collaborative working were found as the indicators of the value of openness.

Besides, the statement suggesting the use of interesting mathematical games was found as the only one indicator of mystery. In the last part of the MACC, *Assessment and Evaluation Process*, three types of mathematical values were found. The value of rationalism was embedded in the statements suggesting the development of students' reasoning and logical thinking skills should be assessed by such methods as classroom observations, self-evaluation reports, etc. Besides the value of objectism was found in the statements that ask teachers to evaluate students' ability to use different symbolizations while explaining their problem solving process. Finally, the value of openness was implied in the suggestions about the assessment of collaborative work.

Conclusion and discussion

The present study was designed to examine the mathematical values embedded in MACC which is the most popular elective course among the Turkish middle school students in 2014-2015 academic year. For this purpose, the written curriculum was analyzed by the researchers in a detailed manner. In general, it can be concluded that all of the mathematical values, namely objectism, rationalism, control, progress, openness and mystery, are embedded in MACC. Although the balance among these embedded mathematical values in MACC is not equal, the findings clearly proved that the mathematical values are taken into consideration by curriculum developers. Further, the results indicated that the value of openness was the mostly-embedded mathematical value in MACC and thus, it can be concluded that the democratic side of mathematics is intended to be promoted through communicating with the mathematical ideas and questioning the mathematical facts. In other words, the intended implementation process of MAC seems more likely to focus on the appreciating the role of public sharing and discussions in facilitating understanding of mathematics. On the other hand, a considerable amount of the signals were also placed on the value of rationalism and objectism in MACC. This situation might support a widespread image of mathematics as abstract, theoretical, ultra-rational discipline (Ernest, 2004).

One of the more noteworthy findings to emerge from the present study is that both the value of progress and control were rarely mentioned in the curriculum. When considering one of the main aims of MAC that provide learning opportunities for students to experience mathematics through mathematical problems and to develop their mathematical knowledge, it is quite surprising. Besides, there was only one reference related to the value of mystery found in MACC. Such little emphasis on the value of mystery might limit the opportunities indicating the mystical, surprising, and fascinating side of mathematics. Taken together, the results of the present study indicated that the image intended to transmit through MACC might be mathematics as symbolized, open to discussion, theoretical and questionable discipline. What research has found about the mathematical values embedded in math curricula yielded the similar results with the present study (Clarkson & Bishop, 2000; Seah et al., 2016). Moreover, the following statement “...it is important for students to develop true values about mathematics” (MACC, p.1) might be considered as evidence that explicitly mentioned “values about mathematics” in MACC. Nevertheless, it is too vague for teachers to interpret what are the true values about mathematics, so further explanation should be provided in the written curriculum.

Considering the place of the mathematical values, the results indicated that the value signals were embedded in almost all parts of MACC. However, while the value of openness was placed in each part of the MACC, the value of mystery was only mentioned in the teaching and learning approach

part. One of the main reasons behind this situation might be due to MAC itself. In other words, MAC mainly focuses on the development of students' problem solving and mathematical thinking skills through the applications of mathematics. Thus, students are expected to learn collaboratively; to solve and pose problems from daily life and other areas of science; to share and discuss their ideas through mathematical reasoning and to test and evaluate their problem solving process rather than focusing on mystic and fascination sides of mathematics. Taken together, these results clearly indicated that the mathematical values were mostly embedded in the form of implicit statements in the different parts of MACC. Therefore, the reflection of these mathematical values from the intended to enacted curriculum might probably stay as hidden and vague. On the one hand, the image of mathematics embedded in the curriculum will shape students' future choices and career plans about mathematics; on the other hand it will be shaped by the mathematical values hold by the curriculum developers. Therefore, it is essential to raise the awareness about the values in mathematics education as well as to conduct more studies on the mathematical values in the intended, enacted and attained math curriculum.

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