Contextual Examination of the Turkish Middle School Mathematics Teachers' Exam Questions

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The current study aims to present the distribution of the middle school mathematics Turkish teachers' exam questions in terms of Bloom's cognitive process and knowledge dimension as well as the question types. Additionally, it will prove if there is statistically difference on the questions' placement in the Revised Bloom's taxonomy with the question types. In the study, 10 middle school mathematics teachers' exam questions posed during the first semester of the 2013-2014 academic year were analysed. A total of 77 exam papers were reviewed in the study and the total of 1152 questions from these papers were examined separately. A chi-square test was used to determine whether the cognitive process and knowledge dimensions of the questions were statistically different by question types. The results gained from the study reveal that mathematics teachers usually prepare questions at the lower cognitive dimensions of the Bloom Taxonomy. According to chi-square test results, there was a significant difference between knowledge dimensions of the questions as well as the question types. Besides, there was also a significant difference between cognitive process dimensions of the questions and the question types.

Keywords: mathematics exam; Bloom Taxonomy; question types

Introduction

The four key elements of curricula are "goal", "content", "teaching process", and "assessment and evaluation" respectively (Akpınar, 2003; Küçükahmet, 1997; Ornstein and Hunkins, 1993). While goal, content, and teaching process guide curricula, the assessment and evaluation process plays an important role in determining whether a curriculum has achieved its goal.

In Turkey, students' performance is usually assessed through country-wide standard tests and written exams carried out by teachers. The nature of these assessments is set forth in various regulations and principles. The regulation on primary education institutions notes that the goals and acquisitions indicated in curricula have to be taken as basis in the assessment and evaluation of success in accordance with the general principles and the principles of assessment and evaluation included in the curriculum of relevant course have to be followed (MEB, 2014). In addition, it is stated in this regulation that different question types should be used in the exams carried out by teachers (MEB, 2014). As is seen, questions used in standard tests and assessment activities carried out by teachers must be prepared in such a way that they serve various purposes and involve different types and different levels. In this respect, researchers have created various taxonomies to classify the questions to be used in the educational process.

Some examples of these taxonomies are Bloom's taxonomy, Barrett's

taxonomy, and Pearson-Johnson taxonomy (Armbruster and Ostertag, 1989). Among these Bloom's taxonomy (BT) is considered the most useful in classifying educational goals and question levels (Köğce and Baki, 2009). In 2001, Krathwohl et al. rearranged Bloom's taxonomy (Anderson and Krathwohl, 2001). They handled the cognitive domain in two dimensions: "cognitive process" and "knowledge". The cognitive process dimension includes mental activities called remember, understand, apply, analyze, evaluate, and create. The knowledge dimension, on the other hand, contains four types: factual, conceptual, procedural, and metacognitive.

In this context, it can be said that assessment instruments designed for evaluating students must contain questions involving different knowledge types and different cognitive processes and the content validity of these instruments are also important for educating students having high-level knowledge and skills. Research reports reveal that students' thinking levels depend on the levels of questions posed by teachers (Brualdi, 1998).

A lot of researchers have examined the distribution of the question types in the educational process (Koray, Altunçekiç, Yaman, 2005; Özcan and Oluk, 2007), in course materials (Armbruster and Ostertag, 1989; Kablan, Baran and Hazer, 2013), in central examinations (Güler, Özdemir and Dikici, 2012), and the exams carried out by teachers (Ayvacı and Türkdoğan, 2010; Demircioğlu and Demircioğlu, 2009; Güler, Özdemir and Dikici, 2012; Köğce and Baki, 2009; Tanık and Saraçoğlu, 2011) based on BT of the cognitive domain. Research shows that the questions asked to students in lessons, books, and central- local exams are at the low levels of the Cognitive Domain of BT. In previous studies, questions are mostly examined according to the old version of the BT, and thus the knowledge dimension is ignored by paying attention to the cognitive dimension. Research built upon the Revised BT, on the other hand, focuses on mostly cognitive processes. However, it is still unknown what knowledge types are addressed most in the questions used in educational activities. On the other hand, it is emphasized that the assessment and evaluation instruments used by teachers in their lessons are connected to their expectations from their students as well as goals (Gipps, Brown, McCallum, McAlister, 1995; Hill, 2000), it is not known whether or not the question types they adopt (e.g. multiple-choice, short-answer, long-answer, matching, true-false) are relevant to students' cognitive levels and knowledge types.

This study aims to determine whether or not the questions used in the written exams at middle school (the 5th to the 8th grades) mathematics courses are connected to the cognitive process dimension and the knowledge dimension of the Bloom's taxonomy based on the question types. For this reason, the following sub-questions were answered in the research:

- Do the cognitive levels of the exam questions differ by question type?
- Do the knowledge types of the exam questions differ by question type?

Method

The exams prepared by middle school mathematics teachers were examined in terms of the cognitive process dimension and the knowledge dimension of the BT by question types through document review method.

Data Collection and Analysis

The data were collected from the exams prepared by middle school mathematics teachers working in various provinces of Turkey in the first semester of the 2013-

2014 academic year. 1152 questions were reviewed from a total of 77 exams through content analysis. The questions were coded by question type in the first place. During the coding, the question types such as multiple-choice, long-answer, matching, short-answer, or true-false which the questions fitted were detected.

Coding regarding the cognitive process dimension and the knowledge dimension of the BT was completed based on the sub-levels of each dimension. Table 1 shows the distribution of the examined questions by the knowledge dimension, the cognitive processes dimension, grade, and question type.

Table 1. The distribution of the questions by the knowledge dimension, the cognitive process dimension, grade, and question type

Knowledge dimension	f	%	Cognitive process dimension	f	%	Grade	f	%	Question type	f	%
Factual	150	13.1	Remember	59	5.1	5	214	18.6	Multiple-choice	743	**64.5**
Conceptual	271	23.5	Understand	385	33.4	6	268	23.3	Short-answer	164	14.2
Procedural	731	**63.4**	Apply	703	**61**	7	346	30	Long-answer	221	19.2
Metacognitive	0	0	Analyze	4	0.4	8	324	28.1	Matching	0	0
			Evaluate	0	0				True-false	24	2.1
Total	1152	100	Create	1	0.1	Total	1152	100			
			Total	1152	100				Total	1152	100

As is seen in the Table 1, a great majority of the questions contained *procedural knowledge* (63.4%) and were in the *apply* (61%) cognitive level. There was almost no question at the metacognitive knowledge (analyze, evaluate, create). The ratios of questions in the sub-levels of *analyze*, *evaluate*, and *create* are 0.4%, 0%, and 0.1% respectively. As to question types, the teachers preferred multiple-choice questions most (64.5 %).
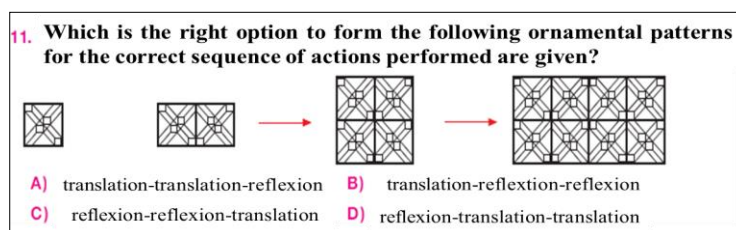

Figure 1. The question asked by T3 to the 7th grade students

The question given in the Figure 1 is a multiple-choice question composed of four options. In addition, to solve this question, students have to know translation and reflection. Furthermore, these operations end up with a constant result. As is known, this knowledge is included in the category of procedural knowledge of the Bloom's taxonomy (Krathwohl, 2002). Moreover, the question was associated with the sub-dimension of apply because its solution required a cognitive process involving applying the operation to a known situation and performing the operation routinely (Krathwohl, 2002).

After coding was completed, the data were transferred into the SPSS package. Then a chi-square test was carried out in order to determine whether or not there was any significant difference between the cognitive levels of the coded questions by question type and whether or not there was any significant difference between the knowledge types of the coded questions by question type.

Findings

The findings of the present study aiming to determine whether or not the Bloom taxonomy's cognitive process and knowledge dimensions varied in the questions posed in the written exams conducted in middle school mathematics courses by question type are presented below.

Table 2. The Distribution of the Cognitive Levels of the Questions based on Question Type

Question Types	Frequency Percentage	Cognitive Levels			
		Remember	Understand	Apply-Analyze-Evaluate-Create*	Total
Multiple-choice	f	37	290	416	743
	%	**5.0**	**39.0**	**56.0**	100
Short-answer	f	16	62	86	164
	%	9.8	37.8	**52.4**	100
Long-answer	f	1	18	202	221
	%	.5	8.1	**91.4**	100
Matching	f	0	0	0	0
	%	0	0	0	0
True-false	f	5	15	4	24
	%	20.8	**62.5**	16.7	100
Total	f	59	385	708	1152
	%	5.1	33.4	61.5	100

Chi-square = 130.008; sd =6; p =0.000<0.05

* Since there were quite few acquisitions associated with analyze, evaluate, and create, the chi-square test taking them independent did not yield correct results. Therefore, apply, analyze, evaluate, and create were combined.

Table 2 demonstrates that there were significant differences between the cognitive levels by question type (X^2= 130.008; sd=6; p=0.00<0.05). 5% of multiple-choice questions involved in *remember*, 39% of them are in *understand*, and 56% of is in *apply* sub-levels. The number of short-answer questions involving *apply* (52.4%) was higher in comparison to the other cognitive processes. While 91.4% of long-answer questions involved *apply*, there was no matching type question. Another striking point is that while the questions from all other types mostly involved *apply*, true-false question types mostly involved in *understand* (62.5%).

Table 3. The Distribution of the Knowledge Types of the Questions based on Question Type

Question Types	Frequency Percentage	Knowledge Types				
		Factual	Conceptual	Procedural	Metacognitive	Total
Multiple-choice	f	100	215	428	0	743
	%	13.5	28.9	**57.6**	0	100
Short-answer	f	36	37	91	0	164
	%	22.0	22.6	**55.5**	0	100
Long-answer	f	5	9	207	0	221
	%	**2.3**	**4.1**	**93.7**	0	100
Matching	f	0	0	0	0	0
	%	0	0	0	0	0
True-false	f	9	10	5	0	24
	%	**37.5**	**41.7**	20.8	0	100
Total	f	150	271	731	0	1152
	%	13.0	23.5	63.5	0	100

Chi-square= 133.371; sd =6; p =0.000<0.05

The chi-square test shows that the knowledge types of the questions prepared by teachers differed by question type (X^2=133.371; sd=6; p=0.00<0.05). The percentage of the multiple-choice questions involving procedural knowledge (57.6%) was close to that of the short-answer questions involving procedural knowledge (55.5%). While

quite low percentages of the long-answer questions involved factual knowledge (2.3%) and conceptual knowledge (4.1%), almost all long-answer questions involved in procedural knowledge (93.7%). Contrary to other question types, true-false questions mostly involved in factual knowledge (37.5%) and conceptual knowledge (41.7%).

Conclusion and recommendations

According to the results, there was a significant difference between the cognitive levels of the questions by question type. Quite a low percentage of the multiple-choice questions involved *remember* while more than half of them involved in *apply*. Short-answer questions involved *apply* more in comparison to the other sub-levels. Another striking point is that while the questions from all other question types mostly involved *apply*, more than half of the true-false questions involved *understand*.

The knowledge types of the questions found to be differed by question type. The percentage of the multiple-choice questions involving procedural knowledge was close to that of the short-answer questions involving procedural knowledge. While quite low percentages of the long-answer questions involved factual knowledge and conceptual knowledge, almost all long-answer questions involved procedural knowledge. On the contrary to other question types, true-false questions mostly involved in factual knowledge and conceptual knowledge.

With curricula that have been implemented in primary education institutions in Turkey since 2005 in a process-based way, the aim was to provide students with high-level cognitive processes such as research, investigation, problem-solving, and decision-making. Thus, questions prepared to assess students involve high-level cognitive processes as well as low-level cognitive processes. Those students who want to succeed in mathematics and geometry in university entrance exams must achieve learning from lower to higher order skills within the hierarchical system of the Bloom's taxonomy including cognitive levels in a proper, balanced, and complementary way.

It should be ensured that the questions asked by primary education mathematics teachers in mathematics exams do not involve low cognitive levels according to the Bloom's taxonomy, rather involve high cognitive levels to ensure a parallelism between the exam questions of primary education mathematics teachers and mathematics questions asked in TEOG (transition from primary to secondary education) exam.

Only those students who have achieved a deep (not superficial) understanding of mathematics and geometry subjects in their 8-year educational period, have learned concepts and relationships between concepts, and have improved their abstract thinking and problem solving skills can succeed in the TEOG exam which is taken by the 8th grade students in Turkey. So, students should solve rich questions among the cognitive process dimensions in order to improve their skills of solving high-level questions. Similar research can be conducted on other courses included in the TEOG exam held in Turkey to compare results with the results obtained from the present study.

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