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PROSPECTIVE PRIMARY SCHOOL TEACHERS' PERCEPTIONS OF RECTANGULAR PRISM THROUGH MODELS*

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Abstract

The purpose of this study is to reveal how prospective primary school math teachers perceive rectangular prisms through models. The survey model was employed for the study. The data were collected through the interviews protocol, consisting of four models and two open-ended questions concerning the models, with 113 students of Mathematics Teaching, the department of primary school teaching, the faculty of education at a university located in a middle-sized province in Eastern Anatolia, Turkey, during the Fall Term of the Educational Year 2010-2011. The data were descriptively analyzed. The findings suggest that most of the students are successful in naming the three models they frequently encounter in a proper way and explaining the characteristics and connections concerning the models but they are less successful in the model "skeleton", which they rarely encounter. In this sense, it is recommended that the teaching process should include the "skeletons" of geometrical objects.
Key-words: prospective teachers, rectangular prism, model

Özet

Bu çalışmanın amacı ilköğretim matematik öğretmen adaylarının modeller yardımıyla dikdörtgenler prizması algılarını belirlemektir. Çalışmada tarama modeli kullanılmıştır. Veriler, 2010–2011 eğitim-öğretim yılı güz yarıyılında Doğu Anadolu Bölgesi'nin nüfus açısından orta ölçekli bir ilinde bulunan eğitim fakültesinin ilköğretim bölümü, Matematik Eğitimi ABD'de öğrenim gören toplam 113 öğrenciden, dört farklı model ve bu modellerle ilgili iki açık uçlu sorudan oluşan görüşme protokolü kullanılarak toplanmıştır. Elde edilen veriler betimsel olarak analiz edilmiştir. Sonuçlar, öğrencilerin çoğunluğunun sıklıkla karşılaştıkları üç modeli doğru isimlendirme ve modellerle ilgili özellikleri, ilişkileri ortaya koymada başarılı olduklarını fakat nadiren karşılaştıkları "iskelet" şeklindeki modelde ise daha düşük düzeyde başarılı oldukları göstermektedir. Bu bağlamda öğretim sürecinde geometrik cisimlerin "iskelet"lerinin kullanılması tavsiye edilmektedir.
Anahtar Sözcükler: Öğretmen adayı, dikdörtgenler prizması, model

Introduction

One of the most essential tools to acquire such high-level thinking skills as analysis, evaluation and synthesis, math enables one to learn concepts, to make sense of them, to work up meaningful connections between them and thus to produce new concepts and knowledge (Nakiboğlu, 1999). Furthermore, math helps one realize his/her mental liberty during the organization of his/her ideas (Busbridge & Özçelik, 1997).

Besides math, geometry, a sub-branch of math, also plays a key role in developing one's thinking skill and enabling him/her to solve most of the problems he/she encounters. Geometry deals with point, straight line, plane, plane figures, space, spatial figures and connections among them as well as the length, angle, area and volume of geometric figures and their measurement. Geometry is among the crucial elements of school math. Its concepts and rules are commonly used in other branches of art and disciplines (Baykul, 2009). Geometry makes a great contribution to students' logical and affective development (Akuysal, 2007) by presenting different ways of thinking about and commenting on physical environment in a detailed way (NCTM, 2000). Thanks to these characteristics, geometry is included in all curricula in Turkey, as is the case for most countries throughout the world (Altun, 2006). Despite the high level of importance attached to geometry and geometry teaching, many studies found that students have a low level of achievement in geometry and they do not even know some basic geometrical concepts (Melemezoğlu, 2005; Akuysal, 2007; Mullis et al., 2000; NCTM, 2000; Okur & Dikici 2006; Prescott, Mitchelmore & White, 2002). In the case of Turkey, the results of national examinations and a number of international studies suggest that primary school students have a low level of achievement in subjects based on geometry (Bekdemir & Işık, 2007; Olkun & Aydoğdu, 2003; Ardahan & Ersoy, 2004; MEB-EARGED, 2003).

Since attempts are generally focused on teaching geometry on the basis of memorizing certain formulas and rules (Yılmaz, Turgut & Kabakçı, 2008), it is thought that teachers are also responsible for the fact that students are ignorant about the basic concepts and they have a low level of achievement (Olkun & Aydoğdu, 2003). As teachers develop their knowledge of geometry and pedagogy, a corresponding change is observed in what and how they teach (Swafford, Jones & Thornton, 1997; Mistretta, 2000). In order to improve geometry teaching, it is necessary for teachers to have enough knowledge of and experience in the process of geometry teaching and to enjoy a level of content knowledge higher than that of the group of students they work with (Toluk, Oklun & Durmuş, 2002).

Teachers gain their content knowledge and teaching experience primarily through the programs at faculties of education. Research suggests that these programs fail to enable prospective teachers to gain enough knowledge and skills. For instance, Çetin and Dane (2004) discovered that prospective teachers use the geometric concepts that are defined dependent on each other as though they are independent of one another. Dane (2008) found that prospective teachers have rather insufficient knowledge or even misconceptions about point, straight line and plane. Similarly, Üzel and Özdemir (2009) maintained that half of the final grade students of Primary School Math Teaching do not have a sufficient level of geometric thinking.

In 2006, The Curriculum for Primary School Math Teaching, Faculty of Education, was gradually changed by the Council of Higher Education in order to train competent teachers that can implement the 2005 Curriculum for Primary School Mathematics Teaching (2005 CPMT), which had been modified owing to the reasons mentioned above. Focusing on learning through discovery and comprehension, 2005 CPMT requests teachers to employ concrete models and instruments in geometry teaching (MEB, 2005), for instructional materials play a key role in enabling students to concretize abstract concepts and connections among them. Furthermore, the more numerous and varied instructional materials are used in teaching-learning process, the greater contribution is made (Bulut, 2004; Toptaş, 2008). In consistent with 2005 CPMT, the 2006 Curriculum for Primary School Math Teaching included courses on knowledge of geometry and geometry teaching as of the first term. In this way, it is expected that prospective teachers will have increased content knowledge and teaching experience and developed skills in designing and using materials.

In our daily life, we encounter a number of concrete objects that can be associated with a prism, the most basic and fundamental element of space geometry, a sub-branch of geometry. Knowing the geometrical characteristics of concrete objects similar to a prism will enable students to put this knowledge into practice in their daily life and facilitate their future learning. It is essential that teachers, the leading factors in enabling students to acquire this knowledge and skills, should have a sufficient level of knowledge about a prism, give examples from daily life and be skilled enough to design and use appropriate materials. Therefore, it is necessary to study whether the prospective teachers at the Department of Primary School Math Teaching have such knowledge and skills.

Methodology

The purpose of the Study

The purpose of this study is to reveal how prospective primary school math teachers perceive rectangular prisms through models. In consistent with the purpose, answers are sought for the following questions:

1. How do prospective teachers name different models similar to rectangular prism?
2. What is their justification for the names they propose for different models?
3. How can the correct, partially correct and incorrect naming of prospective teachers be distributed across grades?

The Population

The population is comprised of 113 students of Math Teaching, the department of primary school teaching, the faculty of education at a university located in a middle-sized province in Eastern Anatolia, Turkey, during the Fall Term of the Educational Year 2010-2011. Table 1 presents the distribution of students by grade.

Table 1. The number and percentage of students by grade

Grade	n	%
First Grade	35	31
Second Grade	31	27.4
Third Grade	25	22.1
Fourth Grade	22	19.5
Total	113	100

The Curriculum for Primary School Math Teaching, for which the students are registered, includes the course Geometry in the second term, Instructional Technologies and Material Design in the fourth term, Analytical Geometry I-II and Special Teaching Methods I-II in the sixth and seventh terms. At the time the present study was conducted, none of the first grade students had taken any of these courses. Second grade students had taken only Geometry. Third grade students had taken Geometry, Instructional Technologies and Material Design and were continuing Analytical Geometry I. Fourth grade students had taken all the courses involved.

The Method

The present study used the survey model. The survey model is a research approach that aims to describe a past or continuing situation as it exists. The model makes an attempt to describe events, individuals, groups or objects involved within their own conditions (Karasar, 2008). In this model, both quantitative data collection methods and qualitative ones such as observation or interviews (Büyüköztürk, Kılıç, Çakmak, Akgün, Karadeniz & Demirel, 2008) can be employed. The present study only employed qualitative data collection methods in consistent with the purpose.

Data Collection Instrument

The data for the study were collected through an Interview Protocol (IP). The IP includes two structured open-ended questions for revealing how prospective primary school math teachers perceive rectangular prisms through models. The pilot scheme of the IP was conducted on 30 eleventh grade students. At the end of the pilot scheme, the questions were revised in accordance with the opinions expressed by five field specialists, a Turkish philologist and two math teachers so that any misunderstanding could be eliminated. In this way, the validity of the IP was ensured. The finalized questions were as follows: "Could you write down the geometrical names of the models you see?" and "Could you justify the names you propose?"

Data Collection and Analysis

In consistent with the purpose of the study, four different models were designed (Figure 1). The model A is a hollow rectangular prism made out of opaque and rigid plastic; the Model B is a hollow rectangular prism made out of glass; the Model C is a stuffed rectangular prism made out of wooden block; and the Model D is a model made out of wooden sticks that display the details of a rectangular prism. All the models are 10cm x 15cm x 20cm.

Figure 1: The Photographs of the Models Used in the Study.

As can be concluded from Figure 1, the models A, B and C are the kind of models that students generally see in their course books and use as instructional materials or they encounter in their daily lives. On the other hand, the Model D is relatively rarely encountered by students either during their lessons or in their daily lives.

These models were introduced to each classroom by a particular practitioner and students were granted with an opportunity to study them. During the introduction, the practitioner emphasized that the material, color and weight of the models should not be taken into account during the process of naming and justification and that the size of the models were equal. Afterwards, the models were placed somewhere in the classroom where all of the students could see and study them. Each student was asked to answer the IP within a class time. During the process, practitioners did their best to prevent students from affecting each other.

Each IP form was numbered; the data were computerized and descriptively analyzed. Each model was considered as a theme. The geometrical names provided by the prospective teachers were grouped under three sub-themes: "correct", "partially correct" and "incorrect". Those who did not produce any answers were evaluated as "incorrect". By taking geometrical definitions into consideration, five lecturers at Math Teaching decided under which sub-theme the geometrical names would fall. The names and justification provided by the prospective teachers were grouped depending on each sub-theme with a consideration to common emphasizes. With a consideration to grade, tables were drawn regarding the names proposed for each model by grade and the distribution of these names across the sub-themes. Direct quotations were included so that the prospective teachers' opinions could be reflected in a proper way.

Findings

This section includes tables on the data for each model concerning the first and second sub-problem: "How do prospective teachers name different models similar to rectangular prism?" and "What is their justification for the names they propose for different models?" In the presentation of findings, the names and justification for the models A, B and C were studied together since they were generally similar. However, the names and justification for the model D were evaluated separately. Finally, the data for the third sub-problem "How can the correct, partially correct and incorrect naming of prospective teachers be distributed across grades?" were presented in tables by grade.

Naming and Justification for the Models A, B and C

Table 2 presents the distribution of naming for the models A, B and C by sub-themes.

Table 2. The frequency and percentage values of naming for the models A, B and C by sub-themes.

Models	Sub-Themes	Naming	f	%
A	Correct	Rectangular Prism	81	72
		A hollow, closed, stuffed rectangular prism	17	15
		Total	**98**	**87**
	Partially Correct	Cube	5	4
		Prism	1	1
		Rectangular cube	1	1

		Total	**7**	**6**
	Incorrect	Surface area of rectangular prism	2	2
		Surface, transparent model	4	3
		Rectangle	1	1
		A two-dimensional object whose area is important	1	1
	Total		**8**	**7**
B	Correct	Rectangular prism	82	73
		A hollow, transparent, closed rectangular prism with an exterior surface area	22	19
	Total		**104**	**92**
	Partially Correct	Cube	3	2
		Rectangular cube	1	1
		Prism	1	1
		Total	**5**	**4**
	Incorrect	Surface set of a rectangular prism	1	1
		Surface, symbolic model	2	2
		An object occupying a place in space	1	1
		Total	**4**	**4**
C	Correct	Rectangular prism	80	71
		A stuffed, closed rectangular prism with a volume	23	20
	Total		**103**	**91**
	Partially Correct	Cube	3	2
		A rectangular wooden block	1	1
		Quadratic, tetragonal prism	2	2
		Rectangular cube	1	1
	Total		**7**	**6**
	Incorrect	Square	1	1
		A three-dimensional object whose volume is important	1	1
		Normal model	1	1
	Total		**3**	**3**

The percentage of correct naming for the models A, B and C varies between %87 and %92 (Table 2). Most of the students who named the model "rectangular prism", as a correct answer, justified their decision by stating that the models had edges, surfaces, volumes and dimensions whereas the others emphasized that the models looked like what they had learned and seen before. Among these students, S-82 and S-9 state as follows:

S-82: "*It has 6 faces and 12 edges. Each of its sides is a rectangle and three-dimensional.*"

S-9: "*The reason is that it connotes a rectangular prism. All the rectangular prisms I have ever seen are based on this model.*"

Most of the students who named the models rectangular prism by using certain adjectives emphasized that the model was hollow, stuffed and solid, that it consisted of rectangles and had surface areas whereas some did not justify their decision at all. Among the students using adjectives, S-104 and S-109 justified their decision as follows:

S-104: "*It appears as a rectangular prism. However, one can guess that it is hollow when he/she touches it…*" (The models A and B)

S-109: "*If this is a prism, then it is stuffed and has a volume.*" (The model C)

Most of the students who proposed "partially correct" names likened the models to cube. Some of the students included only some characteristics of the models in their justification and provided the name "prism". The justifications of S-2 and S-33, who named the models "cube" and "prism" respectively, are as follows:

S-2: "*A cube is also a rectangular prism. This prism connotes a cube.*"

S-33: "*The reason is that its bilateral sides are equal and it is three-dimensional.*"

Most of the students who provided an "incorrect" name emphasized such characteristics of geometrical figures as visible surface, calculable area, two-dimensional, four sides and lines. The justifications of S-106 and S-13, who named the models "surface model" and "rectangle" respectively, are as follows:

S-106: "*I have proposed this name on the grounds that only the exterior surface is visible.*"

S-13: "*It has four corners. It consists of four straight lines.*"

Naming and Justification for the Model D

Table 3 presents the distribution of naming for the model D by sub-themes.

Table 3. The frequency and percentage values of naming for the model D by sub-themes.

Sub-Themes	Naming	f	%
Correct	The skeleton of a rectangular prism	19	17
	Just a geometrical figure with the edges of a rectangular prism	2	2
	A hollow rectangular prism only with sides	8	7
	A lined rectangular prism without an area that is open in all directions.	4	3
	Total	**33**	**29**
Partially Correct	A hollow rectangular prism made out of wooden sticks with hollow edges	12	10
	A prism-like figure with the edges of a rectangular prism	1	1
	Skeletor cube	1	1
	Total	**14**	**12**
Incorrect	Rectangular prism	46	41
	A rectangular prism with edges whose sides are hollow. Only its corners are obvious and it does not have lateral edges.	3	2
	Surface area of a rectangular prism	1	1
	Rectangular cube	1	1
	Cube	3	2
	A prism by appearance	1	1
	An edge model	1	1
	Regular tetrahedron	1	1
	Hollow/ Rectangle	3	2
	An object whose circumference is significant	1	1
	A hollow rectangular object with sides	1	1
	No proposals	4	3
	Total	**66**	**59**

Nearly one-third of the students (% 29) provided a correct name (Table 3). Most of the students who named the model correctly emphasized that it did not have a base, surface area and volume, it consisted of only edges, it was hollow, it only had sides, and therefore it could not be called a rectangular prism. In addition, some of the students used the metaphor "skeleton" since they likened it to a framework of a house or building, or skeleton of a human body. S-104, S-102 and S-103 stated as follows:

S104: "*Framework of a rectangular prism. It is comprised of just edges. Since it does not have a lateral surface, its volume cannot be calculated.*"

S102: "*If we cover the exterior surface of this figure with woods, i.e. like the walls of a house, we get a rectangular prism. Therefore, I have called it the skeleton of a rectangular prism. Imagine a human skeleton. If we cover its exterior with flesh, then we get a human body.*"

S103: "*The reason why I have called it a rectangular prism is that it does not meet the requirements of a prism since it does not have lateral faces…*"

The percentage of partially correct names for the model D is 12.4%. One of the names proposed for the model is "a rectangular prism made out of hollow wooden sticks with hollow edges". The students who proposed these names only emphasized that the model was hollow but ignored the fact that it did not have lateral surfaces.

The percentage of incorrect names for the model D is 54.8%. The most commonly proposed incorrect name is "rectangular prism". Others are "a rectangular prism which has edges and hollow sides, only its sides being visible and not having lateral edges", "cube" and "hollow rectangle". Nearly half of the students who named the model "rectangular prism" placed emphasis in their justification on such basic characteristics of a rectangular prism as dimension, length, hollowness, rectangle, surface, edge and corner. Some of them focused on the fact that it resembled a rectangular prism whereas only a few of them noted that it was an object. The remaining students either proposed irrelevant justification (for example, S-54: measurable diagonal length) or no justification at all. Out of the students naming the model rectangular prism, S-39, S-92 and S-41 stated as follows:

S-39: "*The model is a rectangular prism, for its base is rectangle, it has a certain length and it is three-dimensional. Its volume and area can be calculated through the same formula whether it is hollow or stuffed.*"

S-92: "*The reason is that it is an object formed through the combination of 12 sides.*"

S-41: "*The reason is that it resembles a rectangular prism. It has a latitude, length and width. At least two of its dimensions have different lengths and all its sides cut vertically each other.*"

Some students proposed an incorrect name other than rectangular prism. Their justification was as follows:

S-33: "*Its bilateral sides are equal and it is three dimensional.*"

S-3: "*It has edges and hollow sides.*"

S-21: "*I can say that regular tetrahedron, like cube and tetragonal prism, is an object that rectangular prism connotes.*"

S-19: "*It is a rectangle, for it is hollow.*"

Only a few of the students did not propose a name or justification.

Table 4 presents the frequency and percentage values of naming for the models A, B, C and D by grades.

Table 4. The frequency and percentage values of naming for the models A, B, C and D.

Models	Sub-Themes	1st Grade		2nd Grade		3rd Grade		4th Grade		Total	
		f	%	f	%	f	%	f	%	f	%
A	Correct	28	80	30	97	23	92	17	77	98	87
	Partially Correct	5	14	1	3	0	0	1	5	7	6
	Incorrect	2	6	0	0	2	8	4	18	8	7
B	Correct	29	83	30	97	24	96	19	77	102	90
	Partially Correct	5	14	1	3	0	0	1	5	7	6
	Incorrect	1	3	0	0	1	4	2	9	4	4
C	Correct	29	83	29	94	25	100	20	90	103	91
	Partially Correct	4	11	2	6	0	0	1	5	7	6
	Incorrect	2	6	0	0	0	0	1	5	3	3
D	Correct	3	9	6	19	5	20	19	86	33	29
	Partially Correct	3	9	5	16	4	16	2	9	14	12
	Incorrect	29	82	20	65	12	48	1	5	62	55
	No proposals	0	0	0	0	4	16	0	0	4	4

Correct or partially correct naming for the models A, B and C ranges from 82% to 100% depending on the grade (Table 4). It is interesting to note that correct or partially correct naming for the model D by the first, second and third grade students varies between 17% and 36% whereas it is 95% for the fourth grade students.

Conclusion, Discussion and Implications

A great majority of the students proposed a "correct" or "partially correct" name for the models A, B and C. A review of the finding and justification for their naming suggests that the students can use the fundamental characteristics of a rectangular prism, such as edge, surface area and polygon on the base, in a proper way. This might have been resulted from the fact that students frequently encounter and use models similar to A, B and C during their educational life, an idea also proposed by Bulut (2004) and Toptaş (2008).

Most of the students who proposed a partially correct name for the models A, B and C chose "cube" whereas some of them named the models "prism". A review of the justification provided by the students who chose "cube" indicates that they do not pay attention to the characteristics that distinguish a cube from a rectangular prism, such as different edge lengths. As for those who named the models "prism", they appear to have ignored the necessity of naming a prism depending on the name of the polygon on its base.

A review of the justification provided by those students who proposed an incorrect name for the models A, B and C, such as "rectangle", "square" or "surface area", suggests that such students do not have a clear idea about the fundamental concepts concerning a rectangular prism or cannot establish connections among these.

Nearly two out of five students proposed a "correct" or "partially correct" name for the model D. The rate is considerably lower when compared to the rate for the other models. These students emphasized that it did not have a base, surface area or volume, that it consisted of only edges, and therefore it cannot be called a rectangular prism. In addition, the name "skeleton of a rectangular prism" can be regarded as one of the best ways to describe the model. A review of correct naming and justification indicates that the students have a clear idea about the fundamental concepts concerning a rectangular prism and can establish high-level connections among these concepts. As for those students who proposed a partially correct name put emphasis in their justification only on its hollowness but ignored whether it had lateral surface or not, which indicates that they do not have a clear idea about the fundamental concepts concerning a rectangular prism, that they cannot establish connections among them in an adequate manner, and that they cannot express these connections.

Most of the students proposed an "incorrect" name for the model D. Especially those who called the model a rectangular prism apparently thought that the model was similar to A, B and C and proposed similar naming and justification. The students who proposed other names than rectangular prism have confusion between edge and side, side and surface area, regular tetrahedron and rectangular prism, and rectangle and rectangular prism. The findings suggest that most of the students are successful in naming the models A, B and C which they frequently encounter in a proper way and explaining the characteristics and connections concerning the models but they are less successful in the model D, which they rarely encounter and which requires high-level connections among the concepts. This finding supports that of Çetin and Dane (2004), who discovered that students tend to use the geometric concepts that are defined dependent on each other as though they are independent of one another. However, the model D constitutes the skeleton of other models like A, B and C, as stated by some of the students in the following words: "If we cover the exterior surface of this figure with woods, i.e. like the walls of a house, we get a rectangular prism. Therefore, I called it skeleton of a rectangular prism. Imagine a human skeleton. If we cover its exterior with flesh, then we get a human body." Therefore, the use of different models like D could make a contribution to meaningful learning through discovery (MEB, 2005), in consistent with the idea of 2005 CPMET. In order for students to be able to construct concepts concerning prism in a proper way, activities could include initially erecting the skeleton of a prism with wooden sticks, then covering its surface with paper or similar materials or constructing its model by piecing their surfaces together and finally stuffing it with different materials like unit cube and sand. The same process could be carried out in reverse. Furthermore, other activities could be organized with skeleton models of a prism or pyramid which consists of only edges like triangle, rectangle and pentagon or with their slightly covered skeleton models.

Most of the students in all grades proposed a "correct" or "partially correct" name for the models A, B and C. Nevertheless, the rate of "correct" or "partially correct" naming for the model D varies depending on the grade. The rate is nearly one-third for the first, second and third grade students while it is approximately hundred percent for the fourth grades. High levels of achievement for all models in the fourth grade contradict with the finding of Üzel and Özdemir (2009), who found that half of the fourth grade students do not have an adequate level of geometrical thinking. This controversial finding could be studied on different subjects and grades.

The study concluded that the students are successful in naming the models A, B and C which they frequently encounter in a proper way and justifying their decision but they are less successful in the model "skeleton" like D, which they rarely encounter. In this sense, the use of different skeleton models will make a great contribution to a better construction of such concepts as prism and pyramid, which play a crucial role in geometry teaching.

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