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The Analysis of Elementary Mathematics Preservice Teachers' Spatial Orientation Skills with SOLO Model

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Abstract

Problem Statement: The SOLO model places responses provided by students on a certain level instead of placing students there themselves. SOLO taxonomy, including five sub-levels, is used for determining observed structures of learning outcomes in various disciplines and grade levels. On the other hand, the spatial orientation skill is the ability to visualize an object's view from a different perspective. A number of studies on examining preservice teachers' spatial abilities have been performed. In this study, elementary mathematics preservice teachers' spatial orientation skills as components of spatial skills were evaluated through the SOLO model in ways that are different from other researches.

Purpose of the Study: The purpose of this study was to analyze the spatial orientation skills of elementary mathematics preservice teachers by using the SOLO model. In addition, responses of students who were at specified levels (low-middle-high) according to the Purdue Spatial Visualization Test scores were also classified. Preservice teachers' responses between different dimensions were also examined according to SOLO taxonomy.

Method: The present research was a qualitative study and a case study method was employed. The sample of the study included junior elementary mathematics preservice teachers from a state university. Firstly, the Purdue Spatial Visualization Test was carried out with eighty-one students and then clinical interviews were conducted with six students according to three levels which were specified by looking at the

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results of the test in this study. The students' answers were placed into a suitable SOLO level according to an evaluation scale by analyzing each of the eight questions used in the Geometrical Achievement Test prepared by the researchers.

Findings: Elementary mathematics preservice teachers' responses in a geometrical achievement test relating to spatial orientation skills were generally on a multistructural level according to SOLO taxonomy. Whereas the responses of preservice teachers who were on the low and middle levels were mostly on a multistructural level, the responses of the students on the high level were on a relational level. In addition, the responses of preservice teachers from two-dimension to three-dimension were mostly on a relational level and the responses from three-dimension to two-dimension were mostly on a multistructural level.

Conclusion and Recommendations: Results obtained indicated that preservice teachers were not generally successful at combining their information within a consistent structure in terms of spatial orientation skills. They could only evaluate situations which were independent from each other separately. Therefore, students had surface learning rather than deep learning. Obtained data can be evaluated with a different taxonomy and a comparison could be made between these two models in further studies.

Keywords: SOLO taxonomy, spatial ability, clinical interview

Introduction

The SOLO Model has been developed by analyzing the Piaget's studies on the development theory in a detailed manner. The Model helps teachers by evaluating learning outcomes by testing understanding (Halloway, 2010). The SOLO Model can be used for evaluating students' cognitive knowledge (Biggs & Collis, 1991; Jurdak, 1991; Lian & Idris, 2006). It is also used for determining observed structures of learning outcomes in various disciplines and grade levels (e.g., Pegg & Coady, 1993; Lam & Foong, 1996; Chick, 1998; Jones, Thornton, Langrall, Mooney, Perry, & Putt, 2000; Groth & Bergner, 2006; Dudley & Baxter, 2009). SOLO taxonomy is also being used to define and interpret mathematical thinking skills of students and their understanding regarding specific concepts in mathematics (e.g., Pegg & Coady, 1993; Lam & Foong, 1996; Pegg & Davey, 1998; Jones, et al., 2000; Money, 2002; Groth, 2002; Wongyai & Kamol, 2004; Lian & Idris, 2006). Therefore, SOLO taxonomy is a different way to evaluate students or preservice teachers' mathematical understanding and some skills. In addition, a number of different studies on the evaluation of preservice teachers' spatial skills have been performed (e.g., Unal, 2005; Baki & Guven, 2007; Yolcu, 2008; Dursun, 2010; Nagy-Kondor, 2014; Sezen Yuksel & Bulbul, 2014; Ozdemir & Goktepe Yildiz, 2015; Sezen Yuksel & Bulbul, 2015; Goktepe Yildiz, Goktepe Korpeoglu, & Korpeoglu, 2015). The aspect of this study that makes it different from other studies is evaluating their spatial skills through the SOLO model. This is important because it is one of the first studies that includes both the SOLO model and spatial skills and will enlighten future studies. In addition, it is thought that this study may provide opportunities for preservice teachers to see and remove their deficiencies by having preservice teachers raise awareness for their own visual skills.

Each thinking level stated in the SOLO model includes five sub-levels of response. These levels are also called "SOLO Taxonomy." These are prestructural, unistructural, multistructural, relational, and extended abstract levels. As the complexity of the responses increases, the level increases. In addition, as the level increases, skills such as making consistent explanations, creating relations, and thinking by considering more than one situation also increase. The information about SOLO taxonomy is as follows (Biggs & Collis, 1991; Celik, 2007):

Prestructural Level: The answers of the students are not sufficient. The aspects of the problem which does not lead you to the solution frequently distract students' attention. The way that the students find a solution does not lead them to a correct solution and they take steps which are suitable to a phase in a lower level.

Unistructural Level: The student focuses on the problem but uses only a relational data for the solution. The student cannot understand the value of the used data in whole and the relation of the data with others. Therefore, the answers of the student may not be consistent.

Multistructural Level: The student uses multiple data which lead to a solution but cannot grasp the relation among those data. Therefore, some inconsistencies can be seen in the answers of the student.

Relational Level: The student uses all of the data which leads to answers to problems and understands their value as a whole and the relation between them. The student constructs a consistent structure.

Extended Abstract Level: The student thinks beyond the data used in the problem while reaching a solution and makes generalizations. The student can create new thinking styles.

The basic difference between unistructural level and multistructural level is the use of multiple related data on a multistructural level. The student finds the solution by following certain steps on a multistructural level and makes operations such as defining and ranking the data. While passing from a multistructural level to a relational structure level, it is necessary to approach the data with a broader perspective after the data has been defined. After defining the data which help you to find a solution on a multistructural level, these data are put into a whole on a relational level. The student further extends generalizations that he finds in an extended abstract level and makes more advanced inferences (Pegg & Davey, 1998; Celik, 2007). Thus, passing from a relational level to an extended abstract level is the most difficult, but also the most desired part.

The student considers many things at the same time on relational structure and extended abstract structure levels and makes correlations between them. As a result, the student does not establish relationships on a unistructural level as he or she focuses on a single structure and there is no other direction. On a multistructural level, multiple data are used by the students but the student cannot make a correlation between these directions. A generalization is obtained in an extended abstract but this generalization is ahead of the current situation (Hattie & Brown, 2004). The relationships between SOLO levels can be summarized as mentioned above.

On the other hand, spatial orientation skill is the ability to visualize an object's view from a different perspective (Contero, Naya, Compnay, Saorin, & Conesa, 2005). Strong and Smith (2002) gave such examples of spatial orientation as a swimmer who changes his direction when he dives but can determine his position when he turns or a pilot who knows his position when he maneuvers.

It is necessary for teachers to be self-sufficient in visual-spatial areas to be able to develop their students' spatial aspects. In addition, it will be useful to know the level and geometrical background information of preservice teachers; this information is necessary for them to be successful in spatial geometry lessons. In conclusion, they will have opportunities to see and complete their deficiencies before starting their careers.

In line with the above, the main aim of this study was to analyze the spatial orientation skills of elementary mathematics preservice teachers according to the SOLO model. The research question: "What is the level of elementary mathematics preservice teachers' spatial orientation skills according to SOLO taxonomy?" guided this study. The level of students' responses was at which specified level (low-middle-high) according to SOLO levels was also researched. In addition, their responses for the questions between different dimensions (from two dimensions to two dimensions, from two dimensions to three and from three dimensions to two and from three dimensions to three) were classified according to SOLO levels.

Method

Research Design

A qualitative approach was used in the present research. A case study method was employed to analyze elementary mathematics preservice teachers' spatial orientation skills; this method allows searching in a selected subject in detail (Cohen, Manion, & Morrison, 2000). Since clinical interviews provide an opportunity to deeply analyze students' thinking processes (Guven, 2006), the spatial skills of preservice teachers were evaluated through clinical interviews. In addition, the descriptive analysis method was used in the phase of analyzing qualitative data.

Research Sample

The sample of this research included junior preservice teachers who were enrolled in the Department of Elementary Mathematics Education in a state university in Turkey. Firstly, the Purdue Spatial Visualization Test (PSVT) was conducted with eighty-one preservice teachers and then clinical interviews were carried out with six preservice teachers. Purposeful sampling (Patton, 2002) was employed to select six interviewees. According to the Purdue Spatial Visualization Test scores, Merve and Taner were at the low level, Elif and Gamze in the middle level and Bilal and Emre were in the high level. Preservice teachers voluntarily participated in the research. The names used for the preservice teachers are their nick names.

Research Instruments

Data were collected through the Purdue Spatial Visualization Test (PSVT) and Geometrical Achievement Test prepared by the researchers. In addition, clinical interviews were conducted with students in light of the geometrical achievement test questions.

Purdue Spatial Visualization Test (PSVT)

The Purdue Spatial Visualization Test was used for the selection of students participating in clinical interviews. The test was created by Guay in 1977 and composed of three sections and 36 questions. There were 12 multiple choice questions in each section (Bodner & Guay, 1997). The sections were as follows: Developments, Rotations, and Views. One example for the questions used in the Purdue Spatial Visualization Test is as follows.

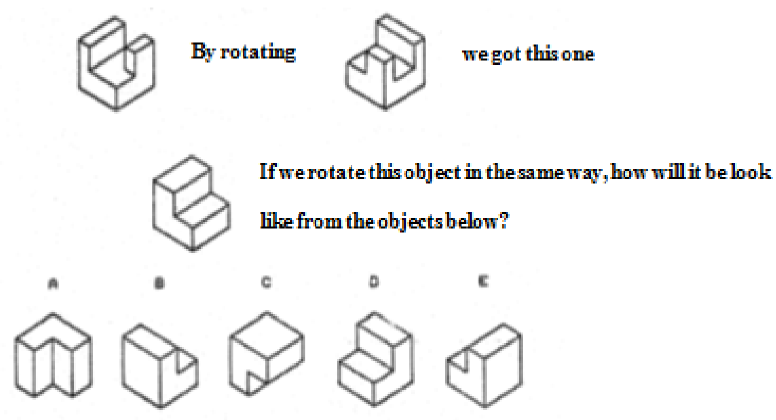

Figure 1. An example question in the Purdue Spatial Visualization Test

Geometry Achievement Test

The Geometry Achievement Test, which tests students' spatial orientation skills, was prepared by the researchers and was also used during clinical interviews. The questions were organized in a way that requires moving in the dimensions themselves and between dimensions. The test consisted of eight problems. It was considered appropriate to conduct a pilot study for guiding the researchers before clinical interviews and for giving pre-information to them about how they would analyze and interpret the data. In accordance with the data obtained through the pilot study, an evaluation scale was created regarding how the problems were evaluated by giving examples to competencies which correspond to each level. The first and second questions in the test were testing preservice teachers' spatial orientation skills from two-dimension to two-dimension, the third and fourth questions were concerned with going from two-dimension to three-dimension, the fifth and sixth questions examined participants' skills from three-dimension to two-dimension, and the last two questions tested their spatial skills from three-dimension to three-dimension. The pilot study was carried out with sixty-six senior elementary mathematics preservice teachers. After conducting validity and reliability studies, the final version of the test was created. An example of the questions used in the Geometry Achievement Test is presented below:

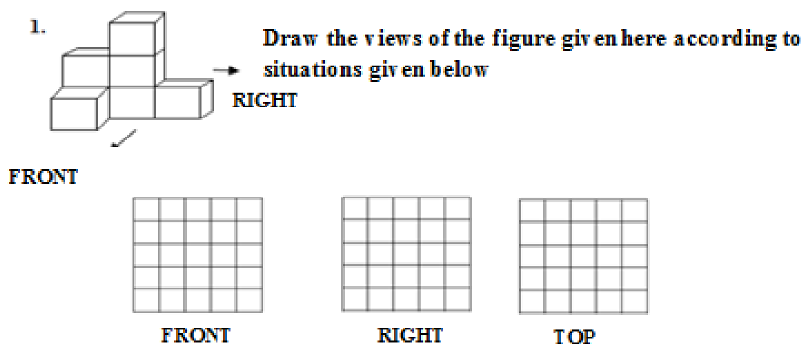

Figure 2. An example question in the Geometry Achievement Test

This problem required preservice teachers to think from three-dimension to two-dimension. This question was accepted as suitable for evaluating spatial orientation skills since spatial orientation was defined by McGee (1979) as not to confuse when different orientations of a spatial object were given. They were asked to transfer views of a three-dimensional figure which was made from unit cubes from three different aspects (front, right, and top) into a two-dimensional plane.

While the responses provided for the above problem were analyzed with the evaluation scale according to SOLO taxonomy, the explanations stated for each level were as follows:

In the prestructural level, the student cannot fully understand what is asked in the question. He cannot correctly draw the view of the object from any of the directions. In the unistructural level, the student understands what is asked in the question but is interested in only one aspect. For example, he transfers only one view of the three-dimensional object into a two-dimensional plane. In the multistructural level, the student uses all of the directions given in the question. He draws all the views from the right, front and top for this question. However, he cannot predict whether or not to use the view of the other directions for drawing the view from one direction. He cannot provide consistent answers when it is asked whether or not there is a correlation between right-left, front-back and top-lower views of the figures. In the relational level, the student knows exactly what to do for the solution. He draws all of the views from all directions and knows how he can use different directions while drawing. He can make different correlations when it is asked whether or not there is a correlation between right-left, front-back and top-lower views of the figures. In the extended abstract level, the student does not have any difficulty in transferring three-dimensional objects into a two-dimensional plane. He completes his drawing quickly. He creates rules or makes correct generalizations for the relations between figures by making correlations between the different views of the figures.

Clinical Interviews

The clinical interviews were carried out using audio recorders at the seminar room of the school. Each interview lasted approximately 60 minutes. During the interviews, the students were asked to answer questions one by one; they were also asked to explain how they found the solutions in detail. The following additional questions were posed to students: "What kind of a generalization do you make about this question?" "How did you make this generalization?" and "What can be your conclusion as a result of the desired rotation move?" The spatial orientation skills of preservice teachers were attempted to be determined according to SOLO taxonomy, as well as by asking different questions to students in accordance with their responses to questions.

Procedures

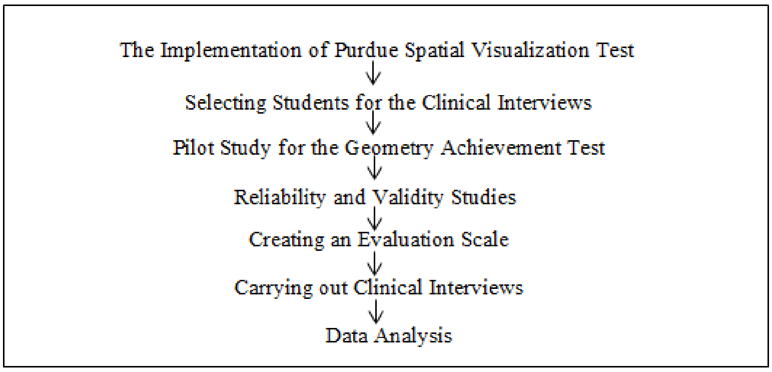

Figure 3. The Flowchart showing the procedures

Validity and Reliability

In this study, the Purdue Spatial Visualization Test was conducted with eighty-one elementary mathematics preservice teachers and an alpha reliability co-efficient was found to be 0.834 according to KR-20 reliability analysis. As stated by Kalayci (2010), the scale was highly reliable.

Two different researchers evaluated the level of the preservice teachers' responses obtained via clinical interviews according to SOLO taxonomy. Inter-coder reliability was calculated with the formula determined by Miles and Huberman (1994). The researchers stated that reliable coding occurs in cases when this value is over 70. In this study, since this value was found to be approximately 96%, it was concluded that the scale, which was developed for this study in which spatial skills of the preservice teacher were analyzed according to the SOLO model was consistent and reliable.

Data Analysis

The data obtained are summarized and interpreted according to pre-determined categories in descriptive analysis. The purpose of this kind of analysis is to present collected data in an organized way to the readers and described systematically and overtly (Yildirim & Simsek, 2011). In cases when researchers put the students' responses into different SOLO levels, a consensus was reached after discussing the probable best solution for the suitable level; the response was then put into a suitable level.

Results

The levels of the students' responses regarding the spatial orientation skills according to SOLO taxonomy are given in this part. Firstly, the findings regarding forty-eight responses in total (to eight questions) which were stated by six students used in the geometry achievement test were included. The evaluations between dimensions are also presented. Finally, the levels of the responses are placed according to the levels of the students (low, middle, and high).

Table 1.
The Overall Evaluation of Preservice Teachers' Spatial Orientation Skills

SOLO Levels	Pre structural	Unistructural	Multistructural	Relational	Extended Abstract
Number of Responses	0	10	27	11	0

In terms of spatial orientation skills, 27 of the preservice teachers' responses were on a multi-structural level, 11 of them were on a relational level, 10 of them on a unistructural level and there were not any responses on prestructural or extended abstract levels.

Table 2.
The Level of 2D-2D Spatial Orientation Skills of Preservice Teachers

Students	Question 1	Question 2
Merve	Unistructural	Multistructural
Taner	Unistructural	Unistructural
Elif	Multistructural	Multistructural
Emre	Unistructural	Multistructural
Bilal	Relational	Relational
Gamze	Unistructural	Multistructural

All of the responses of Taner showed features of a unistructural level, Elif's responses were at a multistructural level and Bilal's responses were on a relational level. Merve, Emre, and Gamze responded mostly on a multistructural level and on a unistructural level least often. There were not any responses which were suitable to the features of prestructural and extended abstract levels. When we analysed in general, the responses of elementary mathematics preservice teachers to the questions testing spatial orientation skills from two-dimension to two-dimension were mostly on a relational level and, least often, on a unistructural level.

Table 3.
The Overall Evaluation of 2D-2D Spatial Orientation Skills

SOLO Levels	Pre structural	Unistructural	Multistructural	Relational	Extended Abstract
Number of Responses	0	5	5	2	0

For the questions assessing 2D-2D Spatial orientation skills, five of the preservice teachers' responses were on a unistructural level, five of them on a multi-structural level, two of them on a relational level and there were not any individuals on prestructural and extended abstract levels.

Table 4.
The Level of 2D-3D Spatial Orientation Skills of Preservice Teachers

Students	Question 3	Question 4
Merve	Multistructural	Multistructural
Taner	Relational	Multistructural
Elif	Relational	Relational
Emre	Unistructural	Relational
Bilal	Relational	Relational
Gamze	Unistructural	Multistructural

All of the responses of Merve were on a multistructural level and all of the responses of Elif and Bilal were on a relational level. Taner responded to questions mostly on a relational level and, least often, on a multi-structural level. Most of the responses of Emre displayed relational level features and unistructural level features were displayed the least often. In Gamze's responses, multistructural level was seen most and unistructural level was seen least often. There were not any responses on prestructural and extended abstract levels. When we analysed in general, the responses of the elementary mathematics preservice teachers to the questions testing spatial orientation skills from two-dimension to three-dimension were mostly on a relational level and, least often on a unistructural level.

Table 5.
The Overall Evaluation of 2D-3D Spatial Orientation Skills

SOLO Levels	Pre structural	Unistructural	Multistructural	Relational	Extended Abstract
Number of Responses	0	2	4	6	0

For the questions assessing 2D-3D spatial orientation skills, two of the responses of preservice teachers was on a unistructural level, four of them were on a multistructural level, six of them were on a relational level and there were not any individuals on extended abstract and prestructural levels.

Table 6.
The Level of 3D-2D Spatial Orientation Skills of Preservice Teachers

Students	Question 5	Question 6
Merve	Relational	Multistructural
Taner	Unistructural	Multistructural
Elif	Multistructural	Multistructural
Emre	Relational	Multistructural
Bilal	Multistructural	Multistructural
Gamze	Multistructural	Multistructural

Merve and Emre were mostly relational level and were least often on a multistructural level. All of the responses of Elif, Bilal and Gamze were on a multistructural level. The responses of Taner displayed mostly multi-structural features and unistructural features the least often. There were not any students in prestructural and extended abstract levels. When we analysed in general, the responses of the elementary mathematics preservice teachers to the questions testing spatial orientation skills from three-dimension to two-dimension were mostly on a relational level and least often on a unistructural level.

Table 7.
The Overall Evaluation of 3D-2D Spatial Orientation Skills

SOLO Levels	Pre structural	Unistructural	Multistructural	Relational	Extended Abstract
Number of Responses	0	1	9	2	0

For the questions assessing 3D-2D spatial orientation skills, one of the responses of preservice teachers was on a unistructural level, nine of them were on a multistructural level, two of them on a relational level and there were not any individuals on extended abstract and prestructural levels.

Table 8.
The Level of 3D-2D Spatial Orientation Skills of Preservice Teachers

Students	Question 7	Question 8
Merve	Multistructural	Multistructural
Taner	Multistructural	Multistructural
Elif	Unistructural	Unistructural
Emre	Multistructural	Multistructural
Bilal	Multistructural	Multistructural
Gamze	Relational	Multistructural

While all of the responses of Merve, Taner, Emre, and Bilal displayed multistructural features, all of the responses of Elif displayed unistructural level. Gamze's responses displayed mostly relational features and multistructural features least often. There were not any students on prestructural and extended abstract levels. When we analysed in general, the responses coming from the elementary mathematics preservice teachers to the questions testing spatial orientation skills from three-dimension to three-dimension were mostly on a relational level and on a unistructural level least often.

Table 9.
The Overall Evaluation of 3D-3D Spatial Orientation Skills

SOLO Levels	Pre structural	Unistructural	Multistructural	Relational	Extended Abstract
Number of Responses	0	2	9	1	0

For the questions assessing 3D-3D spatial orientation skills, two of the preservice teachers' responses were on a unistructural level, nine of them were on a multi-structural level, one of them was on a relational level and there were not any individuals on extended abstract structure and pre-structural levels.

Table 10.
The Evaluation of Preservice Teachers' Spatial Orientation Skills according to their Levels

		2D-2D		2D-3D		3D-2D		3D-3D	
Low	Merve	US	MS	MS	MS	R	MS	MS	MS
	Taner	US	US	R	MS	US	MS	MS	MS
Middle	Elif	MS	MS	R	R	MS	MS	US	US
	Gamze	US	MS	US	MS	MS	MS	R	MS
High	Bilal	R	R	R	R	MS	MS	MS	MS
	Emre	US	MS	US	R	R	MS	MS	MS

US: Unistructural
MS: Multistructural
R: Relational

Merve, who was on the low level according to the Purdue Spatial Visualization Test, gave responses on a multistructural level mostly and on a unistructural level least often to the questions requiring thinking from two dimension to two dimension. The responses of Taner who was at the same level to these questions were on a unistructural level. Finally, low level students' responses to the 2D-2D questions were mostly on a unistructural level. While Merve was on a multistructural level for questions requiring thinking from two-dimension to three-dimension, Taner was on a relational level mostly and on a multistructural level least often. In questions requiring a passing between these two dimensions, preservice teachers who were on a low level were on the multistructural level. In questions requiring passing from three-dimension to two-dimension, while Merve was least often on a multistructural level, she was mostly on a relational level. Taner was on a unistructural level least often and on a multistructural level mostly. The responses that they provided for these questions between these dimensions were mostly on multistructural level. In questions requiring passing from three-dimension to three-dimension, both Merve and Taner were on a multistructural level for these four questions.

Elif, who was on the middle level according to the Purdue Spatial Visualization Test, responded on a multistructural level for the questions requiring thinking from two dimension to two dimension; however, Gamze responded on a multistructural level the most and a unistructural level least often. In conclusion in this dimension, the responses of students who have low level spatial visualization skills were on a multistructural level. In questions requiring thinking from two-dimension to three-dimension, while Elif was in the relational level, Gamze was on a unistructural level least often and on a multistructural level most often. In questions requiring passing between these two dimensions, middle level preservice teachers were generally on a relational level. The responses provided by Elif and Gamze for all the questions requiring passing from three-dimension to two-dimension were on a multistructural level. For the questions requiring passing from three-dimension to three-dimension while Elif responded according to unistructural level, Taner responded according to a multi-structural level least often and a relational level most often. Therefore, most of their responses were on a unistructural level.

Bilal, who was on the high level according to the Purdue Spatial Visualization Test, responded on a relational level for the questions requiring thinking from two dimension to two dimension but Emre who was at the same level responded on a multistructural level most often and a unistructural level least often. In conclusion, most of the responses of the students on a high level were on a relational level. In questions requiring thinking from two-dimension to three-dimension, Bilal was on a relational level for all questions, Emre was on a unistructural level least often and a relational level most often. In questions requiring passing from three-dimension to two-dimension, Bilal was on a multistructural level least often and a relational level most often. Emre was on a relational level for both questions. When we looked at the responses to these questions requiring passing between two dimensions, it was seen that they were mostly on a multistructural level. In questions requiring passing from three-dimension to three-dimension, both Merve and Taner were on a multistructural level for all four of these questions.

Discussion and Conclusions

Elementary mathematics preservice teachers were mostly on a multistructural level in terms of spatial orientation skills, which is one of the components of spatial skills. With the help of this information, it was seen that preservice teachers were not successful at combining their information within a consistent structure in terms of spatial orientation concepts. They could only evaluate situations which were independent from each other separately (Celik, 2007).

It was concluded that the responses of students for the questions assessing spatial orientation skills from two-dimension to two-dimension were generally on unistructural and multistructural levels. The responses of preservice teachers from two-dimension to three-dimension were mostly on a relational level. The responses of preservice teachers for the questions assessing spatial orientation skills from three-dimension to two-dimension were mostly on a multi-structural level. When tridimensionality was added to the questions, there was a decrease in the levels of responses. This is an expected result because the abstraction level and the difficulty of questions have been increasing. While the levels determined for the questions requiring thinking from two-dimension to two-dimension differed from the levels in the studies carried out by Groth and Bergner (2006), Lian and Idris (2006), and Celik (2007) as they were in an upper level, similar results were obtained from the problems between the other dimensions.

The responses of preservice teachers who were in the low and middle levels were mostly on a multistructural level; they had superficial learning rather than in-depth learning (Hattie & Brown, 2004). Also, preservice teachers tried to use more data in solving problems. The responses of students who were on the high level according to the Purdue Spatial Visualization Test were on a relational level for questions requiring thinking from two-dimension to two-dimension and from two-dimension to three-dimension. They performed what was asked of them by correlating given concepts regarding spatial orientation skills. For example, they were able to draw an object after its right, top, and front view had been given to them by visualizing; they could also create correlations between their views from different directions. The displayed relational level's features by predicting the fact that one figure's right view and left view are symmetrical to each other. The highest level in transforming between dimensions in terms of spatial orientation skills belongs to this part. When we looked at the responses that they provided for the questions requiring thinking from three-dimension to two-dimension and three-dimension to three-dimension, it was seen that they were generally on a multistructural level. Therefore, the level of responses decreased when tridimensionality was added. With the help of this information, it was concluded that pre-service teachers who were on a high level could generally be on a multistructural level or relational level. In the SOLO model, as was advocated by Biggs and Collis (1991), we can see that we cannot place students into one level. One level could not be determined for these students; however, it was shown that they were in a more advanced level as it was expected for them to be in the half relational level. When we examined the studies of the SOLO model, although the subjects were different, the findings obtained from the studies of Groth and Bergner (2006), Lian and Idris (2006) and Celik (2007) showed that the participants stayed under the relational level; but in this study, the responses of preservice teachers who had high level spatial visualization skills also displayed the features of a relational level. With this side, this study had an aspect which was different from the other studies. This was an important result on behalf of having quality education that preservice teachers' SOLO levels were slightly above middle level.

The data obtained in this study were analyzed according to thinking levels of the SOLO model. The same data can be evaluated with a different taxonomy and a comparison can be made between these two models, so that the subject was considered with a different perspective. In this way, additions can be made if there are any missing or overlooked points. SOLO model can be suggested to researchers who would like to use an alternative model as the model classifies the responses given in the current situation by the students instead of placing students into classes individually.

For the research, eight questions were asked and the responses of the students classified according to the levels. In addition, an evaluation was made by asking two questions from each of the dimensions (from two-dimension to two-dimension, from two-dimension to three-dimension, three-dimension to two-dimension, three-dimension to three-dimension). In this study, since the clinical interview method was used, though the number of the questions was less, more specific results can be obtained by increasing the number of questions at the spatial skill components of the students and specified dimensions. In another method, Celik (2007) preferred to make a more sensitive evaluation by adding weak or strong to the response levels of the students in their studies. While determining the competencies for each level, features expected during weak and strong situations can be added.

The study was carried out with six elementary mathematics preservice teachers. There can be more students or preservice teachers from different majors or teachers who are in the in-service teacher training courses. Later on, the collected data can be compared so that contributions can be made to improve the current study.

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İlköğretim Matematik Öğretmen Adaylarının Uzamsal Yönelim Becerilerinin SOLO Modeli ile İncelemesi

Atıf:

Ozdemir, A. S., & Goktepe Yildiz, S. (2015).The analysis of elementary mathematics preservice teachers' spatial orientation skills with SOLO model. *Eurasian Journal of Educational Research*, 61,217-236. http://dx.doi.org/10.14689/ejer.2015.61.12

Özet

Problem Durumu: SOLO modeli Piaget'in gelişim teorisi üzerine yaptığı çalışmalar ayrıntılı bir şekilde incelenerek geliştirilmiş olup, model öğrencilerin kendilerini bir seviyeye yerleştirmek yerine problemlere verdikleri cevapları bir seviyeye yerleştirmektedir. Ayrıca farklı sınıf seviyelerinde ve farklı disiplinlerde öğrenme çıktılarının gözlemlenen yapılarını belirlemeye yardımcı olmaktadır. Benzer şekilde SOLO taksonomisi matematikte de öğrencilerin belli kavramlarla ilgili anlamalarını ve matematiksel düşünme becerilerini tanımlamak ve yorumlamak için kullanılmaktadır. SOLO modelinde yer alan her bir düşünme evresi beş alt seviyeyi içermektedir. Bunlar yapı öncesi, Tek yönlü Yapı, Çok Yönlü Yapı, İlişkisel yapı ve Genişletilmiş Soyut yapı seviyeleridir. Cevapların karmaşıklığı arttıkça seviye yükselmektedir. Diğer taraftan uzamsal yeteneğin bir bileşeni olan uzamsal yönelim becerisi ise bir cismin görüntüsünü başka bir açıdan zihinde canlandırabilme becerisidir. Literatürde öğretmen adaylarının uzamsal yeteneklerini çeşitli şekillerde inceleyen çalışmalar bulunmaktadır. Bununla birlikte öğretmen adaylarının uzay geometri derslerinde öğrenme-öğretme süreçlerinde başarılı olabilmeleri için gerekli geometrik alt yapılarının ve seviyelerinin ne olduğunu bilmek faydalı olacaktır. Böylelikle öğretmen adayları mesleğe başlamadan önce eksiklerini görme ve tamamlama imkânı bulacaklardır. Bu çalışma da ise diğer çalışmalardan farklı olarak ilköğretim matematik öğretmen adaylarının uzamsal yönelim becerileri SOLO Modeli aracılığıyla incelenmiştir.

Araştırmanın Amacı: Çalışmanın temel amacı ilköğretim matematik öğretmen adaylarının uzamsal yönelim becerilerini SOLO modeline göre incelemektir. Bu amaçla "İlköğretim matematik öğretmen adaylarının uzamsal yönelim becerileri SOLO Taksonomisine göre hangi seviyelerde yer almaktadır?" problemine cevap aranmıştır. Ayrıca öğrencilerin cevaplarının Purdue Uzamsal Görselleştirme Testinde belirlenen seviyelerine göre (düşük-orta-yüksek) hangi SOLO düzeylerinde yer aldığı araştırılmıştır. İlaveten öğretmen adaylarının farklı boyutlar arasındaki (iki boyuttan iki boyuta, iki boyuttan üç boyuta, üç boyuttan iki boyuta, üç boyuttan üç boyuta) sorulara verdikleri cevaplar da SOLO düzeylerine göre sınıflandırılmıştır.

Araştırmanın Yöntemi: İlköğretim matematik öğretmen adaylarının uzamsal yönelim becerilerini inceleyen bu çalışma nitel bir araştırmadır. Seçilen bir konunun derinlemesine ayrıntılı bir şekilde araştırılmasına olanak veren durum çalışması yöntem olarak belirlenmiştir. Çalışmaya bir devlet üniversitesinde ilköğretim

matematik öğretmenliği programının üçüncü sınıfında öğrenim gören öğretmen adayları katılmıştır. Öncelikle seksen bir öğretmen adayına Purdue Uzamsal Görselleştirme (PUGT) testi uygulanmış ve sonrasında bu teste göre üç farklı seviyede seçilen toplam altı öğretmen adayıyla klinik mülakatlar gerçekleştirilmiştir. Klinik mülakatlarda kullanılmak üzere öğrencilerin uzamsal yönelim becerilerini farklı boyutlar arasında ölçen "Geometri Başarı Testi" araştırmacılar tarafından hazırlanmıştır. Öğrencilerin cevapları pilot çalışma sonrasında oluşturulan değerlendirme ölçeğine göre uygun SOLO seviyelerine yerleştirilmiştir. Klinik mülakatlar ile nitel olarak elde edilen verilerin analizinde betimsel analiz yapılmıştır. Geometri Başarı testinde yer alan sekiz soruya altı öğrencinin verdiği toplam kırk sekiz cevap değerlendirilmiştir.

Araştırmanın Bulguları: İlköğretim matematik öğretmen adayları uzamsal yeteneğin bileşenlerinden biri olan uzamsal yönelim becerileri açısından ağırlıklı olarak Çok Yönlü Yapı seviyesindedir. İki boyuttan iki boyuta, iki boyuttan üç boyuta, üç boyuttan iki boyuta ve üç boyuttan üç boyuta uzamsal yönelim becerilerini ölçen sorulara ilköğretim matematik öğretmen adaylarından gelen cevaplar en fazla İlişkisel yapı seviyesinde en az da Tek Yönlü Yapı seviyesinde yer almaktadır. Uzamsal görselleştirme testine göre düşük ve orta seviyede olan öğrencilerin cevapları çoğunlukla Çok Yönlü Yapı seviyesinde iken yüksek seviyedeki öğrencilerin cevapları İlişkisel yapı seviyesindedir. Araştırmadan elde edilen diğer bulgulardan bazıları şunlardır: Uzamsal yönelim becerilerinde Purdue Uzamsal Görselleştirme testine göre yüksek düzeyde yer alan öğrencilerin cevapları iki boyuttan iki boyuta ve iki boyuttan üç boyuta düşünme gerektiren sorularda ilişkisel yapı seviyesindedir. Çalışmaya katılan tüm öğrencilerin üç boyuttan iki boyuta ve üç boyuttan üç boyuta geçişi gerektiren sorulara verdikleri cevaplara bakıldığında ise genel olarak Çok Yönlü Yapı seviyesinde oldukları görülmektedir. İki boyuttan üç boyuta düşünmeyi gerektiren sorulara öğretmen adaylarının verdikleri cevaplar çoğunlukla İlişkisel yapı seviyesinde iken, üç boyuttan üç boyuta düşünmeyi gerektiren sorularda cevapların seviyesi Çok Yönlü Yapı şeklindedir.

Araştırmanın Sonuçları ve Önerileri: İlköğretim matematik öğretmen adayları SOLO taksonomisine göre genel olarak Çok Yönlü Yapı seviyesinde olduklarından, öğretmen adaylarının uzamsal yönelimin ilişkili kavramları açısından sahip oldukları bilgileri tutarlı bir yapı içerisinde birleştirmede başarılı olamadıkları görülmektedir, sadece birbirinden bağımsız durumları ayrı ayrı değerlendirebilmektedirler. Düşük ve orta seviyedeki öğretmen adaylarının cevapları çoğunlukla Çok Yönlü Yapı seviyesinde yer almaktadır dolayısıyla derinlemesine değil daha çok yüzeysel kalan bir öğrenmeye sahiptirler ayrıca öğretmen adayları problemlerin çözümünde birden fazla veriyi kullanmaya çalışmıştır. Elde edilen bulgulara göre sorulardaki üç boyutluluk seviyesi arttıkça öğrencilerin verdikleri cevapların SOLO taksonomisine göre seviyeleri düşmektedir. Farklı çalışmalarda daha çok öğrenci ile ya da daha farklı branşlardaki öğretmen adaylarıyla ya da hizmet içinde yer alan öğretmenlerle çalışılabilir. İleriki çalışmalar için öneri olarak elde edilen veriler farklı bir taksonomi ile değerlendirilebilir ve SOLO taksonomisi ile karşılaştırması yapılabilir. Böylelikle çalışma farklı bir bakış

açısıyla da ele alınmış olur, eksik kalan, gözden kaçırılan yönler varsa eklemeler yapılabilir. Alternatif bir değerlendirme yöntemi kullanmak isteyen araştırmacılar SOLO modelini kullanabilirler.

Anahtar Sözcükler: SOLO taksonomisi, uzamsal yetenek, klinik mülakat