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The Analysis of Spatial Intelligence of the Twelfth Form Students About Space Geometry and Cognitive Delusion

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Abstract

Problem Statement: It is a known fact that many students have difficulty understanding solid subjects in geometry and space geometry which are the basics of many subjects in Mathematics. This shows that there should be more emphasis on the concept teaching. Therefore, in this research Form 12 students' mistakes and concept misconceptions were assessed and recommendations are presented on the matter.

Purpose of Study: The aim of this research is to define how 12th grade students who are preparing for university perceive concepts like space, plane, point, line and dimension. With this objective in mind, it was tried to provide a sample for concept confusion and suggest a solution for concept fallacies.

Significance of the Research: It is considered that developing spatial ability of the students, who are currently at 12th grade and are preparing for university, will support them both in their daily lives and professional environments. The importance and necessity of understanding, grasping and using the relations between concepts of space, plane, point, line and dimension are emphasized. The research tried to define which "concept model" learners have for words like space, plane and dimension. As a result of this study, concept fallacies have also been identified.

Problem sentence of the Research

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What is the level of understanding on the 12th grade students who are preparing for university on space, plane, point, line and dimension; and what are their conceptual fallacies related to these concepts?

Methods: The sample of this research is formed by 38, 12-grade students who are studying in the Science-Turkish/Maths unit at Nicosia Turkish Education College (TMK) during the 2012-2013 Academic Year. Experimental research model is used in this research.

Findings: Findings of this research put forward that teaching organized based on visualization in geometry is effective. When the findings of the study are evaluated as a whole, it was found that 12th form student who are preparing for university could not answer questions on space and plane concepts before the visualization approach as well as their lack of information on the concept of dimension. It was also found that as a result of the visualization approach, there was an increase in the knowledge of students related to the concepts; in addition to the decrease in their misconceptions. The activities based on the visualization approach are qualified to construct concepts of "space, plane, point, line and dimension". This situation has been clearly observed in the difference between the data of the pre-test and the post-test. Significance of the Research

It is considered that developing spatial ability of the students, who are currently at 12th grade and are preparing for university, will support them both in their daily lives and professional environments. The importance and necessity of understanding, grasping and using the relations between concepts of space, plane, point, line and dimension are emphasized. The research tried to define which "concept model" learners have for words like space, plane and dimension. As a result of this study, concept fallacies have also been identified.

Problem sentence of the Research

What is the level of understanding on the 12th grade students who are preparing for university on space, plane, point, line and dimension; and what are their conceptual fallacies related to these concepts?

Conclusion and Recommendations: Findings of this research put forward that teaching organized based on visualization in geometry is effective. Some studies can be done on affective characteristics of 12th form students like attitude and self-efficiancy toward geometry lessons.

Keywords: spatial intelligence, space geometry, misconceptions

Introduction

Visual – spatial ability is a far-reaching ability which can be related to many fields .This ability needs to be used in many occupations and hobbies. Individuals

with developed visual- spatial ability also have the ability to discover the relationships among different science areas. This characteristic explains why someone with this ability can advance in science. To name some ,architecture ,engineering ,sculpture, chess playing ,seamanship ,topology ,forensic medicine ,field of research ,technical drawing ,medicine especially field of surgery ,chemistry and physics .Visual –spatial ability is not single –handedly enough for some hobbies and occupations but helps to succeed .Some problems cannot be defined verbally .In these cases, spatial knowledge is used to think to acquire knowledge and to formulate the problems in different ways. It is crucial to determine this ability at an early age since it is effective in many fields and can enable individuals to use and improve it. It is thought that it is important to investigate the ability in order for students to perceive objects as a whole, to add drawings or to visualize the opened and closed states of objects.

On this account , to acquire the ability of understanding the real world, interpret and ratiocinate, it is inevitable to have the abilities of perception and personification .Although having mental pictures is a top level ability , to be able to draw , or to think differently and to be able to draw can be accepted as highly top –level ability. In this research, it is aimed to determine the concept misconceptions of form 12 students on space geometry subject which is in their syllabus and to be able to find solutions to their acquiring problems. In education, the most important factor for students is the teacher.

It is very important to investigate form 12 students whose visual spatial abilities still develop and they study for university exams. For two reasons first one is there is a positive relationship between positive science branches and success in geometry with spatial ability.

Secondly it is thought that, an individual who is surrounded by three dimensional objects can understand relocation of objects, their reconstruction, grasping activities, with the use of spatial ability better and can find solutions to real life problems in a more effective way. If it is considered as a part of mathematics program in secondary education, to develop spatial abilities of form 12 students, it is important to use educational technologies to support their abilities.

Sjönlinder (2000) accepts spatial ability as; the humans' cognitive functions towards understanding the spatial relations between objects in space; their visual spatial tasks and tendencies (Akt. Kayhan, 2005). French (1951) who tried to define the concept of spatial ability, described it as visualizing, grasping and moving 3-Dimensional objects in mind that are found in space (Akt. McGee, 1979). According to Bannatyne (2003), 80% of most professions like architecture, astronomy, bio-chemistry, biology, chemistry, cartography (mapping), engineering, geology, mathematics, music and physics are dependent on spatial ability rather than verbal skills. Thurstone worked on the cognitive skills and put forward the concept of "Space" (Akt. Kayhan , 2005). Based on the results of the 56 tests that were carried out on 240 people; he defined the spatial ability as visualizing and turning the objects in minds and categorized this as one of the primary cognitive skills (Sternberg, 1990). Olkun and Altun (2003)

discuss two sub components, spatial relations and spatial visualization, of spatial ability:

- Spatial Relations: It is defined as the ability to rotate and recognize 2-Dimensional and 3-Dimensional objects at different positions in the mind.
- Spatial Visualization: It is defined as visualizing the new forms that occur as a result of moving the 2-Dimensional or 3-Dimensional objects.

Teaching Geometry

Many studies on teaching geometry have shown that most students have difficulty in learning geometry (Clements, D. H et all (1992)). Studies also show that there are many reasons behind the students' failure from geometry class. One of these reasons is the false guidance of teachers as they guide students toward memorizing during the process of gathering geometric information and gaining skills (Olkun & Aydoğdu (2003)). The National Council of Teachers of Mathematics (NCTM) on the other hand, explains that geometry is a natural field where students can develop their reasoning and evaluating skills as well as getting help from geometry during problem-solving process. The suggested standards for teaching geometry are as follows:

- Developing mathematical proofs related to solving the features of 2 or 3 dimensional shapes and geometric relations,
- Defining positional relations through coordinate geometry and projection systems,
- Using symmetry by applying rotations in order to solve mathematical situations,
- Using visualization, reasoning and geometric modelling in order to solve problems (NCTM(2000)).

The most well-known studies carried out on the geometry learning theories are by Piaget, Van Hiele, Clements and Battista (Jones (2002)). Battista has explained that one of the most important factors in geometric success and solving geometric problems is "spatial ability"(Battisa(1990)). Piaget and Inhelder (1967) stated that students cannot learn geometry from textbooks in a classroom but they can only learn it through interaction. Van Hiele (1986) states that development of geometric thought in children goes through five stages: visual level, analytical level, informal deduction (inference based on life), formal deduction (inference) and it is the highest level. The levels of the model that developed geometric understanding are given below:

I. Level (Visual Phase): Student handles geometric shapes based on their appearance at this beginner level.

II. Level (Analytical Phase): Student is able to differentiate the features of geometric shapes but cannot relate them to each other. For example, s/he cannot infer that "if two opposite sides are parallel they are also equal".

III. Level (Experimental Inference): Student puts the geometric shapes in order and can group them based on their features.

IV. Level (Logical Inference): It is possible to use definitions like theorem, axiom while proving geometric connection to students.

V. Level (the top level): Student is able to see the relations between two different axiomatic systems, make abstract inferences and is able to understand non-Euclid geometry at the highest level (Olkun&Toluk (2003), Altun(2000).

Battista and others (1982) carried out a study with 82 prospective primary school teachers on spatial ability, cognitive development and the effect of the interaction of those two on learning geometry. As a result of this study, it was suggested that spatial ability is an important factor in learning mathematics. According to the findings of the study, it was concluded that geometry subject develops spatial ability; that spatial visualization and cognitive development are both important factors in learning geometry. Hershkowitz (1989) reported that spatial visualization is required for the formation of geometric concepts (Akt. Bulut ve Köroğlu, 2000). School's duty is to teach the new geometric shapes and their relations by organizing, making them formal and basing this process on the information gathered and skills earned according to their cognitive development levels (Altun, (2005)).

Concept is the abstract and general idea that brings together the common features of objects or events under a common name (Ubuz , 1999).

The first systematic and didactic approach toward the concept of dimension was done by Freudenthal. Freudenthal (1983) stated that the concept of dimension can be handled through plane geometry, analytical geometry-analysis and topology perspectives.

Even though, the concept of dimension has an important place in Mathematical ideas (Manin, 2006, p.139). It is imperative to know concepts like point, line, curve, surface, plane, area, volume, region, width, length, height, depth, thickness as well as the features of geometric shapes in order to explain the concept of dimension. If an object only has length it is 1-dimensional; if it has length and depth it is 2-dimensional; if it has length, depth and height it is 3-dimensional. Linear shapes are 1-dimensional (e.g. line, rectangle, circle, curves, etc.), surfaces are 2-dimensional (e.g. sphere, circle, prisms, planes, polygonal regions, etc.) and solid objects (e.g. spherical region, cylindrical region, etc.) are 3-dimensional.

Learning Enviorment and Materials

Classroom environment is always more appealing and attractive as part of visual factors. When multiple environments are made part of the learning system, the children tend to become active thinkers rather than passive observers.

The activities related to spatial-visual intelligence in classroom environment can be listed as follows: photos, 3-dimensional experiments, painting cards, animations, concept mapping, making patterns, and graphics. In order to ease learning, real life environment, first level rich learning materials and cooperation is required (Ataizi, 2002). Classroom environment should be ignored as a 4-walled close space and should turn into an environment related to state, science and technology (Pat, 2001),

where it is important for students to be active, construct their own knowledge and gain cognitive skills (üven &Karataş (2004)). When mathematical concepts are taught to students who haven't reached the cognitive matureness through verbal expressions and symbols; learners are not able to understand such abstract concepts (Piaget (1952)).

Purpose

As it was aimed to find out the thoughts of students on the concepts of space, plane, point, line and dimension; an achievement test was developed with the help of Ministry of Education's 12th grade geometry course book units on " Space geometry and solid matters".

The following questions were asked to the students during the study;

1. How many dimensions does a point have?
2. How many dimensions does a number line have?
3. How many dimensions does a vertical coordinate plane have?
4. Give an example for the concept of plane.
5. A. Define the concept of space. B. How many dimensions does space have ?
6. Give an example for the concept of space.
7. How many points is a line and a plane made up of?
8. A. Does a plane have limits ? B. Does a line have limits ?

Methods

Research Design

In this research experimental research model is used. One group pre-test design. Pre-test was applied on the group, activator was given and then the final test was applied.

In order to define the thoughts and concept fallacies on space, plane, point, line and dimension, single group pre-test and post-test pattern was used in this research. In this pattern, the impact of experimental process is tested on a single group. The meaning of the difference between the pre-test and the post-test is evaluated (Büyüköztürk, 2012).

Research Sample

The sample of this research is formed by 38 form 12 students who are studying in the Science-Turkish/Maths unit at Nicosia Turkish Education College (TMK) during the 2012-2013 Academic Year. There are 18 high schools and 12 vocational high schools which are appertain to ministry of education in Turkish Republic of Northern Cyprus .Since space geometry is in the syllabus of form 12, form 12 students formed the research group .The research took place in the class which the researcher taught . In this research purposive sampling was used. For the intended purpose of

this study, purposive sampling leads to selecting information-rich cases where deep research is made possible(Büyüköztürk, 2012).

Limitations of the Research

This research is limited with:

1. The 12 weeks of the first semester of the 2012-2013 Academic Year;
2. The "space geometry" and "solid matters" Units of the Geometry subject.

Research Instrument and Procedure

To advance the achievement test ,secondary school geometry teaching program for 12th forms in Academic Year 2012-2013 was investigated through subjects and acquisition fields .The fundamental conceptions of YGS and LYS exam questions were associated .After common subject areas and targeted acquisitions were assessed , 8 open –ended questions were prepared which covered all acquisition levels .When the achievement test was developing , questions which measure knowledge and acquisition were used according to subject headings . As part of the research, the achievement test was implemented as the pre-test in September 2012 before starting the subjects of space geometry and solid matters. The same tool was implemented as the post-test in mid-January after finishing the space geometry and solid matters subjects. These topics were covered by mid-January during 40-minute lessons that were taking place twice a week. The scores of students from the pre-test and the post-test were compared in order to observe the concepts fallacies and the differences between the levels of thinking related to the concepts of space, plane, point, line and dimension.

Teaching-Learning environment that is designed by the approach of visualizing geometry lessons

Mathematical visualization is the process of shaping the images in the mind or with pen and paper or with technological tools; and using these images effectively in order to explore and understand mathematics. Visualization can help abstraction as well as constructing the concepts. It can help students to develop their skills of transforming an abstract concept or a system into a concrete or semi-concrete environment; or oppositely, transforming a concept or a system that is in a concrete or semi-concrete environment into abstract (Konyalıoğlu, 2003).

The PowerPoint presentations and visual materials designed with the approach of visualizing geometry lessons were prepared based on the following steps;

- Classroom environment that is set to enable working together(posters with the summary of the subject and the shapes that were prepared by the teacher were used)
- The technological equipment of the learning environment was provided.
- The power point presentations prepared by the teacher were displayed via the projector.
- Some shapes and pictures were shown to students. Then, students were asked to talk about the dimension of the shapes in the pictures.

- Activities related to forming concepts of space, plane, point, line and dimension were provided in the learning environment.
- The teacher showed shapes related to the concepts of point, number line, plane and space which helped the students to think in different ways and developed their spatial thinking.
- Examples from daily life objects were given and discussed in terms of their dimensions.
- Versatile materials such as work sheets with example questions were also used.
- Situations and shapes from daily life activities were included into the concepts of geometry (point, plane, line, space and dimension) so the students were enabled to express visually.
- The concepts of plane, line and point were taken out from being abstract and became more concrete by implementing the space geometry set.Example questions were displayed through power point that created a deeper interaction environment.
- The prepared presentation was put on the MOODLE system so the learning was taken outside the classroom.

The visual materials used in the research were developed both visually and educationally. While the dimensions of the pictures prepared were discussed the priority was given to make them motivating and interesting. PowerPoint software is used to show the prepared materials. Experts from the fields of mathematics education, computer and learning technologies have been contacted in order to make sure that the prepared animations are both visually and educationally sufficient. After the feedback the necessary changes were made and the materials were ready to use.

Validty and Reliability

This achievement test was presented to mathematics educators who are experts on their fields and two mathematics teachers for evaluation .The scope of validity of the achievement test was secured with the expert opinions . In order to validate the achievement test two experts' and two Mathematics teachers' opinions were gathered. Based on the feedback of the experts, necessary changes were made and the data gathered from the achievement test that included 8 open ended questions were evaluated. The test was finalized after the pilot implementation.

Data Analysis

Descriptive analysis was used to analyze the data collected in this research. The gathered data have tabulated in terms of frequency and percentage. The answers given to open-ended questions were evaluated based on the type of answer given and their frequencies and percentages have been found. It was tried to state the misconception of the students about the concepts of "space, plane, point, line and dimension" according to the findings. The difference between the scores of the pre-test and post-test were interpreted.

Results

1. How many dimensions does a point have?

In Table 1 , Pretest and Post Test Results Related to the Number of Dimension af a Point are given.

Table 1

Pretest and Post Test Results Related to the Number of Dimension af a Point.

Pre-Test Answers Given	*Numbers Of Students*	*Percentage*	*Post - Test Answers Given*	*Numbers Of Students*	*Percentage*
No Dimension	*16*	42%	No Dimension	20	53%
One Dimensional	12	32%	1 Dimensional	10	26%
Two Dimensional	1	3%	2 Dimensional	2	5%
Three Dimensional	2	5%	3 Dimensional	3	8%
Four Dimensional	1	3%	Infinite	1	3%
Infinite Dimensional	4	11%			
Multi Dimensional	1	3%			
No Response	1	3%			

According to Table 1 Analyzing the Pre-Test results: In the first question of the achievement test the students were asked to tell how many dimensions does a point have. 42% of the students answered the question correctly but saying that it has no dimension. 58% of the students gave a wrong answer when deciding the dimensions of a point. 32% of the students may have thought that it has one dimension as they see the pattern left on the paper by writing a point. The results of the assessment of the Post-test in Table 1: As a result of the teaching method implemented with visualization 53% of the students answered the questions correctly. The percentage of students who has given the correct answer was 42% in the pre-test; whereas, this percentage showed an increase in the Post-test. Yet, 26% of the students still answered the questions as a point is one dimensional. In Table 2 , Pre and Post Test results related to the number of the dimension of a number line are given.

Table 2

Pre and Post Test Results Related to the Number of the Dimension of a Number Line.

Pre- Test Answers Given	**Numbers Of Students**	**Percentage**	**Post- Test Answers Given**	**Numbers Of Students**	**Percentage**
No Dimension	*1*	3%	No Dimension	1	3%
One Dimensional	25	66%	1 Dimensional	23	61%
Two Dimensional	9	24%	2 Dimensional	13	34%
Three Dimensional	1	3%	-	-	-
Four Dimensional	1	3%	-	-	-
No Response	1	3%	No Response	1	3%

Acoording to Table 2 , In the second of the achievement test, students were asked about the dimensions of a number line. 66% of the students gave the correct answer by saying that it is one dimensional. It can be said that students thought it is two dimensional due to its movements from both left and right sides. Student may have thought that number line is two dimensional after working with the concepts of point, number line and plane. The results of the assessment of the Post-test in Table 2 :61% of the students answered that a number line is one dimensional correctly. The decrease in percentage of the correct answers in the post-test can be related to the lack of revision and that some information may be lost over the course of time.

In Table 3 , Pre and Post- Test results related to the dimensions of a vertical coordinate plane are given.

Table 3

Pre and Post- Test Results Related to the Dimensions of a Vertical Coordinate Plane.

Pre-Test Answers Given	*Numbers Of Students*	*Percentage*	*Post -Test Answers Given*	*Numbers Of Students*	*Percentage*
One Dimensional	7	18%	1 Dimensional	3	8%
Two Dimensional	23	61%	2 Dimensional	27	71%
Three Dimensional	2	5%	3 Dimensional	7	18%
Four Dimensional	3	8%	Infinite	1	3%

According to the findings in Table 3, only 61% gave the correct answer related to the dimensions of a vertical coordinate plane. Post-test results showed an increase at 71% after the visualization approach and some improvements were also observed. Even though, there was an increase in the percentage of correct answer; it was found that 29% of the students could not provide the correct answer.

In Table 4 , Pretest and Post Test Results related to the examples fort the concept of plane are given.

Table 4

Pretest and Post Test Results Related to the Examples fort the Concept Of Plane.

Pre-Test Answers Given	*Numbers Of Students*	*Percentage*	*Post - Test Answers Given*	*Numbers Of Students*	*Percentage*
Analytical plane	5	13%	Paper	7	18%
Table	11	29%	Table	8	21%
Paper	4	10%	Blackboard	4	10%
Vertical Coordinate Plane	3	8%	Base we tpuch with our feet	1	3%
Line	1	3%	Shadow	1	3 %
Wall	3	8%	No Response	3	8%
Mirror	2	5%	Page	5	13%
Road	1	3%	Two lines at R^2 form a plane	1	3%
Inclined plan	1	3%	Non- Linear three points give a plane	1	3%
Blackboard	4	10%	A line and a point outside	2	5%
No Answer	7	18%			
Square	1	3%	A line and a point outside	1	3%
			Wall	1	3%
			X-Plane	1	3%
			Stool	1	3%

The results of the assessment of the Post-test in Table 4 : Use of missing words has been observed in the students' answers. For example, they could have used surface of a table, surface of a square, surface of a wall instead of table, square, wall, mirror or road. 24% of the students gave words with the word plane in them as example and considered them as examples such as analytical plane, inclined plane, vertical coordinate plane. The reason behind this can be that the word plane is covered within the topic of analytical plane. The results of the pre-test showed that students are not able to form the concept of "plane". It can be said that students are unsuccessful in giving examples for the concept of plane. Poat test results , An increase in the knowledge of students related to the concept of plane and improvements have been observed after the visualization approach. Answers given to the 4th question represent better information on the subject and 34% of the students gave correct answers. 34% of the students formed correct relations between the concept of plane and daily life examples. 13% of the students who answered wrong, provided features for forming a plane; and 26% of them gave answers like table, wall, and road without thinking of the word "surface". As a result of this, the existence of misconceptions can be discussed. Students still showed some insufficiencies while giving examples for the concept of plane. In Table 5 , Pre and Post Test results related to the definition of space are given.

Table 5

Pre and Post Test Results Related to the Definition of Space.

Pre-Test What is Space	*Numbers Of Students*	*Percentage*	*Post - Test What is space*	*Numbers Of Students*	*Percentage*
Infinite Emptiness	9	24%	Emptiness	11	29%
A different World	1	3%	Infinite Emptiness	7	18%
Environment with no gravity	2	5%	Are we cover volume	1	3%
I don't know	2	5%	R^3	1	3%
Emptiness	11	29%	Set of infinite points	1	3%
No response	11	29%	Combination of infinite planet hat covers the area we live in	1	3%
Place where we live	1	3%	Infinity	3	8%
Set of three dimensional points	1	3%			
Two deviant lines	1	3%			
A plane and a point outside	1	3%	No response	9	24%
Thing with no specific area	1	3%			

The results of the assessment in Table 5, 29% of the students had no comments on the concept of space; it can be seen that 53% of the students used the term emptiness to describe the concept of space. Students considered the concept of space as a different world, place or area we live rather than emptiness where objects exist. According to this, it can be said that students have delusions in their thinking of the concept of space. According to table 5, 11% of the students considered that conditions for space as its definitions; they tried to give examples by listing the features. Student may have had confusions between the concept of space in Science and the 3-dimensional concept of space in geometry. They also gave 2 or 3 Dimensional examples for space. This shows confusion between space and concept of dimension. Students' insufficiencies were observed about giving examples for the concept of space. As a result of the visualization approach students were observed to produce more correct ideas.

Pre-test results related to the dimensions of space : Infinite dimensional 16%, Multi-dimensional 5% , Three Dimensional 24% , Four dimensional 3%, No Dimension 11% , No Response 42% Pre-test results showed that 42% of the students could not give answers about the dimensions of space. 24% of the students answered it

correctly by saying that space is 3-dimensional. It was found that 76% of the students could not form the concept of "space" and its dimensions. According to Post-test results related to the dimensions of space There has been a significant different between the percentages of the pre-test and the post-test after the implementation of the visualization approach. 87% of the students gave the correct answer for the dimensions of space. The answers given for the dimensions of space in the post-test showed that students have more knowledge on the subject and the percentage of correct answers went from 24% to 87%.

Students tried to give examples by listing the features. They also gave 2 or 3 Dimensional examples for space. 90% of the students were not able to give examples for the concept of space.

According to Post-test results related to this question: How many points is a line and a plane made up of? 42% of the students correctly answered that line and plane is made up of infinite number of points. The reduced percentage in the results of the post-test can be a result of the confusion between the concept of infinity with features of space and plane. Additionally, some wrong comments have also been made. In Table 6 , Pre and Post Test results related to questions " Is Plane Limited? / Is Line Limited? " are given .

Table 6

Pre and Post Test Results Related to Questions: Is Plane Limited? / Is Line Limited?

Pre-Test Answers Given	Numbers Of Students	Percentage	Post - Test Answers Given	Numbers Of Students	Percentage
Plane is unlimited	27	71%	It is limited	2	5%
Plane is limited	9	24%	It is not limited	35	92%
Left Blank	2	5%	Left Blank	1	3%
Line is	31	82%	It is limited	9	24%
unlimited	6	16%	It has no limits	28	74%
Line is limited					
Left Blank	1	3%	Left blank	1	3%

As are result of the visualization approach students showed improvement and 92% gave correct answer in the post-test. As are result of the visualization approach students showed improvement. In Table 7 , Pre-Test and Post-Test answers of the achievement Test are given.

Table 7

Pre-Test and Post-Test Answers of the Achievement Test

	N	*M*	*df*	*t*	*p*
Pre Test	*38*	*39,86*	*17,456000*	*-2,577*	*.012*
Post Test	*38*	*49,0789*	*13,44937*		

The t-test results applied for interpretation of the variation between the descriptive statistics and average scores are shown in Table 7. As it can be seen from Table 7, the sampling average scores from the pre-test on point, line, plane and space, implemented before the approach is *M*= 39,86; and the average post-test score after the implementation is *M*=49,07. Based on the findings, there is a significant positive difference in the results of the post-test. The "t" value of the t-test has been found meaningful. [t = -2,577; (p<.05)]. When the pre-test and the post-test results are compared it is possible to say that the visualization approach is effective.

Discussion and Conclusion

Konyalıoğlu (2003), emphasizes that visualization approach can affect students' audial and cognitive ability development in a positive way and this approach should be used starting the first step of primary education in lessons. It was also pointed out that the studies on visualization approach lightens the learned helplessness, showed that when activities including visual materials are used in lessons, they affect students' abstract thinking skills and audial characteristics in a positive way (Koğ and Başer, 2011)

According to some studies, soft wares used in mathematics and geometry lessons (Geogebra, Cabri, 3D Geometers, Sketchpad…) help to visualize geometric objects and abstract concepts. In lessons which these soft wares are used students are more successful. (Taş, 2010; Demir, 2011). Ferla, Olkun, Akkurt , Alibeyoğlu and Gonulates' (2009) study researches the effect of computer manipulative on students' spatial thinking skills. According to the results of this study, it was found out that virtual environments can be a good tool to develop students' spatial skills. According to Kaufmann and his friends (2005) active use of virtual environment technologies in geometry education contribute the development of students' spatial visualization and mental switching abilities. Likewise, Rafi and his friends (2006) also came to a conclusion that to develop spatial visualization and mental switching the use of drawing simulations can be advantageous.

Clements (1998) said that spatial orientation and visualization are important components of spatial sense. Little children can improve their spatial visualization abilities by studying on drawing 2D and 3D objects and by switching them. Ö.D

Temur and N. Tertemiz (2012) stated in their research that when teachers teach geometry subjects , they use links to real life activities, and these activities not only help students to understand geometry subjects but also improve their geometric thinking. Because of this, when teachers teach geometry, they should show more importance to create links to real life and comparative activities.

Turgut, M., Cantürk-Günhan ve Yılmaz, S. (2009) found out in their study that spatial ability of elementary school grade 7-8 students' are very low. In Turgut and Yenilmez's (2012) study reported that fourth grade mathematics teacher candidates' spatial visualization level is very low. Also added that gender , pre-school education, academic success and the faculty they study at do not make any difference. Kosa (2008) said that fields like architecture and engineering have got a relationship with spatial ability like additional computer graphics in their research on high school students on spatial visualization ability, manipulative use in geometry lessons, investigating 3D geometry understanding levels.

Greenfield (1993) stated that skills in spatial representations are an example to cognitive abilities and he also emphasized that these skills can be developed through computer games and computer applications. Avşar (2002) found out that when concepts (Dot, Line, Plane, Space, and Line Segments) which are related to unscaled geometry subjects are taught by fictionalizing, they are more appealing to students and more effective for students to understand. On the other hand, there are researches in the literature which showed no parallelism to this research data . For example, Eraso(2007) could not get any positive feedback when he used Sketchpad Virtual Environment to improve 10 grade students' spatial visualization skills. Küçük, A. &Demir, B (2009)'s research found out that Dots and Line concepts are known as Undefined concepts in Mathematics. Although one of these concepts can be defined, when continuing to define, undefined concept might be reached, it can be found intuitively or by judgment.

- The study should also be applied to the same students in their further education with different technological teaching methods and the difference between these students and the others should be investigated to find out the effect of their visual-spatial abilities.
- This study can also be done to different age groups and a wider sampling can be done.
- It is hoped to use different scales to be able to compare results.
- Students' having knowledge can be explained as the need of starting teaching these concepts at an earlier age.
- Students can be given the opportunity of finding their own mistakes by giving them the opportunity to discuss the subject in different measures in their own words.

According to the results of the research, using both concrete objects and visuals can affect the development of spatial abilities. This research showed a great differ-

ence between pre-test and post-test results. This is a result of using visual education and three dimensional objects in the classroom environment. The use technology in classroom in space geometry lessons which have wide variety of abstract concepts (Prism, Cylinder, Cone, Sphere, Pyramid…) enables students to visualize three dimensional objects better than using colorful chalks in two dimensions on the blackboard and also enables to go back and forth through objects. The role of the teacher in the research is to help students visualize the concepts and to prepare the best classroom environment for learning. The use of concrete objects in the teaching-learning phase not only make students think, discuss geometric concepts and investigate but also create a better learning environment which they can exchange ideas through visual activities and as a result, all of these help students to develop their creative thinking skills. According to pre-test results of the study, it was clear that the students had difficulties understanding even geometric terms of space in conceptual. These conceptions of students are resistant to be changed or positive development because they are themselves are accepted as a whole and affected by life experiences. This condition also has a negative effect because students have a misunderstanding of the concept and its correlates. Because of this reason, students have more difficulties in space and plane concepts. Asking open-ended questions in the tests which aims to find the reasons and processes rather than conclusive questions help to find the reasons under misconceptions concepts.

This research aimed to designate misconceptions of concepts of Form 12 students and to eliminate them so when students go to university or start their professional lives, it will help them to understand or be able to teach geometry lessons in university or in their professions in a more effective way. This research is important not only because it is the first and only one in TRNC but also it can be exemplary for further researches.

According to the data received during the research, students should be helped to renovate and assimilate space and plane subjects through scientific approaches and models. In addition, wider range of comparative studies is needed which investigate imaginary environment and concrete objects to see the effects on spatial ability. Point, line, plane, and space concepts which are named as undefined concepts of geometry can be gained at earlier ages intuitively.

References

Altun, M.(2000). *Matematik öğretimi*. Alfa Yayıncılık , Bursa. [Teaching Mathematics. Alfa Publishing].

Altun, M. (2005). *Matematik öğretimi*, İstanbul: Aktüel Yayıncılık. [Teaching Mathematics, Aktüel Publishing]

Ataizi, M., & Küçük,M. (2002). Çevrimiçi Yapıcı öğrenme çevreleri. *Açık ve Uzaktan Eğitim Sempozyumu:* Eğitim İletişimi ve Teknolojisinde Yeni Ufuklar; Eskişehir, Türkiye; Mayıs 23-25 .[Online Constructive Learning Environments. Open and Distance Education Symposium]

Avşar , O (2002) . Eğitimde yeni yaklaşımlar , *V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi* ,Odtü . [New Approaches in Education, V. International Science and Technology and Mathematics Education Congress, METU]

Bannatyne, A. (2003). *Multiple intelligences.* Bannatyne reading, writing, spellingand language program. Post graduate thesis on the effects of using virtual environment and concre-te materials on the spatial visualization and cognitive spinning skills.

Battista, M. T., Wheatley, G. H., & Talsma, G. (1982). The impor-tance of spatial Visualization and cognitive development for geometry learning in pre-service Elementary teachers. *Journal for Research in Mathematics Education*, 13(5), 332-340.

Battista, M.T. (1990). Spatial visualization and gender differences in high school geometry, *Journal for Research in Mathematics Education*, 21 (3), 47-60

Büyüköztürk,Ş. ,Çakmak ,E., Akgün ,Ö.,Karadeniz , &, Ş.Demirel, F. (2012). *Bilimsel araştırma yöntemleri* , 11.baskı.Pegem Akademi.Ankara.

Bulut, S.,& Köroğlu, S., (2000). On Birinci Sınıf Öğrencilerinin Ve Matematik Öğretmen Adaylarının Uzaysal Yeteneklerinin incelenmesi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi* ,18, 56-61.[Eleventh Grade Students And Teachers of Mathematics spatial skills]

Clements, D. H., & Battista, M. T.(1992). *Geometry and spatial reasoning*. In Handbook of research on mathematics teaching and learning, edited by D. A. Grouws pp. 420-464. New York: Macmillan Publishing Company.

Clements, Douglas H. (1998). *Geometric and Spatial Thinking in Young Children.* (ERIC Servis No. ED436232)

Demir, V. (2011). *Cabri 3D Dinamik geometri yazılımının geometrik düşünme ve akademik başarı üzerine etkisi,* Yayımlanmamış Yüksek Lisans Tezi, Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul. [The effect of Cabri 3D Dynamic Geometry Software on Geometric Thinking and Academic Success, Unpublished Graduation Thesis, Marmara University Educational Science and Tecknology Institute Unpublished master thesis].

Eraso, M. (2007). *Connecting visual and analytic reasoning to imp-rove students' spatial visualization abilities: A constructivist approach*. Unpublished doctoral dissertation, Florida International University, Miami, Florida.

Freudenthal, H. (1983). *Didactical phenomenology of mathematical structures* .(Dordrecht, The Netherlands: Reidel).

Ferla, V. V., Olkun, S., Akkurt, Z., Alibeyoğlu, M. C., & Gonulates, F. O. (2009). An international comparison of the effect of using computer manipülatives on middle grades students' understanding of three-dimensional buildings. *In Proceeding of The 9. International Conference on Technology in Mathematics Teaching* (pp. 1-5). Metz France: ICMT 9.

Greenfield, P. M. (1993) *Representational competence in shared symbol systems: Electronic media from radio to video games*. In R. R. Cocking& K. A. Renninberg (Eds.), The development and meaning of psychological distance (pp. 161-183). Hillsdale, NJ: Lawrance Erlbaum Associates.

Güven, B., & Karataş, İ.(2004) . İlköğretim matematik öğretmen adaylarının sınıf ortamı tasarımı, *İlköğretim-Online*, 3 ,25-34.

Jones, K. (2002). *Issues in the teaching and learning geometry*. In L. Haggarty (Ed.) Aspects of Teaching Secondary Mathematics: Perspectives on Practice (pp.121-139). London: Routledge Falmer.

Kaufmann, H., Steinbügl, K., Dünser, A., & Glück, J. (2005). *Improving spatial abilities by geometry education in augmented reality-application and evaluation design.* In Proceedings of the Virtual Reality International Conference (VRIC) (pp. 25-34). Laval, France.

Kayhan, E.B. (2005). *Lise Öğrencilerinin uzamsal yeteneklerinin incelenmesi* . Yayımlanmamış Yüksek Lisans Tezi ODTÜ Fen Bilimleri Enstitüsü.).[Investigation of High School Students' Spatial Ability Unpublished Graduation Thesis METU.]

Konyalıoğlu, A.C. (2003). *Üniversite düzeyindeki vektör uzayları konusundaki kavramların anlaşılmasında görselleme yaklaşımının etkinliğinin incelenmesi*. Yayımlanmamış Doktora Tezi, Atatürk Üni-versitesi Fen Bilimleri Enstitüsü, Erzurum. [Evaluating the effectiveness of Visualization Approach in Understanding the Concepts on Vector Spaces at University Level, UnPublished PhD Thesis, Atatürk University, Sciences Institute].

Koğ, O.U. & Başer N. (2011). Görselleştirme yaklaşımının matematikte öğrenilmiş çaresizliğe ve soyut düşünmeye etkisi (Elektronik versiyon*). Batı Anadolu Eğitim Bilimleri Dergisi*, 1(3), 89-108. [The effect of Visualization approach on Learned Helplessness and Abstract Thinking. (Electronic Version) West Anatolia Educational Sciences Magazine, 1(3) 89-108.]

Kösa, T, (2008). *The effects of virtual and physical manupilatives on students' spatial visualisation skills.*

Küçük ,A., & Demir,B.(2009).İlköğretim 6–8. sınıflarda matematik öğretiminde karşılaşılan bazı kavram yanılgıları üzerine bir çalışma. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi*, 13 , 97-112 .) .[A Study on Some Misperceived Concepts in the Teaching of Mathematics in 6th-8th Grades.Dicle University]

Manin, Y. I. (2006). *The notion of Dimension in geometry and algebra*. Bull. Amer. Math.Soc. (N.S.), 43 (2), 139–161.

McGee, M. G. (1979). *Human spatial abilities: Sources of sex differences*. New York: Praeger Publishers.

National Council of Teachers of Mathematics(2000). *Principles and standarts for school mathematics.* Reston, Va.: National Council of Teachers of Mathematics.

Olkun, S., & Aydoğdu, T. (2003). Third international science and mathematics research, what is tımms and what does it question? Sample geometry questions and activities. *Primary-Online*, 2 (1), 28-35.

Olkun, S. , & Toluk Z.(2003). *Activity-based Mathematics Teaching in Primary Education*, Anı Publishing, Ankara.

Olkun, S., & Altun, A. (2003) .İlköğretim öğrencilerinin bilgisayar deneyimleri ile uzamsal düşünme ve geometri başarıları arasındaki ilişki. *The Turkish Online Journal of Educational Technology,* 2(4), 1-7.).[Elementary school students experience success with the relationship between geometry and spatial thinking].

Pat, H(2001). The changing role of the teacher, *THE Journal*, November 2001, Vol.26.

Piaget, J., & Inhelder, B. (1967). *In The child's conception of space*. The Coordination of Perspectives. New York: Norton ve Co.

Piaget, J.(1952). *The child's conception of number*. Humanities press, New York.

Rafi, A., Samsudin, K. A., & Ismail, A. (2006). *On improving spatial ability though computer-mediated engineering drawing instruction*. Educational Technology & Society, 9 (3), 149-159.

Sternberg, R. J. (1990). *Metaphors of mind: Conceptions of the nature of intelligence*. USA: Cambridge Univ. Press.

Taş, M. (2010). *Dinamik matematik yazılımı geogebra ile eğrisel integrallerin çözümlenmesi, Y*ayımlanmamış Yüksek Lisans Tezi, İstanbul Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul.[Analysis of Bendable Integrals using Dynamic Mathematics Software Geogebra, Unpublished Graduation Thesis, Istanbul University Science and Technology Institute]

Temur , Ö.D, & Tertemiz ,N.(2012) . *İlköğretim birinci kademe öğretmenlerinin geometri öğretimine ilişkin sınıf içi uygulamalarının van Hiele seviyelerine göre irdelenmesi*. DPUJSS, 32, 255-274 [The Investigation of Van Hiele Levels of Primary School First Rank Teachers on Geometry Teaching of Classroom Applications. DPUJSS NUMBER 32, VOL. II, APRIL]

Turgut, M., Cantürk-Günhan &Yılmaz, S. (2009). Uzamsal yetenek hakkında bir bilgi seviyesi incelemesi, *EJournal of New World Sciences Academy*, 4 (2), 317-326.

Turgut ,M. , & Yenilmez, K.(2012). Matematik öğretmeni adaylarının uzamsal görselleştirme becerileri. *Eğitim ve Öğretim Araştırmaları Dergisi* Mayıs, Haziran, Temmuz 2012 Cilt 1 Sayı 2 ISNN: 2146- 9199.).[The Spatial Visualization Skills of Mathematics Teacher Candidates. Education and Teaching Researches Journal, May, June, July 2012 Volume 1 Number 2. ISNN:2146-9199]

Ubuz, B. (1999). 10. ve 11. sınıf öğrencilerinin temel geometri konularındaki hataları ve kavram yanılgıları. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi,* 16-17, 95-104. [Mistakes and misconceptions of 10th and 11th form students on basic geometry topics. Ankara: Hacettepe University Journal of Education Faculty 16(17); 95-104.]

Van Hiele, P. M (1986). *Structure and insight: A theory of mathematics education.* Academic Pres,Inc. Orlando, Florida.

12. Sınıf Öğrencilerinin Uzay Geometri Konusundaki Uzamsal Yeteneklerinin İncelenmesi ve Kavram Yanılgıları

Atıf:

Özerem, A. (2013). The analyis of spatial intelligence of the twelfth form students about space geometry and cognitive delusion. *Egitim Arastirmalari-Eurasian Journal of Educational Research*, 53/A, 275-296.

Özet

Problem Durumu : Uzay ve düzlem gibi geometrik kavramların soyut olması birçok öğrencinin geometri dersinin zor olduğunu düşünmesine, bu nedenle de geometriden soğumasına sebep olabilir. Özellikle öğrencilerin somutlaştırmakta zorluk çektikleri konuların görselleştirme yaklaşımı ile sunulmasının anlamayı kolaylaştırabileceği, bilgiyi daha kalıcı hale getirebileceği ve geometrik kavramları öğrenme için son derece önemli olduğu düşünülmektedir. 12.sınıfta okuyan ve üniversiteye hazırlanan öğrencilerin ilerki meslek yaşamlarında kullanacakları uzamsal yeteneğin geliştirilmesinin günlük hayatta ve mesleki yaşamlarında onlara destek sağlayacağı düşünülmektedir. Uzay ,düzlem, nokta , doğru ve boyut kavramlarının ilişkilerini anlamayı, kavramayı ve kullanmasının geliştirilmesi gereklidir. Bu araştırmada 12.sınıf üniversiteye hazırlanan öğrencilerin uzay ,düzlem, nokta , doğru ve boyut kavramlarını algılayışlarının düzeyini ve bu kavramlara ilişkin kavram yanılgılarının neler olduğunu incelemeyi hedeflemektedir.

Araştırmanın Amacı: Bu çalışmanın amacı 12.sınıfta okuyan ve üniversiteye hazırlanan öğrencilerin uzay ,düzlem, nokta , doğru ve boyut kavramlarını algılayışlarını belirlemektir. Bu amaçla , üniversiteye hazırlanan lise son sınıf öğrencilerinin uzay ,düzlem, nokta , doğru ve boyut kavramları hakkında yaşadıkları kavram kargaşası için bir örnek sunmak ve kavram yanılgılarının çözümünü belirlemeye çalışılmıştır.

Araştırmanın Yöntemi : Bu araştırmada deneysel araştırma modeli kullanılmıştır. Araştırmada öğrencilerin uzay , düzlem, nokta , doğru ve boyut kavramları hakkındaki düşüncelerini ve kavram yanılgılarını belirlemek için tek grup öntest- sontest desen kullanılmıştır.

Öğrencilerin uzay , düzlem, nokta , doğru ve boyut kavramlarındaki düşüncelerini öğrenmek amaçlandığından " Uzay geometri ve Katı cisimler" üniteleri ile ilgili, MEB 12.sınıf geometri ders kitabındaki kavramlardan yararlanarak bir başarı testi geliştirilmiştir. Başarı testinin kapsam geçerliliği için 2 uzman ve 2 matematik öğretmeninden görüş alınmıştır. Uzman görüşleri doğrultusunda gerekli düzenlemeler yapılmış ve 8 açık uçlu sorudan oluşan bir başarı testi hazırlanmış sonuçlardan elde edilen veriler değerlendirilmiştir. Testin pilot uygulaması yapılarak son şekli verilmiştir. Araştırmada öğrencilere yöneltilen sorular şu şekildedir

- Nokta kaç boyutludur ?
- Sayı doğrusu kaç boyutludur ?
- Dik koordinat düzlemi kaç boyutludur?
- Düzlem kavramına örnek veriniz.
- A) uzay kavramını açıklayınız?

- B) uzay kaç boyutludur ?
- Uzay kavramına örnek veriniz .
- Doğru ve düzlem kaç noktadan meydana gelir ?
- A) Düzlem sınırlı mıdır ?
- B) doğru sınırlı mıdır ?

Araştırma kapsamında , Eylül 2012 'de Uzay Geometri ve Katı Cisimler konusuna başlanmadan önce hazırlanan başarı testi ön-test olarak uygulanmıştır. Aynı ölçme aracı son-test olarak Ocak ayı ortasında Uzay geometri ve Katı cisimler konusundan sonra tekrardan uygulanmıştır. Haftada 2, 40 dakikalık olarak işlenen ders konuları ocak ayı ortasına kadar işlenmiştir. Araştırmanın sonucunda öğrencilerin ön-test ve son-test puanları karşılaştırılarak öğrencilerin sahip oldukları kavram yanılgıları ve uzay , düzlem, nokta , doğru ve boyut kavramları ile ilgili düşünme seviyeleri arasındaki farka bakılmıştır. Geometri derslerinde görselleştirme yaklaşımı ile öğrenme-öğretme ortamı tasarlanmıştır. Hazırlanan bu etkinlikler geometri öğrenme alanının "uzay,düzlem,doğru,nokta ve boyut " alt öğrenme alanındaki; kazanımlarına yönelik olarak; geometri programının öğrencilerden kazanmasını hedeflediği bilgi teknolojilerini kullanma, yaratıcı düşünme, problem çözme, karar verme ve ilişkilendirme becerilerini kazandırmak amacıyla hazırlanmıştır. Hazırlanan materyalleri yürütmek üzere ise Power Point programı kullanılmıştır.

Araştırmanın Bulguları :Araştırmada geometri öğretiminde görselleştirme yaklaşımı ile ders anlatımından sonra ;

1. Öğrencilerin % 53 ü noktanın boyutsuz olduğunu doğru yanıtlamıştır.
2. Sayı doğrusunun 1 boyutlu olduğunu öğrencilerin %61 !i doğru yanıtlamıştır.
3. Öğrencilerin %71 'i dik koordinat düzleminin bir boyutlu olduğunu doğru yanıtlamıştır.
4. Öğrencilerin %34 'ü düzlem kavramını günlük hayattaki örneklerle doğru şekilde ilişkilendirmiştir. Düzlem kavramına örnek verirken kavram yanılgılarının olduğu söylenebilir. Ayrıca düzlem kavramını yapılandıramadıkları tespit edilmiştir.
5. Öğrencilerin büyük çoğunluğu uzay kavramını yapılandıramadığından dolayı açıklayamamışlar ve günlük hayatla doğru şekilde ilişkilendirememişlerdir.Uzayın boyutuna öğrencilerin % 87 'i doğru yanıt vermiştir.
6. Doğru ve düzlemin sonsuz noktadan meydana geldiğini öğrencilerin % 42 'i doğru yanıtlamıştır.
7. Doğrunun sınırsız olduğunu söyleyerek öğrencilerin %92 'i doğru sonuca ulaşmıştır.
8. Öğrencilerin %74 'ü düzlemin sınırsız olduğunu doğru yanıtlamıştır.
9. Öntest ve sontest puanları karşılaştırıldığında görselleştirme yaklaşımı ile yapılan öğretimin etkili olduğu söylenebilir.

Araştırmanın Sonuç ve Önerileri:

Araştırmadan elde edilen bulgular bir arada değerlendirilerek yorumlandığında 12. Sınıf üniversiteye hazırlanan öğrencilerin görselleştirme yaklaşımı öncesinde uzay ve düzlem kavramına ilişkin sorulan soruları öğrencilerin önemli bir bölümünün cevaplayamadığı boyut kavramına ilişkin bilgilerinde eksiklikler olduğu tespit edilmiştir. Görselleştirme yaklaşımı sonucunda ise öğrencilerin ilişkin bilgilerinde

olumlu yönde artış olduğu ,ayrıca öğrencilerin sahip oldukları yanılgıların daha azaldığı tespit edilmiştir. Görselleştirme yaklaşımı ile yapılan etkinlikler " uzay , düzlem, nokta , doğru ve boyut" kavramlarının oluşmasını sağlayacak niteliktedir. Bu durum öntest ve sontest verileri arasındaki farkta açıkça gözlemlenmiştir. Uzay kavramına örnek verirken boyut kavramının karıştırıldığı söylenebilir. Öğrencilerin uzay kavramlarına örnek verirken halen eksikliklerinin olduğu tespit edilmiştir. Görselleştirme yaklaşımı yapılmasının ardından öğrencilerin düzlem kavramına ilişkin bilgilerinde artış olduğu ve gelişim gösterdikleri tespit edilmiştir. Öğrencilerin düzlem kavramına örnek verirken halen eksikliklerinin olduğu tespit edilmiştir. Elde edilen sonuca göre , ön ve son testten aldıkları puanların ortalamaları arasında son test lehine anlamlı fark bulunmaktadır. Öntest ve sontest puanları karşılaştırıldığında görselleştirme yaklaşımı ile yapılan öğretim yönteminin etkili olduğu söylenebilir

Üniversiteye hazırlanan gençlerde yaratıcı düşüncenin gelişimini öngören ve uzay gibi soyut kavramların öğretimi için özel sınıf ortamları oluşturulabilir. Öğrencilerden kendi katı cisimlerini oluşturmaları ve özelliklerini incelemeleri istenilebilir. Bunun sonucunda öğrencilerin tartışmaları , düşünmeleri ve tanımlama yapmaları sağlanabilir.

Öğretmenlere yönelik öneriler:

Öğretmenler, öğrencilerdeki kavram yanılgılarını düzeltmeye kalkışmadan önce onların zihnindeki yanlış kavramlarla yüzleşmelerini sağlayabilir.Bu bir süreci gerektirir, bu süreçte öğretmenler tarafından yapılması önerilenler:

• Öğrencilerin kavram yanılgıları tespit edilebilir.

• Öğrenciler arasında bir tartışma ortamı yaratılarak sahip oldukları kavram yanılgıları ile yüzleşmeleri sağlanabilir.

• Bilimsel yaklaşım ve modellerle öğrencilere bilgilerin yeniden yapılandırılması ve özümsenmesi için yardımcı olunabilir.

Anahtar sözcükler: uzamsal yetenek, uzay geometri, kavram yanılgısı