

The Effect of the Van Hiele Model Based Instruction on the Creative Thinking Levels of 6th Grade Primary School Students

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Abstract

The aim of this study is to determine the effect of the Van Hiele model based instruction process on the creative thinking levels of 6th grade primary school students. Pre test-post test matching control group quasi-experimental design was used in the study. Fifty five students enrolled in sixth grades during the 2005-2006 educational year formed the sample. The study was carried out with two groups. One of these groups was determined as the experimental group and the other was as the control group. While a teaching based on the Van Hiele model was carried out in the experimental group, a teaching with the traditional method was carried out in the control group. The instruction was carried out by the researchers in both groups. In the study, the Shapes Section of the Torrance Creative Thinking Test was administered in order to determine the creative thinking levels of students before and after the teaching. In order to determine whether there is a significant difference between the creative thinking levels of the experimental and control groups before and after the instruction, *t*-test was used. At the end of the study, although there is a significant difference between the creative thinking test, fluency, originality, the titles' being abstract, creative forces lists, and creativity pre test and post test scores of the students in the experimental group, a significant difference between the pre test and post scores of students in the control group related to the sub-dimensions of creativity thinking and total scores was not observed. When the creative thinking levels of the students after the instruction was examined, a significant difference was found in total post test scores related to fluency, originality, the titles' being abstract, creative forces lists and creativity in advantage of the experimental group.

Key Words

Geometry, Van Hiele Model, Creative Thinking.

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Geometry is an important component of mathematics and is required for students to better understand some facts about the world they are living in. Geometrical thinking is related not only to mathematics courses but also to all courses; and it has an important role in the development of many cognitive characteristics of students. Geometry helps students gain basic skills such as analysis, comparison, and generalization and cognitive skills such as investigation, researching, criticizing, creative thinking, illustrating what they learn, being tidy, careful and patient, and self-expression (Baykul, 1999; Kılıç, 2003). Geometry is a natural field in which students can develop their implication and judgment skills proving geometrical theories. Moreover, as shapes and objects are available in the structure of geometry, geometry helps students better know the world they live in (Goos, & Spencer, 2003; Pesen, 2003).

In recent years, the changes in the field of mathematics, particularly in geometry, can be seen clearly. The changes of perspective in mathematics, and accordingly in geometry, and the innovations in these fields are based upon the NCTM (National Council of Teachers of Mathematics) standards. In composing the NCTM standards, which were first developed in 1989 and can be seen as the basis for geometry programs, the effect of various approaches and models was seen. In developing geometry field with the NCTM “the Van Hiele model” was taken as the basis (Choi-Koh, 1999; NCTM, 2000).

In the light of these innovations in the field of mathematics, in Turkey, mathematics course curriculum of primary school, 1st to 8th grades, was changed step by step with the project which was started by the Instructional Division of the National Ministry of Education in 2004. The mathematics curriculum of primary school 6th to 8th grades was divided into five learning sections (numbers, geometry, measurement, probability and statistics and algebra) and activities and acquisitions related to these learning fields. One of the learning fields in 6th grade mathematics curriculum is geometry (Millî Eğitim Bakanlığı [MEB], 2006). It is required that educational settings appropriate to the approaches of the curriculum is formed in order to achieve the objectives determined for geometry field and make students gain required knowledge and skills. In this perspective, models and methods, which are student-centered and, develop high level thinking skills of students have become important.

The Van Hiele Model and Creative Thinking

The Van Hiele Model is a model which was created to provide geometric understanding and develop geometric understanding. With the emergence of the Van Hiele model, most research related to geometrical thinking was conducted taking this model as the basis (Erdoğan, 2006; Olkun, & Toluk, 2003). This model was developed with classroom activities. In the model, it is required that students participate in determined activities and explore some characteristics related to geometric concepts in order to achieve the desired objectives (Gutierrez, 1992). The starting point of the Van Hiele model was thought to be the experiences of two educators related to the difficulties they came across in geometry teaching (Lonnie, 2002; Mistretta, 2000).

The most important feature of the Van Hiele model is that it explains the development of geometric thinking with five related levels. Each of these five levels defines the thinking processes used in geometric context. These levels define how they think and what kind of geometric ideas they are busy with instead of how much knowledge they have (Van de Walle, 2004). Geometric thinking levels determined by the Van Hiele model are as follows:

Visual Period (Level 0): People can make comments about the geometric structures based upon their observations in the setting in this starting level. A student at this level determines names and compares shapes depending on their appearances (Baykul, 2002; Crowley, 1987; Hoffer, 1983; Kılıç, 2003; Olkun & Toluk, 2003; Van Hiele, 1986).

Analysis (Level 1): In the analysis period, the analysis of geometric concepts appears. In this level, students begin to differentiate the features of shapes by means of observation and experiment. In this level, the student explores and proves features and rules about the shape with activities like observation and folding (Altun, 2002; Baykul, 2002; Crowley, 1987; Hiele, 1986; Hoffer, 1983; Kılıç, 2003; Mason, & Schell, 2001; Olkun & Toluk, 2003).

Inferences Related to Experience (Level 2): This level is a period in which seeing relations among shape categories develops. In this level, students can order and group shapes according to their features. Using informal expressions, they can infer the other relations from the relations they know (Altun, 2002; Baykul, 1999; Crowley 1987; Hoffer, 1983; Mason, & Schell, 2001; Olkun & Toluk, 2003; Van de Walle, 2004; Van Hiele, 1986).

Inference Resolutions (Level 3): Students at this level can manage implications with induction and they can make proofs by themselves in this system. They can notice and differ two different logical thinking ways related to the same theorem (Altun, 2002; Baykul, 2002; Crowley, 1987; Hoffer, 1983; Mason & Schell, 2001; Olkun & Toluk, 2003; Van Hiele, 1986).

Advanced Period (Level 4): An individual at the fifth and advanced level can understand the differences among the axiomatic systems. He claims theorems in different axiomatic systems and analyzes and compares these systems (Altun, 2002; Hoffer, 1983; Olkun & Toluk, 2003; Van Hiele, 1986).

These levels, determined by Van Hiele, make important contributions to geometry teaching and classroom activities related to geometry besides explaining the development of students' geometric thinking. The Van Hiele Model mentioned the role of the teacher, who organizes and carries out the classroom activities, on the development of students' geometric thinking (Akkaya, 2006; Duatepe, 2000; Kılıç, 2003; Van de Walle, 2004).

In the Van Hiele model, an instructional plan which is composed of five steps was formed in order to provide a transition from one level to another in students' geometric thinking (Crowley, 1987; Erdoğan, Durmuş & Bekci, 2007; Kılıç, 2003; Olkun & Toluk, 2003).

- (i) *Interview (research)*: The first step is the step in which geometric thinking levels of students are determined. In this step, the students' geometric thinking levels are determined through a communication between the teacher and the student.
- (ii) *Direct Orientation*: In this step, the teacher gives instructions and assignments related to the studies which will be done in the light of the answers he gets from the students. The purpose of the teacher's giving assignments is to make students explore the structures about the topic by means of research.
- (iii) *Making clear (explanation)*: Teacher introduces the topic to students in this step and students combine their experiences with the words they used related to the topic. In this step, it is important for the teacher to arouse students' interests.
- (iv) *Free Performance (activities)*: Students work on different solutions of multiphase problems in this step. They discover the relationships

among the various objects of the structure in the topic they work on. The teacher should guide students for their thinking about different solutions.

- (v) *Integration*: This step is the step in which students summarize and gather what they learned. Students internalize what they learned as a new thinking structure.

In educational settings created according to the Van Hiele model, it is aimed at developing high level thinking skills such as implication, association, communication, problem solving, spatial thinking, and creative thinking besides geometric concepts and the relations among these concepts. Creative thinking is one of the high level thinking skills that model aims at developing for students. Creative thinking is a skill which is aimed to be developed in all mathematics curricula from primary school to higher education.

Creative thinking is a thinking style which enables the individuals to produce new and authentic products, find new solutions, and reach a synthesis. Creativity means being critical and proposing new suggestions (Emir, 2001; Emir, & Bahar, 2003). The characteristics of creativity are defined as being aware of one's own unity and coherence and evaluating the conditions for uniting the knowledge the person uses in the framework of this awareness, understanding the information obtained through observations and experiments, and making it ready to be used, perceiving the problem very quickly and making decisions quickly associating it with his imagination (Özcan, 2000). A creative person is the one who searches for the new fields, makes new observations, makes new guesses, and propose new implications. Creative people need to have the ability to think fluently, authentically, and flexibly (Aslan, 2003; Emir, & Bahar, 2003).

Creative thinking process is a complex process and is fulfilled in four steps as preparation, incubation, enlightenment, and approval (Bartzer, 2001; Erden, & Akman, 1994; Hilgard, & Atkins, 1967 cited in Aslan, 1994; Özden, 2003; San, 1993; Yıldırım, 1998):

- (i) *Preparation Period* includes approaching the problem systematically and logically.
- (ii) *Incubation Period* follows the preparation period. As there is no control of consciousness in this period, new synthesis and original ideas appear.

- (iii) *Enlightenment Period* is the period in which the individual makes various syntheses among the information he obtained in previous period and finds new solutions.
- (iv) *The Approval of the Findings* is a conscious and logical period. The pitfalls of the solutions found before are fixed their accuracy is reviewed.

Creative thinking can be learned and improved as logical rules. This is fulfilled through education in schools and with the help of teachers. The influence of the educational settings on improving creative thinking skills is quite a lot. The things expected from teachers are to contribute to the training of the individuals who can think independently, can solve problems, have the ability to make decisions, and can think creatively (Bekci, & Erdoğan, 2007; Emir, Erdoğan, & Kuyumcu, 2008; Yıldırım, 1998).

In mathematics classes, geometry is one of the important fields of mathematics which may have an important effect on developing students' creative thinking skills. Educational settings formed in these courses play an important role on developing students' high level thinking skills such as creative thinking, critical thinking, implication, and problem solving. In this context, approaches and models used for teaching topics related to geometry are determinant for high level thinking skills which are to be gained. This study becomes important from the point of that it mentions the effect of the Van Hiele model, which is taken as the basis for educational curricula particularly in primary school geometry teaching, on the students' creative thinking levels.

The Aim of the Study

The aim of this study is to determine the effect of instruction process based on the Van Hiele model on 6th grade students' creative thinking levels.

Problem Statement

Is there a significant difference between the creativity levels of the students who are taught according to the Van Hiele model and traditional methods in the sixth grade at primary schools?

Hypotheses

- (i) There isn't a significant difference between the total pre test and post test scores of students taught according to the Van Hiele model on the Torrance Creative Thinking Test fluency, originality, the titles being abstract, enrichment, the resistance to early closure creative forces lists sub-dimensions and creativity.
- (ii) There is a significant difference between the total pre test and post test scores of students taught according to the traditional method on the Torrance Creative Thinking Test fluency, originality, the titles being abstract, enrichment, the resistance to early closure, creative forces lists sub dimensions and creativity.
- (iii) There is a significant difference between the students taught according to the Van Hiele model and the students taught according to the traditional method in their total post test scores on the Torrance Creative Thinking Test fluency, originality, the titles being abstract, enrichment, the resistance to early closure, creative forces lists sub dimensions and creativity.

Method

Research Design

In the study, a pre test-post test matching control grouped quasi-experimental design was used (Büyükoztürk, Çakmak, Akgün, Karadeniz, & Demirel, 2008). The research was carried out with two groups. One of these groups was determined as the experimental and the other was as the control group. While an instruction based on the Van Hiele model was carried out in the experimental group, an instruction with the traditional method was carried out in the control group. Instructions were carried out by the researchers in both groups. In the study, quantitative data were collected by means of experimental design and statistical analyses were preformed.

The Study Group

The study group was composed of 55 students who were enrolled in a 6th grade at a primary school in Bolu during the 2005-2006 academic year. Study group was composed of two groups chosen from four groups in which the researcher was teaching. Control and experimental groups were decided randomly.

Data Collection Tools

In the study, Shapes Section of the Torrance Creative Thinking Test (TCTT) was administered in order to determine the creative thinking levels of students before and after the instruction. The TCTT was developed by E. Paul Torrance in 1966. The TCTT was adopted into Turkish by Yontar (1985) and language equivalency, reliability and validity of the Turkish version was studied by Aslan (1999). The TCTT is based on Guilford's (1986) multiple thinking creativity theory. This is a pen and paper test which can be administered to individuals from all ages and with any skills. The TCTT was translated into 35 languages and is accepted as the most commonly used creativity test (Miller, 2002). The reliability coefficient of this test was reported as .90 and content and structure validity was accomplished (Torrance, 1962, 1990).

Procedure

In the study, a 3-week instruction (12 course hours) about "angles and triangles" was given to the experimental and control groups. While an instruction based on the Van Hiele model was carried out in the experimental group, an instruction with the traditional method was carried out in the control group. At this point, 7 activities were prepared for both groups by the researchers. These activities were carried out by the researchers during the 3-weeks time and 12 course hours. While the activities were conducted through approaches and methods, according to the Van Hiele model, such as discussion, group work, cooperative learning, learning by doing and experiencing and giving the concepts as related to each other in the experimental group, the traditional method which is teacher-centered was used in the control group. The researchers give directions to the students about the activities preparing the appropriate educational setting for the Van Hiele model in the experimental group. Some tools, such as geometry board, ruler, tangram, protractor, compass, computer, overhead projector and triangle cards, which are related to the geometry topics of mathematics curriculum, were used.

The Analysis of the Data

In the study, the creative thinking levels of students before and after the instruction were determined. Data obtained in this context were analyzed using SPSS 11.5. During the data analysis, it was determined whether there is a significant difference between the creative thinking levels of students before and after the instruction using t-test for dependent and independent groups.

Results

Findings Related to First Hypothesis

Whether there is a significant difference between the TCTT subdimensions and creativity total pre test and post test scores of students' in the experimental group were analyzed by means of t-test for dependent groups. It was seen that there is a significant difference between the TCTT fluency, originality, the titles being abstract, creative forces lists, and creativity pre test and post test scores of the students in experimental group ($p < .05$). Besides, it was seen that there is no significant difference between enrichment, the resistance to early closure subdimensions pre test and post test scores of the students in experimental group ($p > .05$).

Findings Related to Second Hypothesis

Whether there is a significant difference between the TCTT subdimensions and creativity total pre test and post test scores of students' in the control group was analyzed by means of t-test for dependent groups. No significant difference was found between the TCTT sub dimensions and creativity total pre test and post test scores of students in control group ($p > .05$).

Findings Related to Third Hypothesis

Whether there is a statistically significant difference between the students in the experimental group and the control group on their TCTT subdimensions and creativity total post test scores was compared by means of t-test for independent groups. A significant difference was found on post test scores on the TCTT fluency, originality, titles being abstract, creative forces list and creativity total dimensions of students in the experimental and control group in favor of experimental group ($p < .05$). Besides, there is no significant difference between post test scores of students in the experimental and control groups on the TCTT enrichment and resistance to early closure sub dimensions ($p > .05$).

Discussion

The present study aimed at determining the effect of the Van Hiele model based instruction process on the creative thinking levels of 6th grade primary school students. The findings showed that there is no

statistically significant difference between the subdimensions of creative thinking test and total pretest scores of students in the experimental and control groups before the instruction. This finding indicates that the creative thinking levels of the students in both groups are equal as the study started.

The students in the experimental group were taught according to the Van Hiele model and the Torrance Creative Thinking test was administered to students in order to determine the creative thinking levels before and after the instruction. After the analysis of the data, it was seen that there is a statistically significant difference between the students' pre test and post test scores on fluency, originality, titles being abstract, creative forces list, and creativity. Besides, it was seen that there is no significant difference between the student's pre test and post test scores on the enrichment and resistance to early closure dimensions of the creativity test. This finding indicates that the instruction according to the Van Hiele model is effective in improving students' creative thinking levels except the subdimensions like resistance to enrichment and early closure. This finding is coherent with the research examining the influence of the Van Hiele model on student's achievement and attitude (Akkaya, 2006; Choi-Koh, 1999; Erdoğan, 2006; Kılıç, 2003; Larew, 1999; Lonnie, 2002; Mistretta, 2000; Toluk, & Olkun, 2004; Toluk, Olkun, & Durmuş, 2002).

Students taught according to the Van Hiele model need to research, try, and explore. This instruction takes the student-centered approaches such as cooperative learning, learning by doing, and experience as the basis. In the process of learning and teaching, particularly in primary school age, using concrete tools and making the student to think, orienting students to discuss and search about geometric concepts, the appropriateness of classroom setting and prepared activities to their levels and sharing their ideas in a comfortable and entertaining environment can be said to be effective in developing the students' creative thinking levels (Akkaya, 2006; Erdoğan, 2006).

Control group was taught according to the traditional method and, as in the experimental groups, the Torrance Creative Thinking test was administered to the students in order to determine the creative thinking levels before and after the instruction. It was seen that there is no statistically significant difference when students' pre test and post test scores related to subdimensions of creative thinking test and total

scores were examined. At this point, it can be claimed that instruction which is carried out according to the traditional methods is not effective on developing students' creative thinking levels. This finding is also supported by the other research studies (Akkaya, 2006; Erdoğan, 2006; Larew, 1999; Toluk, & Olkun, 2004; Toluk, Olkun, & Durmuş, 2002).

In the instruction carried out according to the traditional method, teacher-centered approach was accepted. Generally speaking, direct instruction and question-answer method might have hindered to form a setting in which students can use and develop their thinking skills such as implication, communication, association, and problem solving. A setting in which students can carry out group works, share their ideas, communicate, learn cooperatively, and discuss cannot be formed. Therefore, it can be claimed that teaching and learning process directed by teacher is not effective on developing students' creative thinking levels.

Creative thinking levels of students in both experimental groups were compared after the instruction. It was found that there is a statistically significant difference on the total post test scores on fluency, originality, titles' being abstract, creative forces list and creativity in favor of the experimental group when the creative thinking levels after the instruction were examined. In other words, it was concluded that instruction according to the Van Hiele model is more effective than the instruction according to the traditional method in developing students' creative thinking levels. This finding is coherent with the other studies (Akkaya, 2006; Erdoğan, 2006; Kılıç, 2003; Lonnie, 2002; Mistretta, 2000).

In light of the findings of this study, the following recommendations can be suggested for geometry teaching and further research:

- (i) Educational settings which are appropriate for the Van Hiele model should be formed in teaching geometry topics in sixth grade at primary schools.
- (ii) Similar studies should be conducted in different levels of education and with larger study groups.
- (iii) The effect of the Van Hiele model on different high level thinking skills should be studied.
- (iv) Teachers should be informed about the Van Hiele model and in-service trainings about the model should be organized for teachers.

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