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# IMPROVING OF STUDENTS' CREATIVE THINKING THROUGH PURDUE MODEL IN SCIENCE EDUCATION

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**Abstract.** *The aim of this research is to develop a guide material prepared according to Purdue Model for the 'The Let's Solve the Puzzle of Our Body' unit in the 5th grade Science class at secondary school and to research the effects of this guide material on students' creative thinking. For this purpose, the research was carried out by using the quasi experimental model, with pre-test and post-test control groups. Experimental application was carried out with 43 experimental group and 44 control group students, in total 87 students in Turkey. While in the experimental group applications were carried out based on the Purdue Model, in the control group the course was taught according to the activities stated in 2013 Ministry of National Education Science Curriculum in Turkey. The data of the research were collected using Torrance Test of Creative Thinking Verbal Form A-B and Figural Form A-B. As a result of the research, it was determined that verbal and formal creative thinking levels of the experimental group and the control group students were significantly different in favour of the experimental group students. On the basis of the results obtained from this research, some suggestions have been made to the educators and future researchers.*

**Keywords:** *creative thinking, problem solving, science project, Purdue model.*

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## Introduction

A person uses science, which is a part of everyday life, in order to understand and adopt to the environment in which he/she lives no matter how old he/she is. Tendency towards science starts at very early age. The age at which children ask questions constantly and inquire about everything is between 6 and 14 and they mostly inquire about science at these ages. As these students at this age learn a new subject, they keep asking questions about that subject and this creates a desire to learn more about it (Gürdal, 1992). Through science education, the children ask questions in order to understand the events that occur around their environment and their curiosity increases by facing a new problem with every question. They develop themselves using the scientific process skills to solve the problems they have faced. They use the solutions they produce and the information they learn in order to solve the new problems they confront in their real life. Consequently, the child will have gained the skills that make his daily life easier. Thus, science education will enable the child to produce solutions by applying the information they acquire to new situations and allow them to develop their creative thinking skills.

### *Creative Thinking*

The first scientific research on creativity was initiated in the 1950s by the American Psychological Association, headed by Guilford. Different definitions have been made in the literature related to the concept of creativity, which is tried to be explained by different approaches, and each author emphasizes a different direction of creativity (Demirci, 2007). Creative things are both original and in some way effective and indeed this is the standard definition of creativity (Runco & Jaeger, 2012). According to Bélanger, Akre, Berchtold, and Michaud (2011) identified creativity as the process to surpass existing experiences, take a step forward through the restriction of habits, and form new concepts in problematic situations at the same time not to be restricted to practice and the abilities to solve problems flexibly. Torrance (1974) describes creativity as being sensitive to the problems, inadequacies, lack of knowledge,

inconsistencies and determining the difficulties, searching for solutions, estimation and hypothesising about inadequacies, changing the hypotheses, identifying a solution and testing and revealing the results after retesting.

There are three features of creativity defined by Torrance (1974); fluency, flexibility and originality. Fluency, which refers to the amount of answers given by the student about a problem. Flexibility can be thought as the student's potential to change from one type of thinking to another one when creating solutions. Lastly, according to Kuo (2016) originality is described as the ability of an individual being able to come out with unique ideas, like to do unexpected things or showing abilities different from others.

*Purdue Three-Stage Enrichment Model*

It is one of the basic aims of science education to educate creative and productive individuals who can establish relations between their daily life and science to meet the requirements of the times we live in. It is needed to educate individuals who analyse and interpret the information through their own mental process after reaching the scientific knowledge thus, who realize meaningful learning. In this respect, science programs need to be organized in a way that individuals know how to achieve creative scientific knowledge that can produce original products and in a way that they can actively solve problems. For the education of gifted students who have these qualities in their education systems, developed countries have developed various researches and models, some of which are the autonomous learning model, the Learning Enrichment Service (LES) model, the Integrative Education Model and the Purdue Three-Stage Enrichment Model (Feldhusen & Kollof, 1978).

The Purdue Three-Stage Enrichment Model (Purdue Model) is a program that has been developed and prepared for the development of gifted students (Moon, Feldhusen, Powley, Nidiffer & Whitman, 1993). The Purdue Model was first introduced by Feldhusen, Linden and Awes in a course that they teach college students in 1973. Afterwards, Feldhusen and Kollof experimented in 1977 applying the model to gifted students at elementary school level. The model of regular enrichment which is one of students' simple thinking experiences has gradually evolved from simple thinking experiences to complex independent activities (Feldhusen & Kolloff, 1986).

According to Feldhusen and Kollof (1978), the model includes three types of educational activity. These include research activities that will allow (I) students to discover and develop their own interests and thinking skills, (II) group activities to help students use the knowledge they learn, and (III) individual and small group projects in which students can conduct real, life-related research. Every step of the Purdue Model and the contents of these steps are shown in Table 1 (Feldhusen & Kolloff, 1986).

**Table 1. The content of Purdue three stage enrichment model (Feldhusen & Kolloff, 1986).**

| Stages of Model | General Content | Detailed Content |
|---|---|---|
| **Stage 1.** Separator and Connective Thinking Skills | Integrated scientific process skills, basic scientific process skills | The teacher allows short-term activities. He/she makes the students practice so that they can develop in the subject area<br>There is a balance between mental and visual activities. |
| **Stage 2.** Problem Solving and Creative Problem Solving Techniques | Group work on a problem selected by the teacher | The practises are made in control of the teacher. Many research and investigation techniques are applied (such as brainstorming). |
| **Stage 3.** Independent Project Study | Researching in depth | It is in the control of the student. The teacher is the guide. The subjects are chosen individually or in small groups. The research methods are applied. The product obtained at the end of the study is prepared for presentation. |

The Purdue Model used in the training of gifted students is a three-fold learning model of scientific process skills, problem solving and project production. The first two stages bringing the model to the fair constitute the basis and preparation for the third stage. These three stages are related to each other and they sport the development of each other. For this reason, students are expected to use scientific process skills to reach scientific knowledge, conduct research, use creative thinking skills by questioning knowledge, and solve the problems they face. Individuals who have these knowledge and skills will become science literate individuals.

Although the researches on Purdue Model used in this research are limited (Altıntaş, 2009; Çepni, Gökdere, & Küçük, 2002; Kutlu & Gökdere, 2013; Moon, 2004; Ünlü, 2008), many studies have been carried out separately in science teaching in the three stages of the model, scientific process skills, problem solving and project matters



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(Aktamış, 2007; Bahadır, 2007; Batı, 2010; Çıbık, 2009; Doppelt, 2003; Garrett, 1987; Kanlı & Emir, 2013; Korkmaz, 2002; Lewis, 2006; Yaman & Yalçın, 2005). However, since the research on the three-stage Purdue Model used in the training of gifted students is very limited, scientific research is needed to determine the effectiveness of the model on normal students. The research is significant to ensure that the Purdue Model used for gifted students is available for the normal students in public schools as well. Thus, with the examples of activities developed for the applicability of the model, its dissemination in science education will be ensured.

It is one the main aims of science education to raise creative and productive individuals who can meet the necessities of the times we live in and relate science with everyday life. There is a need for individuals who are capable of achieving scientific knowledge, analysing and interpreting information through their own mental processes, and thus achieving meaningful learning. It is important to raise creative and productive individuals who can solve problems in different ways.

In learning environments that allow creative thinking, thinking is highly valued in comparison to knowledge. In science education, it is expected that the students should try to attain knowledge rather than to memorize the information and to assimilate the knowledge. Memorizing is one of the biggest obstacles to creativity. A child's mind is full of creativity especially in primary school. Over time, creativity starts to decline (Üstündağ, 2011). For this reason, the establishment of educational environment that will develop creativity for the 5$^{th}$ grade students who are in transition period from elementary school to middle school is significant in terms of not creating memorization and developing creativity. In addition, according to Piaget, this period is included in the students' transition period from concrete operational stage to formal operational stage. In this period, students should be taught how to deal with a problem, how to reach the solution, how to create a research plan and how to apply it. In this process, the basic requirements they will often use in science teaching are the scientific process skills. Scientific process skills are, as well as the skills that scientists use during their work, the abilities exhibited in the solution of any scientific problem (Monhardt & Monhardt, 2006). By using these skills, students try to perceive the environment in science teaching and learn about events that occur in nature. At this point, Purdue Model meets basic requirements such as the planning of research process in science education and the problem solving and scientific process skills that the student should have in this process. It allows students to develop their potential that exists beyond their academic success.

This research was designed to develop students' creative thinking in science teaching. When looked at the three stages, Purdue Model is considered as a model that can be effective in realizing meaningful learning in science teaching and developing students' creative thinking. For this reason, in this research, it has been tried to put forward the effects of the Purdue Model on the students' verbal and figural creative thinking skills, used in the teaching of the unit *'The Let's Solve the Puzzle of Our Body'* in the 5$^{th}$ grade Science course of the 2013 Science Curriculum. In particular, the problem of the research seeks to answer the following two questions:

1. Are there any statistically significant differences in the levels of Torrance verbal creative thinking pretest and post-test results between experimental group (using Purdue Model) and control group (using 2013 Science Curriculum)?
2. Are there any statistically significant differences in the levels of Torrance figural creative thinking pretest and post-test results between experimental group (using Purdue Model) and control group (using 2013 Science Curriculum)?

**Methodology of Research**

In this research, experimental research design was used. In experimental research, it may not be possible to assign the participants, who are always the nature of real experimental designs, to the groups. In cases where the controls required by experimental designs are not provided or sufficient, quasi experimental research designs that contain all the features of the experimental investigations are used (Karasar, 2006; Mertler & Charles, 2011). In quasi experimental researches, the choice of subjects is not random (Cohen, Monion, & Morrison, 2000; Creswell, 1994). In this research, since the 5$^{th}$ grade students who are the samples of this research are not assigned to the experimental and control groups randomly, quasi experimental research with matched control group is used.

The research was conducted with totally 87 students (43 in experimental group and 44 in the control group) from Samsun city in Turkey, during the first semester of the school year of 2014-2015. While 'Let's Solve the Puzzle of Our Body' unit was taught to experimental group using Purdue Three Stage Enrichment Model, the control group was instructed to do the activities in 2013 Science Curriculum.

*Sample of Research*

In this research, experimental and control groups were determined by using simple random sampling method. Before research was executed, all necessary permissions about research were granted by Turkish Ministry of National Education. Before research was conducted, the classes were established by the school administration, in accordance with the registration list without considering the students' academic level. The experimental and control group classes among the fifth grade were determined via lot. The research was conducted with 87 students, 43 of which in the experimental group and 44 of which in the control group in Turkey. Besides, all the students were volunteers in research.

*Instrument and Procedures*

'Torrance Test of Creative Thinking (TTCT) Verbal A-B Forms' and 'Torrance Test of Creative Thinking (TTCT) Figural A-B Forms' tests were used as data collection tools in the research. TTCT Verbal Form A-B and TTCT Figural Form A-B has been used with the aim of demonstrating how the teaching of the experimental and control groups in the experimental application process leads to a change in the verbal and formal creativity of the students towards science.

Torrance Test of Creative Thinking (TTCT) developed by E. P. Torrance, was published for the first time in 1966 in the United States to determine the creative thinking levels of students. The scale has a wide range of uses from kindergarten to the university. Statistical analyses of the scale on its linguistic equivalence, reliability and validity were made by Aslan (2001) and it was adapted to Turkish. The test consists of two parts: 'TTCT Verbal A-B form' and 'TTCT Figural A-B form'. While the A forms of verbal and figural tests were used as pre-tests before the application, the B forms were used as post-tests after the application.

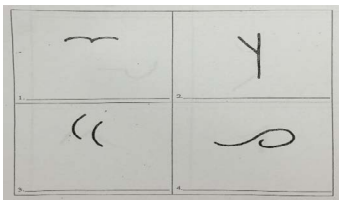
Verbal test forms consist of seven subtests called 'asking questions', 'guessing causes', 'guessing consequences', 'product improvement', 'unusual uses', 'unusual questions' and 'just suppose'. The answers of the students for each test were scored in three aspects as 'fluency', 'abstractness' and 'originality', they were added up and creative thinking score was formed. Sample question for 'TTCT verbal B' is given Table 2.

**Table 2. Sample question for TTCT verbal B.**

| | |
|---|---|
| Just suppose…<br>Now you will be given an improbable event. An event that will perhaps never come true. You will just suppose that this happens. This will give you the opportunity to think about other exciting things and use your imagination. Of course, if this improbable event comes true… just imagine that it happens. Then think about the other things that might happen with the occurrence of this event. In other words, what might the consequences of this event be? Make as many guesses as you can. That is the impossible event: Just suppose that a big fog came to the Earth and only people's feet can be seen. How is this going to change the world? List your thoughts and guesses. |  |

In the figural part, there are three subtests respectively; '*image creation*', '*image completion*' and '*parallel lines and circles*' Table 3. For the application of the TTCTs, the approximate time was 75-80 minutes. For each of the verbal and figural tests, one lesson hour was given and they were applied separately.

**Table 3. Sample question for TTCT figural A.**

| | |
|---|---|
| You can make interesting pictures or objects by adding lines to this and the unfinished figures on the back page. And try not to think about the figures and objects that others cannot think of. Try to make your picture interesting and tell a whole story by adding your first ideas. Think of an interesting title for each figure and write on the line next to the number under each picture. |  |

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Aslan (2001) has conducted Turkish linguistic equivalence, reliability and validity studies of TTCT. The Pearson Moment Product Correlation Coefficient between the scores obtained with the application of the Turkish and English forms of the same group was found to be significant at p<.01 level for all subtests. For the internal validity of the test, an analysis of substance total, substance exclusion and substance discrimination was performed for all age groups. Significant results were obtained for all age groups and all scores of verbal creativity test at p< .01 level in item-total and item-remaining analyses for seven subtests of verbal creativity test belonging to primary, high school and university age groups. In the figural creative test, significant results at p< .01 level were obtained in the item-total, item-remaining analyses; fluency, originality, abstraction of the titles, enrichment, resistance to early closure scores for all age groups including the pre-school age group (Aslan, 2001).

*Data Analysis*

In the analysis of qualitative data, two types of analysis methods are used: descriptive and content analysis (Strauss & Corbin, 1990). While the data obtained in the descriptive analysis are summarized and interpreted according to the previously determined theme, in the content analysis, the resulting data are analysed in depth to allow for the generation of previously unfamiliar themes and dimensions (Yıldırım & Şimşek, 2011). In this research, content analysis method was used in the analysis of qualitative data obtained from TTCT Verbal and TTCT Figural forms.

In TTCT verbal form, the answers given by the students in each test were scored in three dimensions as (1) fluency, (2) flexibility and (3) originality, and a creative thinking verbal test score was generated. In TTCT figural form, two separate scoring criteria; norm-based and criterion-based were created by Torrance and Ball (1984). In the norm-based scoring criteria, the answers were scored according to (1) fluency, (2) originality, (3) abstraction of titles, (4) enrichment, and (5) early closure resistance. In criterion-based scoring criteria, the power of creating a creative product was evaluated according to 13 different criteria under the title of 'the list of creative forces' depending on the figural stimulus in the answers of the students. These 13 criteria are (1) emotional expressions, (2) storytelling, (3) movement or activity, (4) explanations of the titles, (5) uncompleted figures, (6) synthesis of the incomplete lines, (7) unusual visualization, (8) internal visualization, (9) stretching or crossing boundaries, (10) humour, (11) richness of imagination, (12) colourfulness of imagination (13) fantasy. The total creativity figural test score evaluates the thought product according to 18 different measures including the list of creative forces.

In the analysis of the scores obtained from the TTCT verbal and formal A-B forms, the answers given by the students were taken into account according to the above-mentioned evaluation criteria for the verbal and figural forms. The criteria to be followed in the scoring of the data obtained from TTCT verbal and figural A-B forms were made according to the Turkish scoring guide prepared by Aslan (2001) considering the revision made by Torronce in 1984. For each criterion in the scoring guide, categories were given and the student answers were scored according to these categories and the data were converted into quantitative.

Before deciding on the method to be used in the analysis of the data, it was checked whether the scores obtained from each measurement tool provided normality assumptions. In the analysis of the data that show normal distribution, the two-way ANOVA for mixed measures was used.

*Reliability and Validity of Data Collection Instruments*

The TTCT Verbal and Figural Forms were pre-applied to a group of five students chosen from the 5th grade students before the experimental practice. In preliminary practice, the students were assessed from the point of view of whether there were points that were not understood in the questions or in the drawings and the duration of the application, and necessary precautions were taken against the problems that may be encountered in the actual application.

After the experimental treatment (detailed information is available in the following experimental implementation section), the reliability analysis between the raters was used for the reliability analysis of the data obtained from the TTCT verbal and the figural forms. Interrater reliability is expressed as the consistency between scores of two or more raters on the characteristics of different individuals or substances (Aiken, 2000; Anastasi & Urbina, 1997; Güler, 2008). There are many methods that can be used for this purpose such as Pearson correlation coefficient, comparison of averages, percentage of numbness and generalizability. Inter- raters reliability is most commonly calculated by the correlation coefficient (Güler & Gelbal, 2010; Güler & Taşdelen Teker, 2015). The Pearson correlation coefficient shows the linear relationship of the scores of the two raters and their variation together (Baykul,

2010). If the correlation coefficient is less than 0.30 the relation is low, if it is between 0.30 and 0.70 the relation is medium and if it is more than 0.70 the relation is high (Büyüköztürk, Çokluk & Köklü, 2010).

For the scoring of the tests, the researcher was trained according to the 'Torrance Creative Thinking Tests Scoring Training' under the supervision of a specialist. For this purpose, TTCT Verbal Test A (20) and Figural Test (20) forms of 20 students ten of whom were randomly selected for the control group and ten of whom were randomly selected for the experimental group were recoded and rescored by two other specialists. The tests were re-planned. The reliability of the research was evaluated by the researcher and a researcher who explained the scoring guide by the researcher, and another researcher who was trained in scoring training. In the correlation analysis, since the group number was N≤30, the Spearman-Brown correlation coefficient which is one of the non-parametric methods was used (Table 4).

**Table 4. Correlation coefficients between the scores of the three raters to the TTCT verbal and figure A forms.**

| | | Researcher | 1th Rater | 2nd Rater |
|---|---|---|---|---|
| Verbal Form A | Researcher | - | .934* | .909* |
| | 1th Rater | .934* | - | .858** |
| | 2nd Rater | .909* | .858* | - |
| Figural Form A | Researcher | - | .907* | .914** |
| | 1th Rater | .907* | - | .915** |
| | 2nd Rater | .914* | .915* | - |

*$p < .05$

The Spearman-Brown correlation coefficient was used firstly in the reliability analysis between the raters for the TTCT – Verbal A Form. Correlation coefficients for the TTCT - Verbal form were calculated as values ranging from 0.858 to 0.934. The same procedure was performed for the TTCT – Figurer A Form and the Spearman-Brown correlation coefficients were calculated as the values ranging from 0.907 to 0.915. This correlation coefficient value supports the interpretation that the raters are compatible.

It may be wrong to evaluate reliability only by looking at the correlation. The correlation coefficient is insufficient to calculate the reliability between the raters, since the correlation value between points is independent from the average (Goodwin, 2001). For this reason, the difference between the points average of the raters must also be tested. The results of the Friedman test which was used to test the differences between the rankings of the priorities for TTCT Verbal and Figural Form scores of the raters in the research, are given in Table 5.

**Table 5. Friedman test results of TTCT verbal /figural form scores by inter-raters.**

| | | Mean Rank | N | $\chi^2$ | df | p |
|---|---|---|---|---|---|---|
| TTCT Verbal Form A | Researcher | 132.60 | 20 | 3.90 | 2 | .142 |
| | 1th Rater | 125.60 | | | | |
| | 2nd Rater | 122.40 | | | | |
| TTCT Figural Form A | Researcher | 91.55 | 20 | 3.60 | 2 | .165 |
| | 1th Rater | 89.00 | | | | |
| | 2nd Rater | 93.65 | | | | |

According to the Friedman test results shown in Table 5, the difference between the raters score of TTCT Verbal and Figural Form papers was not found significant statistically ($p < .05$). As a result, it was observed that there was a significant positive correlation between the scores of the different raters and there was no significant difference between the scores. These results show that the scores obtained from TTCT Verbal and Figural Forms are consistent results in data analysis.



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*Experimental Implementation*

In experimental treatment '*The Let's Solve the Puzzle of Our Body'* unit was processed with activities based on Purdue Model in experimental group for 9 weeks while in the control group, teaching was done by using the book of 2013 Science Curriculum (MoNE, 2015). In the control group, the science teacher used the methods of lecture, question-answer and experiment.

In the experimental group during the experimental treatment process, firstly the experimental group was informed about the project activities and the project groups were formed at the beginning of the semester. The experimental group was divided into heterogeneous groups of 4-5 persons by taking the pre-test scores and the opinions of the Science teachers into consideration in order to carry out pre-implementation group studies. Students were asked to form a research problem by concentrating on the topics they were curious about *'The Let's Solve the Puzzle of Our Body'* unit. On this subject, the students have been asked for brainstorming in order to make a list on what they know and what they want to know. First of all, project groups have prepared their proposal form and have submitted to the teacher. After the subjects of project which are examined by the teacher have been accepted, every group has started working on their subject. Afterwards, the students have been asked for making a project planning based on the problem of research that they have determined and practicing it. For this purpose, groups have created a project calendar. They have noted the things they need to do on this calendar week by week until the presentation of the project. At the end of the unit, they have been asked for doing presentations about the projects they prepared in the classroom.

Scientific process skills exercises which are the first stage of the model, problem solving exercises as the second and presenting the students projects as the last have been carried out. The exercises used in the practice and the distribution of the exercises according to the subjects are given in the Table 6.

**Table 6. Distribution of the activities used in the practices, duration and related steps.**

| Subject | Week | Activities | Period (min) | Stage |
|---|---|---|---|---|
| Nutrients and Properties | 3 | Let's Test the Nutrients | 40 | Stage 1 |
| | | Explore our nutrients and let's find out score of our friends | 20 | |
| | | Determine the nutrient groups of our characters | 10 | |
| | | Let's compare the nutrients according to protein amounts | 10 | |
| | | Let's determine vitamins the characters are holding | 10 | |
| | | Find the missing vitamins | 10 | |
| | | What should we avoid for a healthy life? | 20 | |
| | | Let's answer the speech bubbles | 20 | Stage 2 |
| | | Who is healthier? | 20 | |
| | | Let's evaluate Demet's shopping bag | 20 | |
| | | Let's solve the Sinan's family problems | 30 | |
| | | Alcohol addict | 20 | |
| | | Let's prepare a nutrient poster | 40 | Stage 3 |
| | | Let's prepare a journal 'Fight Against Alcohol and Smoking ' | 40 | |
| Nutrients Digestion | 3 | Let's sort the organs of digestion system | 30 | Stage 1 |
| | | Digestion system | 10 | |
| | | Let's do crossword puzzle I | 40 | |
| | | Let's colour the teeth | 20 | |
| | | The story of digestion | 20 | Stage 2 |
| | | Who will win the digestion bet? | 20 | |
| | | Murat is dental check-up | 20 | |
| | | How much does my peer know the digestion system? | 40 | Stage 3 |
| | | Let's make teeth model | 40 | |

| Subject | Week | Activities | Period (min) | Stage |
|---|---|---|---|---|
| Excretory in Our Body | 3 | Our excretory system | 15 | Stage 1 |
| | | Let's do crossword puzzle II | 20 | |
| | | Let's investigate our kidneys | 40 | |
| | | Do we know our excretory organs? | 15 | Stage 2 |
| | | The specialists explain excretory organs | 20 | |
| | | Let's solve the problem | 20 | |
| | | What should we do for our kidneys health? | 20 | |
| | | Let's make a excretory model | 40 | Stage 3 |
| | | Let's compose our scenario | 40 | |
| | | Project presentations | 80 | |

In the first stage of the model, students have performed activities based on scientific process skills. In the second stage, problem solving activities have been used. In this stage, mainly group discussions, brain storms and problem scenarios related to topics have been used in the problem-solving process. In the first two stages, the students have been made ready for the project phase, which is the third stage of the model, with the scientific process skills and problem solving activity implementation. Since, in order for the student to be able to create a project, he should be able to create a problem, to be able to research the problem and to use scientific process skills during this research process.

## Results of Research

*The Findings Related to TTCT Verbal A-B Forms*

The correctness of the hypothesis *of 'There is a significant difference between Verbal scores of the Torrance Creative Thinking Test of experimental and control group students when compared before and after teaching process'* has been researched. The TTCT verbal pre-test and post-test averages of the students in the experimental and control groups are given in Table 7.

**Table 7. Descriptive data related to TTCT verbal pre-test and post-test scores.**

| | Group | N | Mean | Median | Mode | Std. Deviation | Skewness | Kurtosis | Variance |
|---|---|---|---|---|---|---|---|---|---|
| Pre | Experimental | 43 | 65.12 | 64.00 | 65 | 11.94 | 1.099 | -1.410 | 142.581 |
| | Control | 44 | 60.50 | 61.00 | 61 | 11.35 | 0.448 | -0.175 | 128.767 |
| Post | Experimental | 43 | 169.51 | 171.00 | 171 | 44.72 | 0.285 | -0.811 | 1999.542 |
| | Control | 44 | 94.45 | 95.00 | 95 | 32.89 | 0.507 | -0.979 | 1082.114 |

Table 7 shows that the arithmetic average values of the TTCT verbal pre-test ($X_E$=65.12; $X_C$=60.50) are close to each other in the experimental and control groups. After experimental practice, the arithmetic average of the students in the experimental group ($X_E$=169.51) is higher than the arithmetic average of the students in the control group ($X_C$=94.45).

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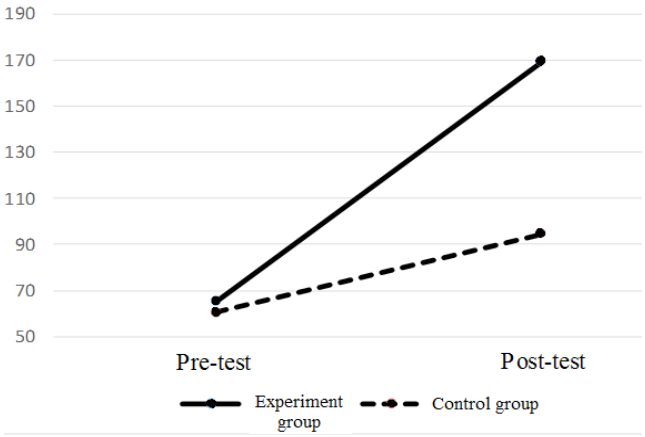


**Figure 1: The difference between TTCT verbal pre-test and post-test average scores of experimental and control groups.**

The change in mean scores of the TTCT verbal pre-test and post-test scores of the students in the experimental and control groups is shown by a line chart (Figure 1). As seen above, TTCT verbal test scores of the both control and experimental group students have increased during the programme. However, the higher increase in the scores of the experimental group is obvious. Two-way ANOVA for mixed measures has been performed in order to test whether the differences in scores are statistically significant and the results are presented below.

In order to use parametric methods in data analysis, the quantitative data obtained from the applied tests should show normal distribution (Seçer, 2015). For this reason, it has been examined whether the scores obtained from TTCT verbal pre-test and post-test treatment applied to the students have showed normal distribution. When Table 7 is examined, arithmetic average and mode median values belonging to the pre-test scores of the experimental and control group are pretty close to each other. If the skewness and kurtosis values of the TTCT verbal pre-test and post-test scores are less than 1.96 for α = .05, it can be interpreted that the distribution does not normally deviate excessively (Büyüköztürk, 2010).

After that scores of TTCT verbal pre-test and post-test have displayed a normal distribution is controlled, analysis through the two-factor ANOVA statistical model for mixed measures has been continued. On 2x2 split-plot factorial design; the first factor indicates independent treatment groups, and the other factor indicates the pre-test and post-test measurements of the dependent variable. Before passing on to the analysis, it has been examined whether the two-factor ANOVA model for mixed measures over a single factor has met the following assumptions. (1) The scores (measures) of the dependent variable are in the minimum range scale, (2) the scores of the dependent variable display a normal distribution in every subgroup. (3) variances of the groups' scores obtained in the same breath are equal, (4) the covariance of the groups is equal for the binary combinations of the measurement sets, (5) the difference score calculated for any subject is independent of the difference score calculated for the other subjects (Büyüköztürk, 2010).

Since TTCT verbal test is an equal interval scale, the first assumption has been met. For the second assumption; in order to examine whether the scores of the dependent variable display normal distributions in the subgroups, arithmetic mean, mod, median, skewness and kurtosis values of the groups have been examined (Table 7). As a result, scores of the dependent variable with the TTCT Verbal test have been found to display normal distribution at each level. For the third assumption that the scores of the groups are equal to the variances; The Levene's Test has been applied to the homogeneity of variances on the TTCT verbal pre-test and post-test scores of the participants in the experimental and control groups. In accordance with the results obtained, it has been seen that there is not any significant difference between variances of the participants' scores of pre-test [$F_{(1,85)}$=0.102, p> .05] and post-test [$F_{(1,85)}$=2.799, p> .05]. For the fourth assumption, the covariance equality of groups was tested and the covariance has been found to be homogeneous, in order to determine the appropriateness of the variance analysis to find the significance of the change in TTCT verbal test scores [$F_{(3, 1323463.652)}$=1.391, p> .05]. Since the difference score calculated for any subject is independent of the difference score calculated for the other subjects, it has been met in the fifth assumption.

**Table 8. Independent samples t-test results of TTCT verbal pre-test scores in accordance with experimental and control groups.**

| Group | N | X | SD | df | t | p |
|---|---|---|---|---|---|---|
| Experimental | 43 | 65.12 | 11.94075 | 85 | -1.849 | 0.68 |
| Control | 44 | 60.50 | 11.34757 | | | |

**p< .05*

When Table 8 is examined, it is clear that TTCT verbal pre-test scores of the students do not differ significantly from group variable [t(85)= -1.849, p> .05]. According to the Purdue Model, the two-factor ANOVA for mixed measures results concerning whether there is a significant difference in the changes observed after the experiment compared to the pre-experiment for verbal creative thinking of the participants in the experimental group of science teaching are given in Table 9.

**Table 9. Two-Factor ANOVA for mixed measures results related to comparison of TTCT verbal pre-test and post-test scores.**

| Source | SS | df | MS | F | p | η2 |
|---|---|---|---|---|---|---|
| **Between Groups** | 149574.667 | 86 | | | | |
| Group | 69023.689 | 1 | 69023.689 | 72.836 | 0.00* | .461 |
| Error | 80550.978 | 85 | 947.659 | | | |
| **Within Groups** | 323567.239 | 87 | | | | |
| Measurement (Pre-test/Post-test) | 208127.538 | 1 | 208127.538 | 287.721 | 0.00* | .772 |
| Group*Measurement | **53953.607** | **1** | **53953.607** | **74.587** | **0.00*** | **.467** |
| Error | 61486.094 | 85 | 723.366 | | | |
| **Total** | 473141.906 | 173 | | | | |

**p< .05*

When two-factor ANOVA for mixed measures analysis results are examined (Table 9) for mixed patterns to test the change in verbal creativity of students participating in experimental practice; if the TTCT verbal scores of the students belonging to the experimental and control group are compared regardless of the differentiation between pre-test and post-test, there is a significant difference between the total scores obtained from TTCT verbal pre-test and post-test [F(1,85)=72.836, p< .05].

Regardless of grouping the students participating in the teaching process (measurement baseline effect) activities included in 2013 Science Curriculum with Purdue Model, there is a significant difference between the averages of the TTCT verbal scores of the students before and after the experimental treatment [F(1,85)=287.721, p< .05].

When the common effect test of group and measurement factors is examined; it has been found that the TTCT verbal scores of the experimental and control group students participating in the experimental practice differ from after the experimental treatment, that is, being in the different treatment groups and the common effects of the repeated measures factors on verbal creativity have been statistically significant in favour of the experimental group [F(1,85)=74.587, p< .05]. The significance of the common effect suggests that Purdue Model-based science teaching and science teaching according to 2013 Science Curriculum have different effects on students' verbal creativity.

*The Findings Related to TTCT Figural A-B Forms*

The correctness of the hypothesis *of 'There is a significant difference between Figural scores of the Torrance Creative Thinking Test of experimental and control group students when compared before and after teaching process'* has been researched. The TTCT figural pre-test and post-test averages of the students in the experimental and control groups are given in Table 10.

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**Table 10. Descriptive data related to TTCT figural pre-test and post-test scores.**

| | Group | N | Mean | Median | Mode | Std. Deviation | Skewness | Kurtosis | Variance |
|---|---|---|---|---|---|---|---|---|---|
| Pre | Experimental | 43 | 69.67 | 68.00 | 64 | 19.853 | 1.000 | 0.5035 | 394.130 |
| | Control | 44 | 72.16 | 72.50 | 84 | 19.927 | -0.13165 | -0.6837 | 397.067 |
| Post | Experimental | 43 | 112.67 | 112.00 | 112 | 24.286 | -0.0277 | -1.3878 | 589.796 |
| | Control | 44 | 72.93 | 74.00 | 82 | 18.246 | -0.12605 | -0.8533 | 332.902 |

When Table 10 is examined, it can be that TTCT formal pre-test arithmetic average values of experimental and control groups ($X_E$=69.674; $X_C$=72.159) are pretty close to each other. After experimental practice, the arithmetic average of the students in the experimental group ($X_E$=112.674) is higher than the arithmetic average of the students in the control group ($X_C$=72.932).

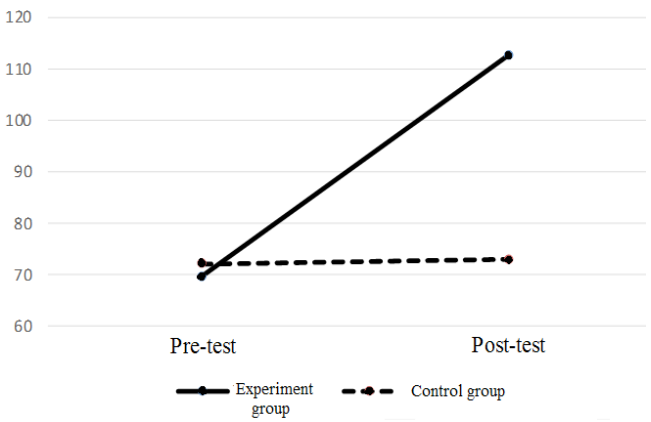


**Figure 2: The difference between TTCT figural pre-test and post-test average scores of experimental and control groups.**

The line chart shows the change in TTCT pre-test and post-test mean scores of the students in the experimental and control groups (Figure 2). As seen above, the TTCT formal test scores of both control and experimental group students have increased during the program. However, the higher increase in the scores of the experimental group is clearly visible. Two-factor ANOVA for mixed measures has been performed to test whether the point differences have been statistically significant and the results are presented below.

Before the analysis of two-factor ANOVA for mixed measures, it has been examined whether the scores obtained from TTCT figural pre-test-post-test applications applied to the students have showed normal distribution. When Table 10 is examined, arithmetic average and mode median values belonging to the pre-test scores of the experimental and control group are pretty close to each other. After that scores of TTCT figural pre-test and post-test have displayed a normal distribution is controlled, analysis through the two-factor ANOVA statistical model for mixed measures has been continued. On 2x2 split-plot factorial design; the first factor indicates independent treatment groups, and the other factor indicates the pre-test and post-test measurements of the dependent variable. Before passing on to the analysis, it has been examined whether the two-factor ANOVA model for mixed measures over a single factor has met the following assumptions. (1) The scores (measures) of the dependent variable are in the minimum range scale, (2) the scores of the dependent variable display a normal distribution in every subgroup. (3) variances of the groups' scores obtained in the same breath are equal, (4) the covariance of the groups is equal for the binary combinations of the measurement sets, (5) the difference score calculated for any subject is independent of the difference score calculated for the other subjects (Büyüköztürk, 2010).

Since TTCT figural test is an equal interval scale, the first assumption has been met. For the second assumption; in order to examine whether the scores of the dependent variable display normal distributions in the subgroups, arithmetic mean, mod, median, skewness and kurtosis values of the groups have been examined (Table 10). As

a result, scores of the dependent variable with the TTCT figural test have been found to display normal distribution at each level. For the third assumption that the scores of the groups are equal to the variances; The Levene's Test has been applied to the homogeneity of variances on the TTCT figural pre-test and post-test scores of the participants in the experimental and control groups. In accordance with the results obtained, it has been seen that there is not any significant difference between variances of the participants' scores of pre-test [$F_{(1,85)}$=0.223; p>.05] and post-test [$F_{(1,85)}$=3.797, p> .05]. For the fourth assumption, the covariance equality of groups was tested and the covariance has been found to be homogeneous, in order to determine the appropriateness of the variance analysis to find the significance of the change in TTCT figural test scores [$F_{(3, 1323463.652)}$=1.143, p> .05]. Since the difference score calculated for any subject is independent of the difference score calculated for the other subjects, it has been met in the fifth assumption.

**Table 11. Independent samples t-test results of TTCT figural pre-test scores in accordance with experimental and control groups.**

| Group | N | X | SD | df | t | p |
|---|---|---|---|---|---|---|
| Experimental | 43 | 69.6744 | 19.85270 | 85 | 0.583 | 0.562 |
| Control | 44 | 72.1591 | 19.92654 | | | |

**p< .05*

When Table 11 is examined, it is clear that TTCT figural pre-test scores of the students do not differ significantly from group variable [t(85)=0.583, p> .05]. According to the Purdue Model, the two-factor ANOVA for mixed measures results concerning whether there is a significant difference in the changes observed after the experimental compared to the pre-experimental for figural creative thinking of the participants in the experimental group of science teaching are given in Table 12.

**Table 12. Two-factor ANOVA for mixed measures results related to comparison of TTCT figural pre-test / post-test scores.**

| Source | SS | df | MS | F | p | η2 |
|---|---|---|---|---|---|---|
| **Between Groups** | 64761.874 | 86 | | | | |
| Group | 15094.172 | 1 | 15094.172 | 25.832 | 0.00* | 0.233 |
| Error | 49667.702 | 85 | 584.326 | | | |
| **Within Groups** | 63269.286 | 87 | | | | |
| Measurement (Pre-test-Post-test) | 20834.309 | 1 | 20834.309 | 76.843 | 0.00* | 0.475 |
| Group*Measurement | **19389.113** | **1** | **19389.113** | **71.513** | **0.00*** | **0.457** |
| Error | 23045.864 | 85 | 271.128 | | | |
| Total | 128031.16 | 173 | | | | |

**p< .05*

When two-factor ANOVA for mixed measures analysis results are examined (Table 12) for mixed patterns to test the change in figural creativity of students participating in experimental practice; if the TTCT figural scores of the students belonging to the experimental and control group are compared regardless of the differentiation between pre-test and post-test, there is a significant difference between the total scores obtained from TTCT figural pre-test and post-test [F(1,85)=25.832, p< .05].

Regardless of grouping the students participating in the teaching process (the main effect of the measure) activities included in 2013 Science Curriculum with Purdue Model, there is a significant difference between the averages of the TTCT figural scores of the students before and after the experimental treatment [F(1,85)=76.843, p< .05].

When the common effect test of group and measurement factors is examined; it has been found that the TTCT figural scores of the experimental and control group students participating in the experimental practice differ from after the experimental treatment, that is, being in the different treatment groups and the common effects of the repeated measures factors on figural creativity have been statistically significant in favour of the experimental group

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[F(1,85)=71.513. p< .05]. The significance of the common effect suggests that Purdue Model-based science teaching and science teaching according to 2013 Science Curriculum have different effects on students' figural creativity.

**Discussion**

In an attempt to test the change in verbal and formal creative thinking levels of students participating in the research, the average of TTCT verbal and TTCT figural pre-test and post-test scores of the experimental and control group students have been examined. It has been proved that TTCT verbal and figural test scores of both control and experimental group students have increased during the program [F(1,85)=74.587, p< .05]. The significance of the common effect indicates that the Purdue Model-based science teaching and the science teaching according to 2013 Science Curriculum have different effects on students' verbal creativity. It has been also found that the TTCT figure scores of students participating in the experimental treatment in the same way also have differed after the experimental treatment, in the different treatment groups, and the common effects of repetitive measurement factors on formal creativity were statistically significant in favour of the experimental group [F(1,85)=71.513, p< .05]. As a result, the level of creative thinking of TTCT verbal form A-B and TTCT figural form A-B of the fifth-grade students in the research is higher than the control group in the experimental group where Purdue Model has been applied, but the difference between them has been found to be statistically significant. This suggests that the Purdue Model increases the verbal and formal creative thinking levels of the students more than the control group according to the 2013 Science Curriculum.

According to Kolloff and Feldhusen (1984), the three-stage Purdue Model is highly influential on gifted students' ability to acquire creative thinking skills. Besides, according to Moon (2004), the use of the Purdue Model in science, technology, engineering, and mathematics courses enriches the creativity of students. Likewise, Altıntaş, Özdemir and Kerpiç (2013) presented in parallel with the results of this research that Purdue Model is more effective in teaching the 7th classes of '*Conscious Consumption Arithmetic*' than the current program on students' creativity.

There are many studies that examine the effects of the scientific process skills, problem solving and project steps that make up the Purdue Model on students' creative thinking levels. Karahan (2006) determined that applications based on scientific process skills in the research conducted by fourth grade students and physical events for learning area positively affected the students' creative thinking. Acquiring scientific process skills in science allows students to develop their creative skills (Kaptan & Korkmaz, 2001). Similarly, there are many studies in the literature showing that the creative thinking skills of students have improved positively in learning environments where problem solving methods are used (Kanlı & Emir, 2013; Yaman & Yalçın, 2005). Kanlı (2008) has implemented various applications for gifted students with probing based learning method in 6th grade science class '*Electricity in our Life*' unit. As a result of the research, it was determined that probation based learning practices increased the students' motivation and creative thinking levels for success, science learning. It is considered that the project implementations realized in the stage of product creation, which is the last stage of the model, have positive effects on students' creative thinking skills. There are many researches showing that students' creative thinking skills are evolving especially in the teaching environment where the project method is applied in science education (Birinci, 2008; Koray, 2003; Korkmaz, 2002). Since, the interest of the students in the class can be increased by creating a creative class supported with project works in the science classes, and the ability to relate between the reality and the science subjects can be provided (Dede & Yaman, 2003). According to Shearer and Quinn (1996), a creative class environment can be created by using science project works and the interest of students in the class can be increased.

In this research, it is shown that the Purdue model used in science teaching is an exemplary teaching model for increasing creative thinking in students. Because each stage of the model contains effective teaching methods used in science teaching and each stage supports each other.

**Conclusions**

For the development of creative thinking in students, it is significant for the students to produce different solutions for solving the problems in the teaching environment and to carry out researches on these solutions. In this research, positive interaction is provided on verbal and creative thinking of the students by means of various methods and application process as the Purdue Model is in practice.

The Purdue Model enriches the teaching process by dividing it into three phases, and prepares each stage for the next stage in terms of implementation process. Thus, the student is able to apply the knowledge he learned

in the previous phase in the next stage to achieve more effective results. The methods used in the model provide students active exploration, problem solving, solving, researching and creating a product in the science learning process. In this respect, teaching of other topics in science teaching needs to be made widespread by using the model.

The model not only includes the use of active methods, but it also provides these methods to support the weaknesses of each other and it eases teaching. For as student who has taken scientific process skills and problem solving steps consecutively, it is easier for him to plan the research process and to present a solution –oriented product. Moreover, it is important to apply the model developed for gifted students on normal students to obtain positive results in order to popularize the model in science education. It is believed that the model not only has creative thinking but also positive effects on different variables such as academic success, attitude, scientific process skills, motivation. For this reason, it is considered that in future researches, the research of the different topics and the effect of the model on different variables will be significant in terms of increasing the efficiency in teaching environments.

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