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# The Relationship between the Level of Mathematical Thinking and Creative Thinking Skills among the Preparatory Year Students at Najran University

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**Abstract**

This study aims at identifying the relationship between the level of mathematical thinking and the creative thinking skills of the preparatory year students at Najran University in Saudi Arabia. It also aims to know the effect of the secondary general point average (GPA) on the performance of students. To achieve the goal of the study, the researcher used Khatib's (2006) Mathematical Thinking Skills Scale because this measure includes most mathematical thinking skills: induction, conclusion, forced thinking, mathematical proof, logical thinking, guessing, modeling, reasoning, causation, criticism and prediction. This test consists of (80) paragraphs, so that each skill is assigned five paragraphs.

The Torrance Scale of Creative Thinking in its verbal image (A), prepared by Paul Torrance in 1966, was translated and codified on the Saudi environment by Muhammad Hamza Khan (1990). The verbal image of the test consists of 6 sub-tests: 1.Ask questions 2. Guess questions. 3. Guess the results. 4. Improving production. 5. Unusual uses. 6. Suppose that.

The study sample consisted of (85) students of preparatory year students in four sections (two control sections and two experimental sections). The control group consisted of (40) students and the experimental group consisted of (45) students.

To analyze the results, descriptive methods (mean and standard deviations) were used for the results of the pre/test and post-test in the mathematical creativity of the control and experimental groups. The T-test and the two-way ANOVA analysis of variance were used to make a comparison between the control group and the experimental group.

The results of the study showed a relationship between the level of mathematical thinking and the skills of creative thinking and its effect on the achievement of students in mathematics, and the presence of differences of statistical significance at the level of significance ($\alpha$=0.05) shows the achievement of preparatory year students with a high and average (GPA) in the control and experimental groups and for the benefit of the high (GPA).

The results also showed that the experimental group was better than the control group. However, the data show that there are no statistically significant differences due to the interaction between the group and the (GPA).

**Keywords: Mathematical Thinking, Creative Thinking Skills, Preparatory Year Students, Najran University**

## Introduction

The human resources are the real wealth of any society and any nation, and the gifted students at the head of that wealth, so the educational system and educators in our country are facing great challenges and difficulties, related to preparing these students and raise them to meet the future and its needs properly. All students are entitled to educational care that is in line with their abilities and aptitudes, as they are a great national energy and wealth that must be nurtured and cared for, in order to invest them and guide them to serve the society and its development. Therefore, attention to gifted students is a civilized and educational necessity that cannot be dispensed with, especially in our Arab countries, whose educational institutions lack programs and strategies to teach students using the latest strategies and provide the best possibilities.

As the scientific progress that we are living today is the result of the efforts of many creative people, the continuation of this progress is dependent on the release of more creative potential inherent in individuals, as this progress has resulted in problems in various aspects of economic life, social and political, and that need to think and find creative solutions can only be achieved by preparing the individual to face such challenges.

This made learning the thinking skills of various types of the main objectives that the educational institutions seek to achieve in order to adapt to new developments, and the search for sources of information, and use the appropriate ones, to address the problems, and enable students to invest the maximum extent of their creative and sports abilities, in order to keep societies, their growth and development (Jarwan, 2007).

Scientists in different fields have been interested in thought and its concept which represents the most complex types of human behavior, it comes at the highest levels of mental activity, and many of them tried to

 

develop definitions that define the concept of thinking, such the definition of De Bono (2003) where he defined thinking as a wise exploration of experience to reach understanding and decision-making, problem solving, control of things, or doing something. De Bono also defined thinking as: the way in which an individual receives experience, organizes, registers, stores and thus integrates it into his knowledge repository (Qatami, 2003).

It is known that intelligence and thinking are essential to the educational process, intelligence is a genetic issue that depends on genes or on the environment or on a combination of both, while thinking is the working skill through which intelligence exercises its activities on experience and this is the correct relationship between intelligence and thinking (Srour, 2000).

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Thinking is not just a retrieval of the experiences of the individual but also the general meaning of all types of mental activity in individuals, which is characterized by the use of symbols, perceptions, language and concepts in the treatment of things and events rather than through apparent virtual activity (Al-Absi, 2009).

**Mathematical Thinking Skills**

1. Inductive thinking: It is a process of mental reasoning, aimed at reaching conclusions or generalizations that go beyond the limits of available evidence, in which the learner begins to examine certain cases to reach a general conclusion (Abu Zeina and Ababneh, 2007).

2. Deductive thinking: is a logical reasoning process aimed at reaching a new conclusion or knowledge based on hypotheses or introductions and available information, in which the learner begins with the general issues or provisions to arrive at a conclusion or outcome related to a particular case or to apply the general case to special examples and cases (Schielack et al., 2000).

3. Forced thinking (Expression with symbols): Herbert & Brown referred to in Badawi (2008) refers to forced thinking as one of the skills of mathematical thinking, namely, the ability of a person to use mathematical symbols and tools to analyze different situations by extracting information from situations and represent it mathematically in the form of words or symbols or drawings or tables or forms or equations and then the interpretation and application of mathematical results, such as the student solve a mathematical equation to find the unknown, or determine the significant relations (Badawi, 2008).

4. Mathematical proof: in which the student works to produce logical arguments and provide official proofs that explain the effectiveness of their thinking, whether in the form of a paragraph or two columns or any other form of proof (Badawi, 2008). Tall (1991) emphasizes that mathematical proof comes at the top of mathematical thinking, and describes it as the essence of mathematical thinking.

5. Intuitive Thinking (Guessing): Badawi (2008) refers to intuition as one of the basic skills of mathematical thinking. Bruner (1963) defines it as a mental process aimed at arriving at acceptable formulas without going through specific analytical stages, it helps to ascertain whether these formulas are true or false (Badawi, 2008).

6. Modeling: Schielack et al. (2000) listed modeling as a manifestation of mathematical thinking. Kahn & Kyle, (2002) defines mathematical modeling as: translating a problem from the real world into a mathematical representation, then solving it mathematically and translating it into the real context, it includes the use of tables, images, graphic representations, and stock charts.

7. Solving the Mathematical Problem: Mathematical problem solving is one of the skills of mathematical thinking. The student is exposed to a new educational position and does not have a ready-made solution at the time, and he must use the knowledge, understanding and skills he has acquired to solve this problem (Wilson, 1993).

8. Caution (causation): Khatib (2007) refers to the skill of reasoning and causation as one of mathematical thinking skills, which means interpretation and reasons, in addition to comparison and mentioned similarities and differences (Khatib, 2007).

9. Criticism and Prediction: Wilson (1993) refers to the skill of criticism and prediction as a mathematical thinking skill, namely, the student's ability to look at the solution given from several

 

angles, to detect the error in the solution, or if it can be resolved in another way or in an easier way. The skill of prediction means the ability to read the data or information available in the problem or situation, and to infer from it beyond that subject.

10. Logical thinking: Logical reasoning aims to assess the ability to abstract logical reasoning involving induction, extrapolation, and analogy, by recognizing relationships and reasoning and using logic rules to arrive at correct conclusions (Jarwan, 2008).

Since mathematical thinking is directed at discovering rules and laws, solving new problems and finding new solutions to old problems or creating new hypotheses, there is a convergence between it and creative thinking in which the individual needs from time to time to reconsider his work and evaluate it objectively in the light of his previous work and judging it in terms of its originality and modernity.

**Creative thinking**

Guilford defined creativity as: a complex and purposeful mental activity, driven by a strong desire to seek solutions or arrive at previously unknown original products. Creative thinking has also been defined as: mental processes characterized by inclusiveness, complexity, and interrelated cognitive, emotional and moral factors that constitute an active state of mind (Guilford, 1986). Torrance defined creative thinking as a process of sensing problems, recognizing gaps and weaknesses, searching for solutions, predicting, formulating hypotheses, testing and rephrasing them, and generating new solutions by using existing data to produce new learner-driven outcomes (Torrance, 2001).

**Creative Thinking Skills**

The most important creative thinking skills that the researchers tried to measure are: (Abu Jado, 2007)

- Fluency: The ability to generate a large number of alternatives, synonyms, ideas, problems or uses when responding to a particular stimulus, and the speed and ease of generating them.

- Flexibility: It is the ability to generate diverse ideas that are not of the type of ideas usually expected, and to guide or shift the course of thinking with dramatic change or position requirements. Flexibility is the opposite of mental inertia.

- Authenticity: the most relevant characteristics of creativity and creative thinking, and originality here in the sense of novelty and uniqueness, which is the common factor between most of the definitions that focus on creative products as a judge to judge the level of creativity.

- Expansion: It means the ability to add new and varied details of the idea or solution to a problem or panel that will help to develop, enrich and implement.

- Sensitivity to problems: It is meant to be aware of problems, needs or weaknesses in the environment or situation.

**The problem of the study and its questions**

Students face many problems, both at the level of their personal lives or their relationships with others or in the fields of study and work, which requires sincere and great efforts by educational institutions and civil society institutions to overcome these difficulties and problems facing them. Thinking of this study came through the researchers' teaching for the course of mathematics for students of the preparatory year at the University of Najran and identifies some of the problems facing them, with the practice of the process of education and experience, the researcher generates great faith in the importance of interest in the concept of thinking and its different patterns, as the researcher is teaching at the University of Najran as mentioned earlier, and that attention to this aspect by the teacher is not a luxury or something secondary, as learning and understanding the different types of thinking has become an important requirement and vital to all students. Given the vast difference and great gap between human life in the past and his life in this age, we realize that this is all a cumulative product of human thought. During the work of the researcher in teaching at the university and direct contact with them, he noted that there is weakness and lack of concentration of some different types of thinking, and not to employ symbols in the treatment of things and events, and focus only on the treatment through concrete activity, and therefore the researcher has many questions about the extent to which students are interested and have different skills and forms of thinking in general, the problem of the study is determined by the following question: What is the level of mathematical thinking and creative thinking among preparatory year

students at Najran University in Saudi Arabia, and is there a relationship between mathematical thinking and creative thinking skills among these students.

**Questions of the Study**

This study sought to answer the following questions:

1. Are there any statistically significant differences at the level of (α= 0.05) between the mathematical thinking and the creative thinking skills of the preparatory year students at Najran University in Saudi Arabia?
2. Are there statistically significant differences at the level of (0.05 = α) in the level of mathematical thinking among the preparatory year students at Najran University in Saudi Arabia due to the variable of the secondary GPA level (high, moderate)?
3. Are there statistically significant differences between the experimental group and the control group due to the interaction between the group and the secondary GPA level?

**Significance of the Study**

The importance of this study comes from the importance of understanding the relationship between the mathematical thinking and the creative thinking skills of the students in the preparatory year at Najran University, where they form university students in different disciplines later, where the results help to classify them in the appropriate disciplines. The importance can be highlighted by:

**First: The theoretical importance of the study:**

1. The importance of mathematical and creative thinking in educational literature, and the need to provide theoretical literature that can be consulted and supported by researchers and educators, which will contribute to enrich the Arabic library in this field.
2. The lack of studies that dealt with the issue of the relationship of mathematical thinking to the skills of creative thinking among Saudi university students, and after reviewing the theoretical literature and within the limits of the researcher's knowledge, this study is one of the few studies that will address the relationship between the level of both mathematical thinking and creative thinking among preparatory year students in Saudi universities.
3. Encourage researchers to undertake further studies on this relationship to increase their theoretical understanding.

**Second: Practical importance of the study:**

1. The possibility of providing suggestions and guidance regarding mathematical thinking and the nature of its relationship to the creative thinking among gifted students for gifted educators from teachers, mentors, parents, school principals, curriculum designers and educational program designers, and thus contribute to the development and enrichment of plans and programs in the areas of caring for talented students.
2. Mathematical thinking is an educational necessity for the student and it is indispensable to achieve a deeper understanding of the content of knowledge, and employ it in his scientific and practical life and in the domains of solving problems and making appropriate decisions thereon.

**Conceptual and procedural definitions:**

**Mathematical thinking:** Known as the ability to mathematical trial by analyzing, understanding and comparing arithmetic, algebraic and geometric mathematical data, whether in the form of tables, graphs, forms or symbols, and the ability to use numbers, basic computations and mathematical concepts to solve problems of varying difficulty (Jarwan, 2008).

It is defined procedurally: The degree that the student obtains on the scale of mathematical thinking skills used in this study.

 

**Creative thinking:** It is a process of sensitivity to problems, weaknesses, gaps in information or dysfunctions, the search for solutions, prediction, formulation of hypotheses, testing it, reformulation or modification, and the generation of new solutions through the use of available data to reach new results transmitted by the learner to others, it includes flexibility, originality, expansion and sensitivity to problems (Torrance, 2001).

It is defined procedurally: The degree to which the gifted person obtains on the Torrance Scale for Creative and Verbal Thinking (A) prepared and codified on the Saudi environment by Khan (1990), and used in this study.

**The study determinants**

The generalization of the results of this study will be determined in light of the following limitations:

This study was limited to preparatory year students at Najran University in the Kingdom of Saudi Arabia and was also determined by the study tools used represented in the mathematical thinking scale and the Torrance scale for creative thinking.

**Previous studies**

Agha (2009) conducted a study aimed at identifying the effect of the use of brainstorming strategy in the development of some of mathematical thinking skills on both sides of the brain among the 11th grade students. The researcher used the experimental method on a sample of 30 students from 11th grade from the scientific stream of the governmental schools in Khan Yunis Governorate in the State of Palestine, the researcher followed the experimental method, where he divided the sample of the study into two groups, one control and the other experimental, and the researcher taught the sequences and serials units using the brainstorming strategy for students of the experimental group, while the students of the control group were taught the same unit in the normal way. The researcher used the brain control test to classify the students in terms of the controlling side. He used the mathematical thinking test which is consisted of (24) items distributed into six domains (induction, inquiry, conclusion, problem solving and expression with symbols). The study concluded that there were statistically significant differences at the level of significance (0.05) between the average of the experimental and the control groups in the post-application to test the development of some mathematical thinking skills among students of the two dominant sides (right-left of the brain) in favor of the experimental group. He also concluded that there were no statistically significant differences at the level of significance (0.05) in the level of mathematical thinking skills among the experimental group students due to the dominant side of the brain (left - right - two sides together).

Al-Khatib (2006) conducted a study aimed at investigating the effect of using a teaching strategy based on problem solving in the development of mathematical thinking and trends towards mathematics in Jordan. The study sample consisted of (104) seventh grade students randomly divided into two groups, one of which was experimental taught by using problem solving strategy, and the other was control taught by using the usual way. Two-Way analysis of variance was used to study the effect of the teaching strategy and the interaction between the teaching strategy and the level of achievement on mathematical thinking and trends towards mathematics. The results showed that there was no significant difference in the mathematical thinking due to the interaction between the teaching strategy and the achievement level. The results also showed that the attitudes of the experimental group students who studied using teaching strategy based on problem solving were better and higher than those of their peers in the control group.

A study by Alshahab (2003) aimed to identify the role of the teacher in the development of creative thinking among students in public schools from the point of view of educational supervisors and teachers in the Sultanate of Oman, the study sample consisted of (501) teachers and (42) educational supervisors chosen by random stratified method. The researcher used a questionnaire specially designed to reveal the teacher's practice of his role in the development of creative thinking. The researcher reached a number of results, the most important of which is that their practicing of their role in the development of creative thinking among students from the viewpoint of educational supervisors was medium. And that the teachers' practice of their role in the development of creative thinking from the point of view of the teachers themselves was high. And that there are statistical significance differences in assessing the degree of teachers 'practice of their role in the development of

 

creative thinking attributed to the variable job title and in favor of teachers' assessment, and the absence of differences of statistical significance in the degree of teachers' practice of their role in the development of creative thinking due to the gender variable and years of experience and scientific qualification.

Achy (2001) conducted a study aimed at examining the possibility of issuing mathematical generalizations through classroom activities and attitudes. The study sample consisted of a group of eighth grade students who were engaged in mathematical projects during a mathematics course. Some documents were noted for descriptive activities, and videotaping and recording it with a focus on a group of students during the projects of mathematical units, the researcher noted how the students' ability developed through an organized set of classroom activities and sources to build mathematical links between the mathematical models in the curriculum on the one hand and real life attitudes on the other. The analysis of these observations developed the concept of a functional learning environment that takes into consideration the methodological tasks and student activities and teacher goals and students, based on the in-depth analysis of these events, the researcher concluded the conditions of the classroom environment in which students can use mathematics as a tool to complete and expand project generalizations, and to identify practices that have developed students' ability to produce generalizations.

Cai (2000) conducted a study aimed at uncovering the reasoning and justifying strategies used by students in solving algebraic issues. The study sample consisted of (542) students in the sixth grade, where (310) students were selected from China and (232) from the United States. This study required students to perform evaluation performance tasks that require solving the problem and explaining these solutions, and are characterized by the existence of many strategies of solution and representation. The results of the study showed that there is a statistically significant difference in the performance of students for all tasks at the level of ($\alpha$= 0.01) for the benefit of students from China, but the average of students in the United States was higher in statistical terms in problem solving. The educational strategies used by US students to solve the problem were as sensual as drawing or scheduling, while Chinese students used abstract strategies such as the use of law or generalization, possibly due to a clear difference in the organization of algebra and teaching methods in both countries. The achievement of the students in China was the same as those of the United States.

**Methodology of the study**

**Population of the Study**

The study population of the study consisted of the preparatory year students at Najran University in Saudi Arabia in 2015/2016.

**The study sample**

The study sample consisted of (85) students from the preparatory year, consisting of 4 sections (two control sections and two experimental sections). The control group consisted of (40) students and the experimental group consisted of (45) students.

**Study variables**

Independent variables: student's score in secondary school

The dependent variable: creative thinking, mathematical thinking.

**Study Tools:**

**First: Mathematical Thinking Scale:**

The researcher used Khatib's Mathematical Thinking Skills Scale (2006) because this scale includes most mathematical thinking skills: induction, reasoning, forced thinking, mathematical proof, logical thinking, guessing, modeling, reasoning, causation, criticism and prediction. This test consists of (50) items, each skill assigned to five items.

**Validity of mathematical thinking scale**

To verify the validity of the scale, the researcher presented the mathematical thinking scale to a group of Saudi university professors with experience and specialization in the following fields: Educational Psychology, Measurement and Evaluation, Methods of Teaching Mathematics and Psychological Counseling, and they were (6), and asked them to express their views on the appropriateness of the items of the scale and the accuracy of the language, the appropriateness of the scale to achieve the objectives of the study as a whole, and in the light of the views of the arbitrators, the required modifications were made.

**Reliability of the mathematical thinking scale**

To confirm the reliability of the tool, two methods were used:

a. Test/retest: Application of the test and re-application with a two-week interval, on a pilot study from outside the study sample of (10) students of the preparatory year at Najran University at the academic year 2015/2016.

 

b. Calculate the internal consistency of the study sample using the Cronbach's Alpha formula.

**Second: The Torrance Scale of Verbal Creative Thinking (a)**

The Torrance Scale for Creative Thinking (A), prepared by Paul Torrance in 1966, was translated and codified by Khan (1990). The verbal image of the test consists of (6) sub-tests which are: 1. Asking questions. 2. Guess questions. 3. Guess the results. 4. Improving production. 5. Unusual uses. 6. Suppose that.

**Signs of validity and reliability of Torrance Scale of Verbal Creative Thinking (a):**

**Validity of the scale**

1. There were indications of the content validity and construct validity by the scale's representation of the dimensions it contains, and the representation of the scale's items of the theoretical basis on which it was built according to the theory of Gilford.

2. There were indications of the concurrent validity of the scale by its ability to distinguish low-level students and high-level students in the ability to think creatively, as estimated by teachers on a sample of (600) students and (29) teachers. The results of the study found the ability of the test to distinguish between the two categories in the ability to think creatively.

3. The predictive validity of the scale was obtained through the sequential study conducted by Torrance, which lasted (12) years for the achievements of a sample of (236) students. When calculating the correlation coefficients between the performance of the test subjects and the achievement test, male students showed a correlation coefficient of (59%), and female correlation coefficient (46%) between achievement and performance on the Torrance scale of creative thinking (Rousan, 2008).

**Reliability of the Scale**

1. There were indications of the reliability of the scale in verbal form in the study conducted by Torrance on a sample of (117) students studying in grades 5, 6 and 7 using test/retest, and by calculating the coefficient of reliability between the tests of the sub-tests it was found to be (71.0) in its verbal form (Rousan, 2008).

2. There were also indications of the reliability of the scale in its original form by the test/retest in Torrance's study on a sample of (54) students from 7th grade. Torrance has obtained acceptable correlation coefficients for fluency, flexibility and originality, and it can be said that this test is sufficiently reliable (Rousan, 2008).

**Procedures of the Study**

The Saudi image of the Torrance scale was obtained for creative and verbal thinking (A) and training on its application and adopts the validity and reliability done in the Kingdom of Saudi Arabia. Since it is prepared and codified for the Saudi environment, the validity and reliability will not be conducted. A scale of mathematical thinking was also used (Khatib, 2007). The researcher then distributed the study tools to the sample members. The data were then collected, checked and analyzed using the appropriate statistical programs, then the results were produced and some recommendations were written.

**Teaching material**

The adoption of the mathematics course material for preparatory year students at Najran University, Saudi Arabia

**Statistical analysis**

The descriptive methods (means and standard deviations) were used for pre-test and post-test results in the mathematical writing of the control and experimental groups. The T-test and the two-way ANOVA analysis were used to compare the control and experimental group.

**Results of the Study**

The aim of this study is to find out the importance of the relationship between mathematical thinking and the creative thinking skills of the first preparatory year students and its effect on their achievement as a national wealth that must be invested and developed. It also aimed to know the effect of the group and the secondary GPA level on students' achievement.

A preliminary and post-test for students in the preparatory year was conducted in mathematics.

 

**Results relating the first question:** Are there any statistically significant differences at the level of (α= 0.05) between the mathematical thinking and the creative thinking skills of the preparatory year students at Najran University in Saudi Arabia? A post-test was conducted and table (1) shows the results

**Table (1): Mathematical averages and standard deviations of students' performance in the control and experimental groups in the post-exam**

| Group | N | Mean | Standard deviation | T | Df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| Experimental | 300 | 80.10 | 7.236 | 3.429 | 93 | 0.001 |
| Control | 300 | 72.67 | 12.971 | | | |

Table (1) shows the existence of statistically significant differences at the level of significance (α = 0.05) between the achievement of the students of the control group and the experimental group in the post-exam and for the benefit of the experimental group. These differences confirm the relationship between the level of mathematical thinking and the skills of creative thinking and its impact on the achievement of students in mathematics. The mean of students in the experimental group in the post-examination was (80,10) while the average of the control group (72,67).

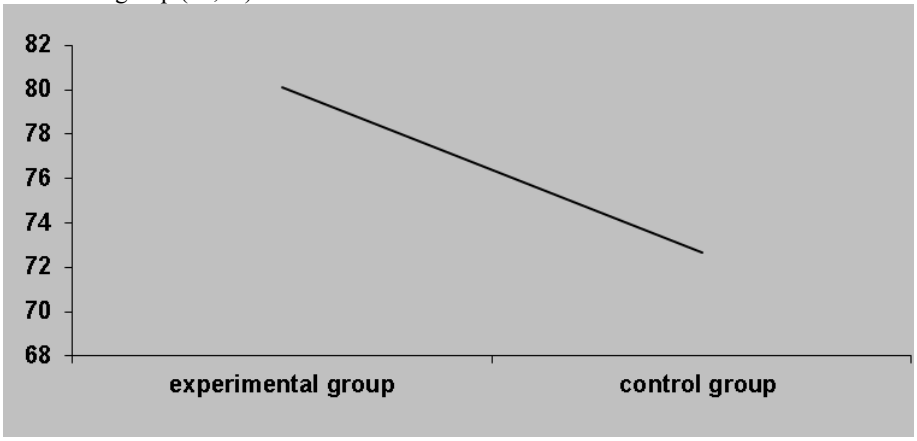


**Chart (1): The arithmetical averages and standard deviations of students' performance in the post-exam.**

**Results relating to the second question:** Are there statistically significant differences at the level of (0.05 = α) in the level of mathematical thinking among the preparatory year students at Najran University in Saudi Arabia due to the variable of the secondary GPA level (high, moderate)? A post-exam was conducted and table (2) shows the results.

**Table (2): means and standard deviations of students' performance according to secondary GPA level**

| GPA | N | Mean | Standard deviation | T | Df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| Moderate | 294 | 77.03 | 10.138 | 0.543 | 93 | 0.590 |
| High | 306 | 75.79 | 11.968 | 0.547 | 91.414 | 0.587 |

Table (2) shows the existence of statistically significant differences at the level of significance (0.05 = α) showing the achievement of preparatory year students with high and moderate GPA levels in secondary in both control and experimental groups and for the group with high rates. These differences indicate that students with high rates have a greater chance of training in creative thinking skills. The average score for students with moderate GPA levels was (77.03) and the mean of high GPA was (75.79).

 

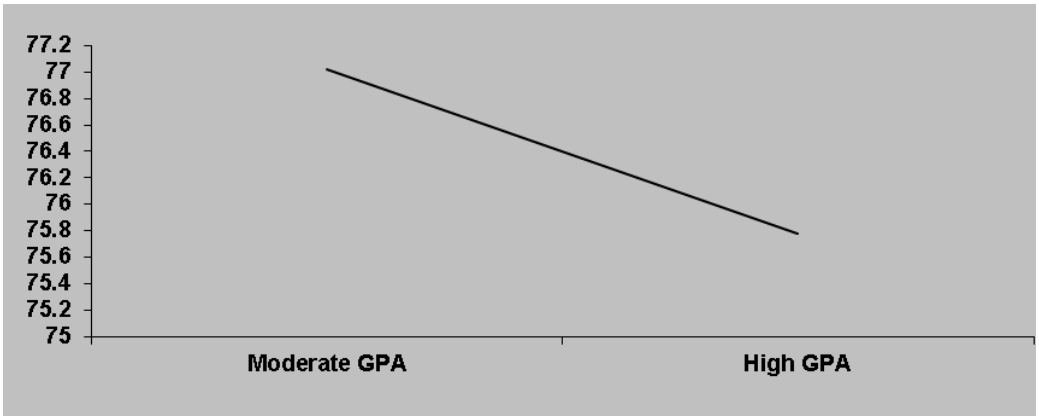


**Chart (2) means and standard deviations of students' performance in the post- testr according to secondary GPA level**

**Results relating the third question:** Are there statistically significant differences between the experimental group and the control group due to the interaction between the group and the secondary GPA level? The researcher also conducted TWO-WAY analysis of variance to analyze final test scores and a table (3) shows the results.

**Table (3): Summary of the results of TWO-WAY analysis of variance of the students' achievement in the posttest**

| Source of variance | Sum of squares | Df | Mean of squares | F | Sig. |
|---|---|---|---|---|---|
| Experimental group | 1251,255 | 1 | 1251,255 | 11.266 | 0.001 |
| GPA | 28.015 | 1 | 28.015 | 0.253 | 0.618 |
| Control group | 122.044 | 1 | 122.044 | 1.100 | 0.298 |
| ERROR | 9996,368 | 91 | 111.072 | | |
| Total | 11441,969 | 94 | | | |

Table (3) shows the existence of statistical significance between the control group and the experimental group in the posttest, the results show that the mean of the experimental group was better than the mean of the control group. However, the data show that there are no statistically significant differences due to the interaction between the group and the secondary GPA.

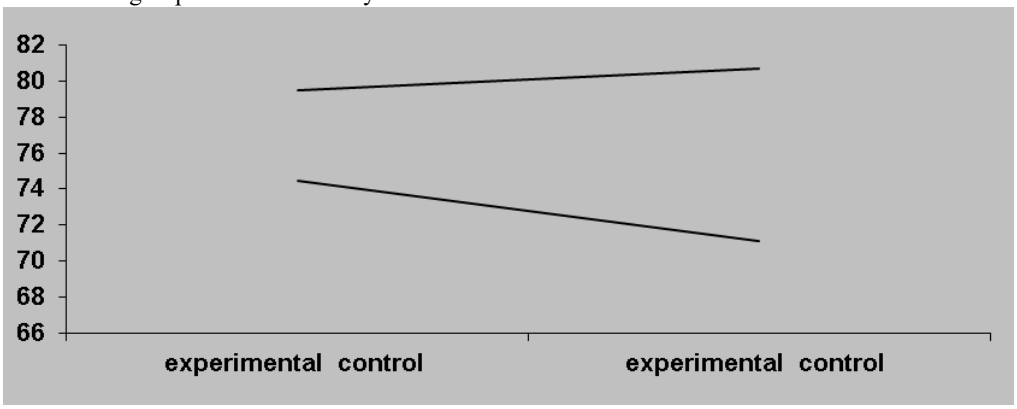


**Chart 3: TWO-WAY Analysis of variance of students' achievement in the control and experimental groups**

**Conclusion**

Our educational institutions should strive to improve educational learning process from the culture of conservation and education to the culture of creativity and thinking. It should provide all educational opportunities that help to develop the mathematical thinking and creative thinking of students and follow all the

 

means available for this, whether by developing mathematics curricula and educational materials or by modern teaching methods and methods of evaluation.

**Recommendations of the study**

In the light of the results of this study and based on the researcher's observations, he recommends the following:

1. Introducing the domain of mathematical and creative thinking in the mathematics curriculum to satisfy the needs of students in mathematics.

2. Organizing and presenting mathematics content based on the development of students' creative thinking.

3. Add questions that help the student to develop both his mathematical thinking and his creative thinking at different organized levels.

4. Holding meetings with teachers in schools, training courses in training centers, and clarifying the importance of focusing on creative thinking in their students and how to invest and develop it in the service of mathematics.

5. Hold courses to illustrate mathematical and creative thinking patterns and how to employ these patterns in solving mathematical problems.

6. Interest in and diversification of student activities that positively contribute to the detection and positive development of their creative thinking patterns.

7. Attention to individual differences through the gradual quality of exercises from easy to difficult, and focus on all types of mathematical thinking.

8. Teaching students mathematical thinking patterns and steps to solve mathematical problems.

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