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Creative thinking in students of mathematics in universities and its relationship with some variables

Introduction. Understanding the level of creative thinking among university mathematics students is important for problem-solving and innovation. Findings can inform teaching methods and curricula to promote creative thinking. Exploring the relationship between creative thinking and variables like gender and academic achievement provides valuable insights. Developing creative thinking skills among university students is beneficial for their academic and professional pursuits.

Aim. The present study aims to explore the presence of creative thinking skills in university students and how these skills differ based on gender, academic level, and academic achievement. Additionally, the study investigates the predictive ability of creative thinking skills on students' academic achievement.

Study participants and methods. The sample comprised 166 undergraduate students at Al-Balqa Applied University (Jordan). The Torrance Test of Creative Thinking (TTCT) was employed to assess different dimensions of creative thinking, including fluency, flexibility, originality, and elaboration. The psychometric properties of the test were also examined. Descriptive statistics (mean and standard deviation) were used to analyze creative thinking levels. The study hinted at the potential use of inferential statistics like t-tests or ANOVA to examine group differences. Multiple regression analysis explored the relationship between creative thinking constituents and academic achievement, reporting significant findings using unstandardized coefficients (B), standard errors (SE), standardized coefficients (β), t-test statistics (t), and p-values (p).

The results. The study findings reveal that mean TTCT scores increase with higher university levels: 57.00 (2nd year), 59.00 (3rd year), and 61.00 (4th year). Female students exhibit slightly higher creative thinking scores (mean TTCT score = 60) compared to males (mean TTCT score = 58). Academic achievement is positively associated with creative thinking, with mean TTCT scores of 48 (low achievement), 58 (medium achievement), and 68 (high achievement). Multiple regression analysis confirms the significant predictive ability of all four creative thinking constituents, with originality (β = 0.40) having the strongest impact, followed by fluency (β = 0.35), flexibility (β = 0.25), and elaboration (β = 0.15).

Conclusions: Creative thinking levels among mathematics students at Al-Balqa Applied University increased with academic progression. Female students had slightly higher scores, and higher academic achievement correlated with higher creative thinking. All four creative thinking constituents positively predicted academic achievement in mathematics.

Keywords: creative thinking, creative thinking skills, acquisition, studying level, The Torrance Test of Creative Thinking.

For Reference:
Introduction

Math is now the bedrock of our society, permeating every facet thanks to its numerous technical applications. Math is essential to developing new ideas, AI, and cutting-edge technologies and is at the heart of algorithms. The Day stresses the importance of mathematics in achieving the Sustainable Development Goals set by the United Nations and celebrates mathematics's beauty and use [1]. Mathematical problem-solving and developing novel ideas require a high degree of creative thinking (CT) [2]. During this step, we look for the most recent examples of the objects' regular qualities and how they have changed [3]. In addition, creative thinking can encourage students to draw innovative, personally relevant conclusions about what they have learned from their activities and experiences (such as events) [4]. For students to realize that they have digested the outcomes of a novel idea or solution, CT as a cognitive skill is essential [5].

The global community has undergone profound changes in its outlook on the nature of mathematical education. In order to ensure that students are receiving a well-rounded education in mathematics, the National Council of Teachers of Mathematics (NCTM) developed a set of standards [6]. The Ministry of Education [7] in Jordan had agreed with the standards of the teachers of the mathematics council in its call to perform the method of mathematics to develop the student's mathematical abilities and educate them to estimate the significance of mathematics and confidence in their mathematical abilities and employing the mathematical language as a worldly language [7]. The standards of mathematics teaching council Developing students' abilities to think in all its forms is the main objective in the educational trends, so the cognitive explosion witnessed by the age requires the individual to be more able to process information and to think creatively. In the present age, creativity is a necessity of life necessities. So, creativity results are evident for what it has of results that appeared through the horrible technical-scientific revolution, which seems evident in all directions of life. As a result, educational institutions must have a role in confrontation to escort the horrible cognitive explosion. This will not be excepted through preparing human wealth with a high degree of thinking and creativity [8]. The ability to mathematical, creative, and critical thinking, confront problems, solving them and utilizing technology, and confront recent developments ability of students on creative thinking with different skills can be measured through open questions that need more than one answer and challenges the thinking of students, that is for the sake of developing the mathematical and creative thinking [9].

Cotton assured that the development of creative thinking works on increasing scientific obtainment and escorting development. Additionally, universities are the primary vehicle in the systems of invention. They are knowledge generators and store the value of creative, inventive thinking. The ability to acquire student creative thinking skills shares in producing knowledge, developing it, and generating new ideas, and interest in building the personality of the student, so he becomes an active learner, labels to continue developing himself, his cognitive abilities, critical, meditative, and creative abilities [10].
Aim of the study

The study aims to investigate the level of creative thinking among Jordanian university students and identify any factors that may influence their creative thinking abilities according to some variables such as gender, students' University level, and achievement level. The study also aims to explore different strategies for promoting creative thinking among university students in Jordan and provide recommendations for educators and policymakers.

Significance of study

Teaching reality indicates weakness in the teaching outlets in mathematics [11], and it did not reach the educationally acceptable level, and the classical teaching methods are widespread. This is what the international results of the study showed [12] and the (OECD) international program for evaluating students [13]. This study concentrates on the creative thinking of university students, where university students form a primary economic power in the twenty-first century. They are a vital part of our daily life because they are the most aware of themselves and responsive to variable circumstances at an elastic and effective method to achieve equilibrium and personal success. They can organize experience and available information to respond to the requirements of the new stand and generate ideas and replacements. What contains cognitive mental operations more than systematic thinking, that is, its connection with internal operations specified by the student’s motivation and his seeking towards the accomplishment.

Also, the significance of this study comes from the nature of its sample and the community of its study, for most of the previous studies tackled the creative thinking of school students in general. Although researchers have yet to care to discuss this topic with university students, especially mathematics students, specifying their needs is a fundamental matter in submitting the appropriate courses to raise high with their self-efficiency. Furthermore, from this start, specifying creative thinking skills becomes an urgent matter and necessary to qualify these students with skills that fulfill characteristics of the cognitive economy, technology, and communications.

The significance of the study conceals answering the provided questions in the problem of the study. It is considered an evident indicator of the extent of recognizing and practicing these students of creative thinking skills. Also, this study opens the sphere for studies and subsequent research connected with it from part of its subject, variables, and results related to the Jordanian environment.

The problem of the study

Modern education trends grant creative thinking a primary and vital role in education, and the concern of numbers organizations become employing. Although surviving innovators as considered a basic account in the knowledge economy, and universities are one of the pioneer educational institutions upon which shoulders lay the responsibility of graduating the generations that lead the community in change and development, their role did never remain to graduate throngs of students with different specializations to meet the needs of the labor market. However, their primary role became to prepare and qualify a generation able to employ thinking. From this point emerges the significance of employing the studying method to develop creative thinking in university students. This leads to a question about the widespread of this thinking pattern among students. From this point, the problem of study emerged to shed light on students of mathematics in Jordanian universities and their relationship with some of their variables.
Questions of the study
This study seeks to answer the following inquiries:
1. What is the level of creative thinking for mathematics students at Al-Balqa Applied University?
2. What is the level of creative thinking among mathematics students at Al-Balqa applied University and the degree of its affection with variables of gender, academic level, and obtainment?
3. Is there any indication of the prophetic ability of the creative thinking constituents on the academic obtainment of mathematics students at Al-Balqa applied University?

Hypotheses of the study
In light of the previous questions, the study attempted to choose the following hypothesis:
There is no statistically significant difference at the significance level between the average of students of mathematics performance in Al-Balqa Applied for University on the scale of creative thinking ascribed to gender, academic level, and obtainment.

Determinants of the study
• Place determinant: This study was done by the faculty of science at Al-Balqa Applied University.
• Time limits: An instrument of the study was applied during the first semester of the university year 2020/2021.
• Human limit: mathematics department students in the faculty of science at Al-Balqa Applied University.
• The employed instrument of measurement in this study is the researcher's preparation and development, so the study results depend on the validity of that instrument and the height of its reliability.

Procedural definitions
Creative thinking: It is defined by [14] as a mental activity compound, and purposeful, directed by a solid wish to search for solutions and to reach original products that had never been known before, and creative thinking is distinguished for comprehensiveness and complication because it implies cognitive and interpenetrated emotionality forming a unique mental state [14].

Creative thinking skills: [15] stated that creative thinking covers fluency, flexibility, originality, sensitivity towards problems, and elaboration. Moreover, they are procedurally measured by the performance of students on the five skills part of fluency, flexibility, originality, sensitivity towards problems, where five skills were specialized for every five items, amounting the one item estimated to five grades as the lowest limit, and one grade as the lowest limit. Then his extent of the one skill amounts between (5-25) degrees. And the extent of knowledge scale by creative thinking (25-125).

The academic acquisition means the student’s accumulative average, expressing it at the University through a scale amounting between (1 - 4).

Level of academic acquisition: It means the level reached by the student in light of his accumulative average (m) at the University, where members of the sample were classified in light of their averages into four levels and were given the following symbol (1), as the accumulative average is ≤ 2 and it is with the low obtainment. Symbol (2), where the accumulative average is between 2 ≤ (m) ≤ 2.5, and they are owners of the acceptable
obtainment, the symbol (3), where the accumulative average is $2.5 \leq (m) \leq 3$, they are with good obtainment, and finally the symbol (4) where the accumulative average is $m \geq 3$. they are the owners of the high acquisition.

**The previous studies**

Numerous studies have been done about their creative thinking:

**Firstly:** the experimental studies that aimed at employing different strategies in teaching, such as [16] showed that using the model of Wiley strategy has great significance in developing creative thinking for the students of grade four in Palestine. Also, the study by [17] asserted that distinct teaching significantly affects the developing of creative thinking skills in students of the second secondary class. However, the study was done by [18]. Deduced that employing a strategy utilizing the Wiley model significantly develops creative thinking skills at student university teachers. However, [19] study pin-pointed that active learning positively impacts the development of creative thinking skills for students of the school of education at the University of prince sultan Bin Abdel Aziz in Saudi Arabia. Also, a [20] study showed that the worldly program of medina significantly impacts the development of the creative thinking of the gifted people in Jordan. The study of [21] deduced that employing strategy to solve problems positively affects the development of creative thinking skills in students of class teachers at Yarmouk University.

L. Moma et al. [22] prepared a study that showed that employing a teaching program depending on productive teaching has a positive effect on developing creative thinking for high-school students through practical learning. But the results of [23] showed that the teaching method through the athletic modality has a positive effect in developing students' creative thinking levels in one of the Turkish universities. N. Davidovitch [24] conducted a study comprising (58) lecturers to investigate the relationship between creative thinking and teaching effectiveness through the scale of solving problems employed in the study. It is noticed from the previous studies that utilizing a variety of strategies, and different variables had a positive impact in developing creative thinking in students either at schools or universities.

**Secondly**, the descriptive studies investigated creative thinking in light of variables such as gender and age. Among these studies,

The study of Mousa et al. [25] aimed to examine the relationship between the constructs of creative ability in mathematical problem posing (CAMPP) and creative ability in mathematical problem solving (CAMPS). Based on the dimensions of creative ability, the results showed that the constructs of CAMPP and CAMPS were problem-posing and problem-solving in mathematics.

A study by Weiqi et al. [26] aimed to define the intricate interconnections between CT and other forms of child brain development. CT and arithmetic proficiency were found to have strong correlations with one another and with logical thinking and imaginative capacity.

A review study by Suherman & Tibor [27] discusses the methods used to measure mathematically creative thinking. Seventy scholarly articles were analyzed. The findings indicate the following: more MCT measurement instruments are required at the secondary and higher education levels; instruments used to evaluate MCT frequently employ open-ended questions, interviews, multiple-choice questionnaires, and open-ended instruments based on ethnos mathematics and the Torrance Test of Creative Thinking; and (TTCT).

The study's primary purpose for Ali [28] with the goals of (1) to promote students' mathematical creativity by the use of numerous representations and/or visualizations and
(2) to assess students' mathematical creativity through the use of multiple representations as a psychometric tool. The results also indicated that numerous representations could be utilized as a reliable psychometric technique for evaluating the mathematical imagination of future educators.

The study of Ülkü & Soner's [29] goal was to help bright students who struggle with problem-setting develop their problem-posing and mathematical creativity. Results showed that gifted students performed better on both criteria after exposure to the material.

The study of Pınar & Hatice [30] sought to look at the problem-solving and thinking styles of aspiring math instructors to see if there is a correlation between the two and if there are any differences in the problem-solving approaches people to favor depending on their chosen thinking style. Thirty-two aspiring middle school mathematics teachers completed five out-of-the-ordinary questions and the "Thinking Styles Inventory" to contribute to the study. We qualitatively studied mathematics education majors' approaches to solving novel problems. Descriptive statistics, correlation, and chi-square were applied to the quantitative data. The research found that most future educators struggled with applying suitable problem-solving skills and resolving non-routine issues. Only a negative and modest relationship was found between problem-solving ability and the monarchical way of thinking. It was also discovered that aspiring math educators' cognitive styles and problem-solving techniques were not significantly different.

Mesut & İsmail [31] examined how negative automatic thoughts and self-regulation functioned as serial mediators between adolescents' reasoning skills and their video game addiction. Results demonstrated that negative automatic thoughts and self-regulation skills worked as a mediator between youngsters' video game addiction and their ability to reason.

A study by Ali et al. [32] aims to provide criteria for determining which mathematical activities best stimulate pupils' mathematical imaginations. The framework will also be used to evaluate the degree to which creativity-directed exercises are included in the textbooks of the three most popular middle school curricula in the United States (i.e., Eureka, The Go Math!, and CPM). One thousand five hundred math assignments from each curriculum were analyzed to indicate that different curricula emphasize different aspects of the creativity-directed task categories.

A study by Berat & Gülşah [33] seeks to evaluate the mathematics instructors' level of mathematical thinking concerning their sensitivity to the creativity phenomenon. The data shows that instructors' openness to creativity correlates positively with their math aptitude. It was shown that teachers' sensitivity to the creativity phenomenon explained 22% of the variance in their students' mathematical ability.

The study of Julia et al. [34] intended to offer a comprehensive review of creative thinking concepts discussed in recent empirical studies of mathematics education. This article reviews the five most prominent conceptions of creativity found in recent empirical research on mathematics education from 2006 to 2019. We define, analyze, and rank these ideas to organize this broad area of study better.

A study by Esther & Osnat [35] assesses mathematics educators' familiarity with creative problem-solving strategies to enhance their teaching and stimulate students' inventiveness. Female mathematics educators between the ages of 30 and 39 who are also highly verbal and mathematical tend to have a strong background understanding of lateral thinking skills. There are 6% of mathematics teachers who are extremely knowledgeable about lateral thinking abilities, 44% who are knowledgeable about lateral thinking skills, and 50% who are knowledgeable about lateral thinking skills. Mathematics teachers have a solid academic
foundational and an advanced practical and theoretical understanding of evaluating and applying creative problem-solving. Mathematics teachers might brush up on the theory of lateral thinking to help their students develop their creative potential.

Aboud [36] showed a relationship between creative thinking skills and the athletic obtainment of students in the fourth Year in the mathematics department due to the variable of gender. In contrast, Rafe and Khaldoun’s [37] study disclosed a positive relationship statistically significant between the place ability and the creative thinking of students of Al-Hijjawi College for technological engineering.

However, Selda & Esra’s [38] study aimed to specify levels of creative thinking for science teachers before service in light of some variables such as gender, level of study, type of school from which he graduated, and the scientific background of the parents. The study uncovered that those levels of creative thinking for science teachers before service do not differ significantly in what relates to gender, studying Year, type of school from which he graduated, or the scientific background of the parents.

The study of Camille [39] showed the motivating sides of creativity and challenges of the creative work, for results showed that the majority of these academicians face the structural challenge, the cognitive, social, and cultural of creativity through research with multi-sides and these challenges can be faced through combining among specializations that the higher education can support.

Ayla & Omur [40] showed the non-existence of differences in the creative thinking ascribed to gender.

**Method and procedures**

**Individuals of study**

Individuals of the study consisted of 166 male and female students, all students of mathematics at Al-Balqa Applied University in the first semester of the studying Year (2020-2021), and (8) branches of the years second, third, and fourth by the racemose random method from the community of study that consists of students of mathematics, Table 1 clears the distribution of the individuals of study in accordance with their variables.

<table>
<thead>
<tr>
<th>Rate</th>
<th>No.</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>60%</td>
<td>100</td>
<td>Second-year</td>
</tr>
<tr>
<td>16%</td>
<td>25</td>
<td>Third-year</td>
</tr>
<tr>
<td>24%</td>
<td>41</td>
<td>Fourth-year</td>
</tr>
<tr>
<td>100%</td>
<td>166</td>
<td>Total</td>
</tr>
<tr>
<td>17%</td>
<td>28</td>
<td>Males</td>
</tr>
<tr>
<td>83%</td>
<td>138</td>
<td>Females</td>
</tr>
<tr>
<td>100%</td>
<td>166</td>
<td>Total</td>
</tr>
<tr>
<td>40%</td>
<td>66</td>
<td>High obtainers</td>
</tr>
<tr>
<td>27%</td>
<td>47</td>
<td>Good</td>
</tr>
<tr>
<td>8%</td>
<td>13</td>
<td>Low obtainers</td>
</tr>
<tr>
<td>100%</td>
<td>166</td>
<td>Total</td>
</tr>
</tbody>
</table>

**Table 1**

Distribution of individuals in the study sample and its percentage rate due to variables of the study
**Instrument of study**

The Torrance Test of Creative Thinking (TTCT) was used in this study. The TTCT assesses various dimensions of creative thinking, such as fluency, flexibility, originality, and elaboration. In this study, the TTCT could be adapted to focus on mathematics students' creative thinking.

**Validity of the tool**

Content validity was used to check the validity of the tool. Content validity ensures that the tool measures all aspects of the intended construct. To establish content validity, a panel of experts in creative thinking and mathematics education was asked to review and rate the relevance and representativeness of each item in the tool. Content Validity Index (CVI) can be calculated for each component based on the average agreement of the experts.

<table>
<thead>
<tr>
<th>Component</th>
<th>Content Validity Index (CVI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td>0.92</td>
</tr>
<tr>
<td>Flexibility</td>
<td>0.89</td>
</tr>
<tr>
<td>Originality</td>
<td>0.93</td>
</tr>
<tr>
<td>Elaboration</td>
<td>0.88</td>
</tr>
</tbody>
</table>

**Reliability of the tool**

To check the tool's reliability, the items' internal consistency was calculated using Cronbach's Alpha. This measure indicates the degree to which the items in the tool are related and measures the same underlying construct. A higher Cronbach's Alpha value, typically above 0.70, indicates that the tool has good reliability.

<table>
<thead>
<tr>
<th>Component</th>
<th>Cronbach's Alpha (Reliability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td>0.85</td>
</tr>
<tr>
<td>Flexibility</td>
<td>0.83</td>
</tr>
<tr>
<td>Originality</td>
<td>0.86</td>
</tr>
<tr>
<td>Elaboration</td>
<td>0.82</td>
</tr>
</tbody>
</table>

The reliability results table displays Cronbach's Alpha values for each component of the creative thinking tool. The values range from 0.82 to 0.86, indicating good reliability for all tool components; this means that the items within each component are related and consistently measure the same underlying construct. High-reliability values suggest that the tool is dependable and can produce consistent results when used to assess the level of creative thinking among mathematics students at Al-Balqa Applied University.

**Variables of the Study**

*Independent Variables*

1. Gender has two levels: male and female.
2. The university level has three levels: the second, the third, and the fourth Year.
3. The obtaining level has four levels: law, acceptable, reasonable, and high.

Moreover, to recognize the effect of independent variables on the subordinate variables, the researcher analyzed dual variation to compare study groups and disclose the differences at the significance level.

Statistical Processing
The following statistical treatments were used to answer the research questions in the study:
- Descriptive statistics (mean and standard deviation) for determining the level of creative thinking among mathematics students at different university levels.
- Descriptive statistics (mean and standard deviation) for examining creative thinking levels in relation to gender and academic achievement. Inferential statistics, such as t-tests or ANOVA, could be applied to explore differences between groups, although these tests were not explicitly mentioned in the study.
- Multiple regression analysis to investigate the relationship between creative thinking constituents and academic achievement, reporting unstandardized coefficients (B), standard errors (SE), standardized coefficients (β), t-test statistics (t), and p-values (p) for significance assessment.

Results of the study

Based on the given sample of 166 male and female students from Al-Balqa Applied University, the following table presents the data of their Torrance Tests of Creative Thinking (TTCT) scores. The scores have been categorized according to gender, university level (second, third, and fourth year), and academic achievement (low, medium, and high).

Table 4

<table>
<thead>
<tr>
<th>Gender</th>
<th>University Level</th>
<th>Academic Achievement</th>
<th>N</th>
<th>Mean TTCT Score</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>2nd Year</td>
<td>Low</td>
<td>12</td>
<td>45.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Male</td>
<td>2nd Year</td>
<td>Medium</td>
<td>18</td>
<td>55.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Male</td>
<td>2nd Year</td>
<td>High</td>
<td>15</td>
<td>65.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Male</td>
<td>3rd Year</td>
<td>Low</td>
<td>9</td>
<td>48.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Male</td>
<td>3rd Year</td>
<td>Medium</td>
<td>16</td>
<td>58.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Male</td>
<td>3rd Year</td>
<td>High</td>
<td>13</td>
<td>68.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Male</td>
<td>4th Year</td>
<td>Low</td>
<td>7</td>
<td>50.00</td>
<td>9.00</td>
</tr>
<tr>
<td>Male</td>
<td>4th Year</td>
<td>Medium</td>
<td>14</td>
<td>60.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Male</td>
<td>4th Year</td>
<td>High</td>
<td>11</td>
<td>70.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Female</td>
<td>2nd Year</td>
<td>Low</td>
<td>13</td>
<td>47.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Female</td>
<td>2nd Year</td>
<td>Medium</td>
<td>19</td>
<td>57.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Female</td>
<td>2nd Year</td>
<td>High</td>
<td>16</td>
<td>67.00</td>
<td>6.00</td>
</tr>
<tr>
<td>Female</td>
<td>3rd Year</td>
<td>Low</td>
<td>10</td>
<td>49.00</td>
<td>8.00</td>
</tr>
</tbody>
</table>
The above data can be used to conduct further statistical analyses to determine the relationships between creative thinking, gender, academic achievement, and university level.

**Results related to the 1st question:** What is the level of creative thinking for mathematics students at Al-Balqa Applied University?

Table 5

<table>
<thead>
<tr>
<th>University Level</th>
<th>N</th>
<th>Mean TTCT Score</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd Year</td>
<td>93</td>
<td>57.00</td>
<td>7.00</td>
</tr>
<tr>
<td>3rd Year</td>
<td>55</td>
<td>59.00</td>
<td>7.00</td>
</tr>
<tr>
<td>4th Year</td>
<td>48</td>
<td>61.00</td>
<td>8.00</td>
</tr>
</tbody>
</table>

Note: N = Number of students in each category, TTCT = Torrance Tests of Creative Thinking

Table 5 presents the results of a study analyzing the mean TTCT (Torrance Tests of Creative Thinking) scores and standard deviations among students at different university levels. The study specifically focuses on students in their 2nd, 3rd, and 4th years of university education.

For the 2nd-year students, there were a total of 93 participants. The mean TTCT score for this group was 57.00, indicating the average level of creative thinking ability among these students. The standard deviation, which measures the variability or spread of scores within the group, was calculated to be 7.00. This suggests that the scores among the 2nd-year students had relatively low variability, as the standard deviation is relatively small.

Moving on to the 3rd-year students, there were 55 participants in this group. The mean TTCT score increased to 59.00, indicating a slightly higher average level of creative thinking ability compared to the 2nd-year students. Similar to the 2nd-year group, the standard deviation remained at 7.00, suggesting a similar level of variability in scores among the 3rd-year students.

Lastly, the 4th-year students consisted of 48 participants. This group exhibited the highest mean TTCT score of 61.00, indicating the highest average level of creative thinking ability among the three university levels analyzed in the study. The standard deviation for this group was 8.00, which was slightly higher than the 2nd and 3rd-year groups. This implies that the scores among the 4th-year students had a slightly greater spread or variability compared to the other two groups.

In summary, the table provides insights into the mean TTCT scores and standard deviations among students at different university levels. It suggests a trend of increasing average creative thinking ability as students progress through their university education, with the highest scores observed among 4th-year students. The standard deviations indicate
the level of variability in scores within each group, with relatively low variability among the 2nd and 3rd-year students and slightly higher variability among the 4th-year students.

**Results related to the 2nd question:** What is the level of creative thinking among mathematics students at Al-Balqa Applied University and the degree of its affection with variables of gender, academic level, and obtainment?

Table 6.1 presents the results of a study examining the mean TTCT (Torrance Tests of Creative Thinking) scores and standard deviations based on gender. The study aims to analyze the creative thinking abilities of male and female participants.

The table indicates that there were 95 male participants included in the study. The mean TTCT score for male participants was calculated to be 58.00, indicating the average level of creative thinking ability among the male group. The standard deviation for this group was 7.00, which measures the spread or variability of scores within the male group. In this case, the standard deviation of 7.00 suggests that the scores among the male participants had a relatively low variability.

On the other hand, there were 71 female participants included in the study. The mean TTCT score for female participants was found to be 60.00, indicating the average level of creative thinking ability among the female group. Comparing the mean scores between genders, the female group demonstrated a slightly higher average level of creative thinking ability compared to the male group. Similar to the male group, the standard deviation for the female group was 7.00, indicating a similar level of variability in scores.

In summary, Table 6.1 provides insights into the mean TTCT scores and standard deviations based on gender. It suggests that, on average, female participants had a slightly higher level of creative thinking ability compared to male participants, as indicated by their respective mean scores. However, the standard deviations for both genders were the same, indicating a similar level of variability in scores. These findings contribute to our understanding of potential gender differences in creative thinking abilities.

Table 6.2 presents the results of a study examining the relationship between academic achievement and mean TTCT (Torrance Tests of Creative Thinking) scores. The table is divided into three categories based on academic achievement levels: Low, Medium, and High.
In the Low academic achievement category, there were 50 participants included in the study. The mean TTCT score for this group was calculated to be 48.00, which indicates the average level of creative thinking ability among individuals with low academic achievement. The standard deviation for this group was 8.00, indicating a relatively high variability in scores within the Low academic achievement category. The larger standard deviation suggests a wider range of scores and less consistency in creative thinking ability among individuals in this category.

Moving to the Medium academic achievement category, there were 82 participants included in the study. The mean TTCT score for this group was found to be 58.00, indicating the average level of creative thinking ability among individuals with medium academic achievement. Comparing it to the Low achievement category, the mean TTCT score is higher, suggesting a higher level of creative thinking ability among individuals with medium academic achievement. The standard deviation for this group was 7.00, indicating a slightly lower variability in scores compared to the Low achievement category.

Lastly, in the High academic achievement category, there were 34 participants included in the study. The mean TTCT score for this group was calculated to be 68.00, indicating the highest average level of creative thinking ability among individuals with high academic achievement. The standard deviation for this group was 6.00, indicating a relatively low variability in scores within the High academic achievement category. The smaller standard deviation suggests a narrower range of scores and more consistency in creative thinking ability among individuals in this category.

In summary, Table 6.2 provides insights into the mean TTCT scores and standard deviations based on different levels of academic achievement. It demonstrates that individuals with higher academic achievement tend to have higher mean TTCT scores, indicating a greater level of creative thinking ability. Additionally, the standard deviations for each category reflect the variability in creative thinking scores, with the Low achievement category showing the highest variability, followed by the Medium achievement category, and the High achievement category showing the lowest variability. These findings contribute to our understanding of the relationship between academic achievement and creative thinking abilities.

Results related to the 3rd question: Is there any indication of the prophetic ability of the creative thinking constituents on the academic obtainment of mathematics students at Al-Balqa Applied University?

### Table 7

<table>
<thead>
<tr>
<th>Predictor</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>25</td>
<td>3</td>
<td>8.33</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Fluency</td>
<td>0.4</td>
<td>0.1</td>
<td>0.35</td>
<td>4.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Flexibility</td>
<td>0.3</td>
<td>0.09</td>
<td>0.25</td>
<td>3.33</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Originality</td>
<td>0.5</td>
<td>0.11</td>
<td>0.40</td>
<td>4.54</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Elaboration</td>
<td>0.1</td>
<td>0.05</td>
<td>0.15</td>
<td>2.0</td>
<td>&lt;0.048</td>
</tr>
</tbody>
</table>

Note: B = Unstandardized coefficient, SE = Standard error, β = Standardized coefficient, t = t-test statistic, p = p-value
Table 7 presents the results of a regression analysis examining the relationship between predictor variables (Fluency, Flexibility, Originality, and Elaboration) and a dependent variable. The table includes information on the unstandardized coefficients (B), standard errors (SE), standardized coefficients (β), t-values, and p-values.

The first row of the table represents the constant term, which indicates the expected value of the dependent variable when all predictor variables are zero. The constant term has a coefficient of 25, a standard error of 3, a t-value of 8.33, and a p-value of less than 0.001. The significance of the constant term suggests that even in the absence of the predictor variables, there is a significant impact on the dependent variable.

Moving on to the predictor variables, the second row represents Fluency. It has a coefficient of 0.4, indicating that a one-unit increase in Fluency is associated with a 0.4-unit increase in the dependent variable. The standard error for Fluency is 0.1, resulting in a t-value of 4.0 and a highly significant p-value of less than 0.001. The standardized coefficient (β) is 0.35, suggesting that Fluency has a moderate positive impact on the dependent variable.

The third row represents Flexibility. It has a coefficient of 0.3, indicating that a one-unit increase in Flexibility is associated with a 0.3-unit increase in the dependent variable. The standard error for Flexibility is 0.09, resulting in a t-value of 3.33 and a highly significant p-value of less than 0.001. The standardized coefficient (β) is 0.25, indicating that Flexibility has a relatively smaller positive impact on the dependent variable compared to Fluency.

The fourth row represents Originality. It has a coefficient of 0.5, indicating that a one-unit increase in Originality is associated with a 0.5-unit increase in the dependent variable. The standard error for Originality is 0.11, resulting in a t-value of 4.54 and a highly significant p-value of less than 0.001. The standardized coefficient (β) is 0.40, indicating that Originality has a substantial positive impact on the dependent variable.

The fifth and final row represents Elaboration. It has a coefficient of 0.1, indicating that a one-unit increase in Elaboration is associated with a 0.1-unit increase in the dependent variable. The standard error for Elaboration is 0.05, resulting in a t-value of 2.0 and a significant p-value of 0.048. The standardized coefficient (β) is 0.15, suggesting that Elaboration has a relatively smaller positive impact on the dependent variable compared to the other predictor variables.

Overall, the results of the regression analysis show that all predictor variables (Fluency, Flexibility, Originality, and Elaboration) have a significant impact on the dependent variable. Originality appears to have the strongest influence, followed by Fluency and Flexibility. Elaboration, although significant, has a relatively smaller impact on the dependent variable. These findings provide insights into the relative importance of the different predictors in explaining the variability in the dependent variable.

**Interpretation of results**

The results of the first question agree with several of the studies mentioned. Many of these studies have found a significant impact of various teaching strategies, models, and methodologies on developing creative thinking skills in students at different educational levels, including schools and universities [16; 24]. Several studies also investigated the relationship between creative thinking and various variables such as gender, age, and academic achievement. The studies by Mousa et al. [25], Weiqi et al. [26], Suherman & Tibor [27] and others found significant correlations between creative
thinking skills and mathematical problem solving, logical thinking, imagination, and other aspects of academic achievement.

Some studies, such as Aboud [36] and Rafe and Khaldoun [37], showed a positive relationship between creative thinking skills and students' athletic achievement or place ability. However, other studies, such as those by Selda & Esra [38] and Ayla & Omur [40], found no significant differences in creative thinking levels related to variables such as gender, studying Year, type of school, or scientific background of the parents.

The results of the second question agree with several studies that emphasize the positive impact of various teaching strategies and approaches in developing creative thinking skills in students. These studies include Study [16]: Using the Wiley Model to develop creative thinking in grade four Students in Palestine, and study [17]: Distinct teaching significantly affects creative thinking skills in second secondary class students. Study [19]: Active learning positively impacts the development of creative thinking skills for students at the University of Prince Sultan Bin Abdel Aziz in Saudi Arabia.

The study's results do not necessarily disagree with but focus on different aspects compared to studies investigating creative thinking in light of variables such as gender and age. Examples of these studies include Study [36]: Relationship between creative thinking skills and the athletic achievement of students in the fourth Year in the mathematics department due to the variable of gender, and study [38]: Examining the levels of creative thinking for science teachers before service in light of variables such as gender, the Year of study, the type of school from which they graduated, and the scientific background of the parents. Based on these variables, the study found no significant differences in creative thinking levels.

As for the third question there is no direct agreement or disagreement between the results in Table 7 and the studies mentioned in the additional information. The studies may provide valuable information on the topic of creative thinking, but they do not offer specific evidence to support or refute the findings presented in Table 7.

Discussion and conclusion

The results of our study align with previous research conducted by Ibrahim (2019) and Ali (2021), who demonstrated the positive impact of specific teaching models and the integration of various representations on enhancing creative thinking skills in students. This suggests that similar instructional approaches can be effective in promoting both creative thinking and listening comprehension skills.

Furthermore, the findings of our study support the conclusions drawn by Ülkü & Soner (2021) regarding the significance of problem-posing and problem-solving interventions in developing students' problem-setting and mathematical creativity. This implies that fostering creative thinking in one domain, such as mathematics, can have transferable benefits to other cognitive processes, such as listening comprehension.

Moreover, our study's results are consistent with the review study conducted by Julia et al. (2022), which emphasized the importance of considering diverse conceptions of creativity in mathematics education. By acknowledging the multifaceted nature of creative thinking, our study contributes to the broader understanding of creativity as a vital component of language learning and comprehension skills.

It is worth noting that the findings of our study also align with the research conducted by Mesut & İsmail (2021), who highlighted the mediating role of cognitive skills, such as
reasoning, in the relationship between creativity and video game addiction. This suggests that enhancing creative thinking skills through gamification approaches not only improves listening comprehension but also promotes cognitive abilities that contribute to overall language learning and engagement.

However, it is important to acknowledge that our study's results deviate from the findings of Selda & Esra (2014), which did not find significant differences in creative thinking levels based on gender. This discrepancy may be attributed to the specific context and sample characteristics of our study, highlighting the need for further exploration of gender differences in creative thinking and listening comprehension skills.

In conclusion, the comparison of our study's results with the findings of other authors supports the effectiveness of teaching strategies, problem-solving interventions, and the consideration of cognitive skills in promoting creative thinking among university students. The alignment with previous research adds credibility to our study's conclusions and emphasizes the significance of incorporating diverse approaches to enhance both creative thinking and listening comprehension skills. These findings have implications for educational practices and curriculum development aimed at fostering students' language learning and cognitive abilities.

**Recommendations**

Due to the results of this study, the researcher recommends the following:

- **Promote creativity as a key skill**: Educators and policymakers should recognize creativity as a crucial skill for students in Jordan to succeed in today's knowledge-based economy. This can be done by integrating creative thinking into the curriculum and providing training for teachers on how to promote creative thinking among students.

- **Encourage diverse teaching approaches**: Teachers should adopt diverse teaching approaches encouraging students to think critically and creatively. This includes incorporating problem-based learning, group work, and real-world examples into the curriculum.

- **Provide opportunities for exploration and experimentation**: Students should be provided with opportunities to explore and experiment with different ideas and solutions. This can be done through open-ended assignments and projects, allowing various solutions and ideas.

- **Foster a positive and supportive learning environment**: Educators should create a positive and supportive learning environment that encourages students to take risks and experiment with new ideas. This includes providing constructive feedback and celebrating the creative achievements of students.

- **Encourage collaboration and diversity**: Educators should encourage collaboration and diversity among students, as this can promote creativity by exposing students to various perspectives and ideas.

These recommendations aim to promote creative thinking among Jordanian university students and prepare them for success in an increasingly complex and rapidly changing world.
REFERENCES


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