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INVESTIGATION OF PRE-SERVICE MATHEMATICS TEACHERS' CREATIVE THINKING TENDENCIES

(Research article)

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Abstract

Creative thinking has played a critical role in a number of fields such as science, technology, economy, and education. Given the necessity of creative thinking in mathematics teaching, it can be argued that teachers are responsible for transforming their students into creative thinkers. In this context, the present study aims to determine pre-service mathematics teachers' levels of critical thinking tendency and the main as well as interaction effects of demographic variables (i.e., gender, year, and academic achievement) on critical thinking tendency. The study makes use of the survey and causal-comparative designs. The study included 130 pre-service elementary mathematics teachers and used "The Marmara Creative Thinking Tendencies Scale" developed by Özgenel and Çetin (2017) as the data collection tool. Descriptive and two-way analysis of variance were used. The study reported high creative tendency levels of pre-service teacher. Another outcome of the study shows that the variables of gender, year, and academic achievement did not have significant main effect on creative tendency levels of pre-service teachers. Besides, the interaction effect of gender-year and gender-academic achievement on the creative thinking tendency levels of pre-service teachers are not statistically significant. Based on the findings, recommendations for future research and educational implications are presented.

Keywords: Creative thinking, creative thinking tendency, mathematical creativity, pre-service teachers

1. Introduction

The skills required by today's workforce and the world are changing (Organisation for Economic Co-operation and Development [OECD], 2017). The four C's of these skills are essential skills in a knowledge-based economy and are interlinked: critical thinking, communication, collaboration, and creativity (Varona, 2020). In the past few decades, creative thinking has played a critical role in a number of fields such as science, technology, economy, and education (OECD, 2019). Therefore, creative thinking has moved from a periphery to the center in recent years (Craft, 2006). Thanks to the developments in the field of education, the importance of creative thinking as a teacher ability has increased in Turkey (Counsil of Higher Education, 2021) and in the world (Pellegrino & Hilton, 2012). Given the necessity of creative thinking in mathematics teaching, it can be argued that teachers are responsible for transforming their students into creative thinkers (Bicer, Lee, Perihan, Capraro, & Capraro, 2020; Leikin & Elgrably, 2020; OECD, 2019). In this context, the present study examined pre-service mathematics teachers' creative thinking tendencies.

1.1. Creative Thinking

The concept of creativity has been discussed since ancient Greece. It is derived from the English word ‘create’ and Latin word ‘creare’ which mean ‘to produce’, ‘to reveal’, ‘to make something happen’ (Andreasen, 2015). Torrance (1977) defines creativity as a process of finding problems in the given information, offering related hypotheses, testing these hypotheses, making progress and, finally, synthesizing the obtained findings and revealing the results, and states that this process is likely to result in presenting a verbal or non-verbal or an abstract or a concrete product.

Creative thinking (CT), a concept related to creativity, is a way of thinking which yields new and valuable ideas (Sternberg, 2003) and usually aims at associating irrelevant concepts/ideas with each other (Rawlinson, 2017). Runco, Millar, Acar, and Cramond, (2010) state that CT is an original way of thinking based on the relationship of imagination, genetics, talent, intelligence, and thought. Similarly, according to the expression of Dou, Li, and Jia, (2021), CT is a form of regenerative thinking built on the dissemination and implementation of new products. Besides, the essence of CT is originality and divergent thinking at its core. In divergent thinking, students produce numerous answers to a problem that does not have a standard solution (Volle, 2018). OECD (2019), on the other hand, considers CT as the skill to generate, evaluate and develop ideas that can lead to the expression of imagination, the development of knowledge and producing novel solutions. Considering the definitions, it is seen that CT is considered as an original and regenerative way of thinking, and the concepts of imagination, originality and novel solutions are emphasized.

Even though creativity and CT are not equivalent concepts, they are often used interchangeably. However, it can be argued that creativity is more comprehensive compared to CT. While creativity involves both mental and performance activities, CT is more related to mental activities (Olsen, 1954). In the process of developing CT, knowledge and skill have parallel importance, because knowledge is the raw material of creativity (Couger, Higgins, & McIntyre, 1990; Duo et al., 2021). Thus, creativity clearly involves CT. In addition, originality, which is an important indicator of creativity, and the fact that CT requires novelty is an important intersection of the two concepts (Hardy, Ness, & Mecca, 2017).

According to Davis (2003), individuals who can think, produce, question, and solve and create problems possess the CT ability. CT is not an innate skill; it can be rather learned and improved within time (Renshaw, 2011). Therefore, teachers undoubtedly play a central role in the development and improvement of students’ CT skills in a school environment.

CT skills do not always suffice on their own for an individual to become creative because an individual’s tendency to benefit from their CT skills is a pre-condition for creativity. In other words, it is difficult to turn a skill into a product/idea without a preliminary tendency, as these tendencies contribute to an individual’s general thinking performance to a great extent (Tishman & Andrade, 1996). In this respect, CT tendency can be defined as an individual’s orientation towards using their CT skills (Özgenel & Çetin, 2017). Rogers (1959) stated that a major indicator of creativity was an individual’s tendency for self-actualization, since an individual must tend to reveal their personal traits and use CT skills. Therefore, creative actions are usually related to skills and tendencies (Batey, 2012). It can be observed that individuals with CT skills are usually curious, determined (assertive and persistent), cooperative and disciplined (Lucas, Claxton, & Spencer, 2012). Also, measuring CT is a vital part of educational assessment (Kaufman, 2006). CT can be measured through testing and non-testing methods. Testing methods may include thinking skills tests, and tests have been developed to determine individuals' CT skills (Kim, 2017). For example, The Torrance Tests of Creative Thinking is one of the most widely used tests to measure creative thinking skills (Bart, Hokanson, & Sahin, 2015). In this study, the test method was used to measure the CT tendency. In addition to CT and tendency, the nature of creativity and its relationship with subject-general and subject-specific creative have always been controversial (Schoevers, Kroesbergen, & Kattou, 2018). At this point, the concept of mathematical creativity must be considered within the framework of subject-specific creativity.

1.2. Mathematical Creativity and CT

There has been so far no consensus on the definition of mathematical creativity as a subject-specific concept (Leikin, 2009). According to Poincare, mathematical creativity is the task of creating a meaningful whole by bringing irrelevant concepts together (As cited in Sriraman, 2009). On the other hand, Hadamard (1945) argued that mathematical creativity brings different ideas together because it is necessary to reach a consensus among various ideas in order to reach a certain level of mathematical creativity. As the number of combined ideas will be infinite, an individual with CT skills need to find the most optimal and meaningful combination for problem-solving (As cited in Regier & Savic, 2020). In short, the intersection of Poincare and Hadamard's definitions of mathematical creativity is 'choices'.

Krutetskii, a well-known psychologist, defines mathematical creativity as the task of interpreting and generalizing a mathematical problem. In addition, mathematical creativity involves developing strategies for problem-solving, finding theorems and proofs, omitting irrelevant generalizations and using different strategies for the solution of ordinary problems (As cited in Haylock, 1997). Laycock (1970) defines mathematical creativity as the ability to approach a problem from different angles, perform analysis and distinguishing between similarities and differences. Sriraman (2005), similarly, considers mathematical creativity paying attention to differences in a mathematical problem and a decision-making process. It can be inferred from these definitions that mathematical creativity is highly associated with problem-solving process.

Leikin (2009) underlines the role of mathematical creativity in activating the human mind and thus sees it as an important skill in the development and appreciation of mental capacity. It must be remembered that a skill which has not been used or reflected upon for a long time will become useless inevitably. Therefore, creativity can be considered as an indispensable element for mental dynamics. In addition, another contribution of mathematical creativity process to an individual is the opportunity to benefit from generalizations (Poincare, 1952; as cited in Schindler & Lilienthal, 2020). Because, mathematics always aims to prove solutions, formulizations occupy an important position in the discipline (Sriraman, 2009). In sum, various definitions of mathematical creativity can be synthesized to reach the following definition:

Mathematical creativity is the task of realizing complex relationships in a mathematical problem, reaching different generalizations through these relationships, solving problems through different strategies, finding the missing information in a given problem, creating new problems, and exploring mathematical knowledge to structure it in the human mind (Balka, 1974; Ervynck, 2002; Haylock, 1987; Sriraman, 2005). Teachers are expected to design creativity-directed learning environments in order to improve CT as a critical element in the development of mathematical thinking capacity (Leikin & Elgrably, 2020).

1.3. Pre-Service Mathematics Teachers and CT

The role of a teacher in the development of CT is undeniable (Akpur, 2020). When the existing literature in Turkey is analyzed, it can be observed that various studies focused on mathematics teachers' behaviors related to supporting students creativity (Yenilmez & Yolcu, 2007; Yıldız & Baltacı, 2018), the relationship between pre-service teachers' (PSTs) beliefs and attitudes towards the history of mathematics and their levels of creativity (Aydoğdu & Yüksel, 2013), pre-service elementary mathematics teachers' views on CT (Dündar, 2015), the differences between genders in terms of pre-service high school mathematics teachers' CT tendencies (Cenberci, 2018; Çenberci & Yavuz, 2018), PSTs' subject-specific creativity scores at the departments of preschool, mathematics, and science teaching (Korur & Yılmaz, 2020).

Studies dealing with PSTs' CT brought gender variable to the forefront (e.g., Ai, 1999; Baer & Kaufman, 2008; Furnham & Nederstrom, 2010; Tsai, 2013). However, the findings which revealed the differences between two genders in terms of CT contradict with each other. This is because some studies reported that male PSTs' levels of tendency were higher (e.g., Stoltzfus, Nibbelink, Vredenburg, & Hyrum, 2011), whereas other studies reported that those of female PSTs were higher (e.g., Gök & Erdoğan, 2011; Kaufman, 2006; Köse, Çelik-Ercoşkun, & Balcı, 2016). In addition, some studies did not report any significant differences between two genders (e.g., Furnham & Nederstrom, 2010; Kozikoğlu & Küçük, 2020; Tican, 2019; Tsai, 2013).

Thanks to the role of educational designs in the development of CT (Leikin & Elgrably, 2020), PSTs' year levels is another variable used in the previous studies (e.g., Durnacı & Ültay, 2020; Fasko, 2001; Furnham & Nederstrom, 2010; Köse et al., 2016; Lee, 2013). However, these studies yielded contradictory findings that PSTs' CT significantly differed in terms of their year levels (e.g., Lee, 2013) or not (e.g., Furnham & Nederstrom, 2010). Additionally, although pre-service preschool, primary, science teaching teachers' CT tendencies were analyzed based on their year levels (e.g., Durnacı & Ültay, 2020; Köse et al., 2016; Yenice & Yavaşoğlu, 2018), no similar studies have been so far conducted on pre-service mathematics teachers.

One of the major reasons why CT has started to occupy a central position in education is the acknowledgment of the idea that students' CT are important for their academic achievement (Ai, 1999; Akpur, 2020; Sebastian & Huang, 2016; Yang & Zhao, 2021). Studies dealing with CT and academic achievement are mostly correlational research. For example, while some studies reported a positive correlation between CT and academic achievement (e.g., Bart, Can, & Hokanson, 2020; Huang, Peng, Chen, Tseng, & Hsu, 2017; Schoevers et al., 2018; Sebastian & Huang, 2016), other studies reported no correlations (e.g., Ai, 1999; Tong & Wo, 2002) or a negative correlation between them (Anderson, White, & Stevens, 1969; as cited in Yang & Zhao, 2021). However, it was seen that the study focusing on the relationship between CT and academic achievement at the university level in Turkey was carried out on university English prep class students (e.g., Akpur, 2020). Considering research results, the existing studies in the literature again reported ambiguous or contradictory results on the topic.

1.4. Rationale and Aim of the Study

Considering the fact that tendency is a pre-condition for the effective use of CT skills (Tishman & Andrade, 1996) the number of studies dealing with pre-service mathematics teachers' CT tendency in the existing literature is fairly limited (e.g., Cenberci, 2018; Çenberci & Yavuz, 2018). Therefore, the present study extends and expands the mathematics education literature. Besides, Torrance (1962) revealed the differences between individuals' CT potentials in different age groups and reported that CT potential tended to decreases during the middle school years (As cited in Ülger, 2014). Therefore, it is considered important to examine the CT tendency of pre-service elementary school mathematics teachers who will teach in a critical period for students' physical and cognitive development, i.e. adolescence.

The present study focuses on pre-service mathematics teachers' CT tendencies in terms of gender, year, and academic achievement variables. The reason why these variables are taken into account lies in the fact that the development of CT is affected by several factors which have not been fully explored yet (Levenson, 2013). Besides, researchs reported ambiguous or contradictory results, therefore further studies are needed. In this respect, the present study fills an important gap in terms of analyzing pre-service mathematics teachers' CT tendency in terms of gender, year, and academic achievement. In addition, the present study also differs from previous studies in the existing literature in that it aims to test the interaction effects of gender-year and gender- academic achievement variables on PSTs' CT tendencies.

Educational programs for pre-service teachers should be designed to train them as a keen user of effective and creative approaches (Goos, 2005). Therefore, the present study contributes to the existing literature in terms of revealing pre-service mathematics teachers' current CT tendencies and giving feedback regarding the effectiveness of teacher training programs. The findings of the present study are likely to yield important results for the improvement of teacher training programs.

Taking into account the above-mentioned factors, the present study aims to determine pre-service mathematics teachers' levels of CT tendency and the main and interaction effects of demographic variables (i.e., gender, year, and academic achievement) on the concept of CT tendency. For the general purpose, answers to the following questions were sought:

(1) What is the level of CT tendency of pre-service mathematics teachers?

(2) What is the effect of gender and year level on CT tendency of pre-service mathematics teachers?

(3) What is the effect of gender and academic achievement on CT tendency of pre-service mathematics teachers?

2. Methodology

2.1. Model

The study makes use of the survey and causal-comparative designs within the context of its quantitative paradigm. The purpose of survey research studies is to define the characteristics of a population regarding one or multiple variables. A type within the scope of survey research, cross-sectional surveys involves collecting information from the population in one attempt (Fraenkel, Wallen, & Hyun, 2012). In causal-comparative research, on the other hand, the objective is to assess the significant differences between two or more non-manipulable groups (Fraenkel et al., 2012; Pallant, 2015). The present study adopts the cross-sectional survey pattern while identifying the level of CT tendency of pre-service mathematics teachers while the causal-comparative design was used to contrast the CT tendencies in terms of gender, year, and academic achievement level.

2.2. Sampling

The research population consists of 211 pre-service elementary mathematics teachers enrolled at the department of education of a public university located in the Eastern Anatolian Region of Turkey. The method of convenience sampling was used to identify the research sample. In convenient sampling, a group of participants who are easy to participate in the study is formed (Fraenkel et al., 2012). Also, the present study identified pre-service mathematics teachers having been/being enrolled on subject-specific mathematics education courses such as Basics of Mathematics I-II, Mathematical Learning and Teaching Approaches, Middle School Mathematics Education Program, Special Teaching Methods I-II. Thus, the information assumed for sample selection was teachers having subject-specific education courses for at least a year. In this respect, the study sample included 130 pre-service mathematics teachers enrolled in their second, third and fourth years of university studies. Thereinafter, the researchers prefer to use PST to refer pre-service elementary mathematics teacher for a shorter and clearer expression. The descriptive analysis results of the demographic information of the PSTs are given in Table 1.

Table 1. *Descriptive analysis results of the demographic information of the PSTs*

Independent variable	Subgroup	N	%
Gender	Female	87	66.9
	Male	43	33.1
Year	2	46	35.4
	3	47	36.2
	4	37	28.5
Academic achievement	Low (2.99 and below)	45	34.6
	Moderate (From 3.00 to 3.49)	61	46.9
	High (3.50 and above)	24	18.5
Total		130	100

As seen in Table 1, the majority of the PSTs are female (66.9% female, 33.1% male). The number of PSTs in terms of their year levels are close (35.4% sophomores, 36.2% junior, and 28.5% senior classes). PSTs have the most "moderate (46.9%)" and the least "high (18.5%)" academic achievement levels.

2.3. Instruments

2.3.1. Demographic information form

The Demographic Information Form was used to determine PSTs' demographic information such as gender, year and academic achievement level (the grade point average [GPA] for the last term). GPAs were evaluated as low if it was “2.99 and below”, moderate if between “3.00-3.49”, and high if “3.5 and above”.

2.3.2. The Marmara Creative Thinking Tendencies Scale

The Marmara Creative Thinking Tendencies Scale was used to identify the CT tendencies of PSTs. The scale developed by Özgenel and Çetin (2017) is structured as a 5-point Likert scale (from Always to Never). Without any negative items, the scale consists of 6 sub-dimensions (e.g., self-discipline, looking for innovation, courage, curiosity, doubting, flexibility) and a total of 25 items. The six factors of the scale explain 55.90% of the total variance. A high point from the scale indicates an increase in the CT tendencies levels of PSTs. The consistency coefficients for the sub-dimensions of the scale (e.g., self-discipline, looking for innovation, courage, curiosity, doubting, flexibility) were calculated as .68, .83, .72, .67, .71, .62, respectively, and as .87 for the overall scale (Özgenel & Çetin, 2017). In the present study, the internal consistency coefficients were calculated for the sub-dimensions as .73, .83, .69, .59, .72, .61, respectively, and as .91 for the overall scale.

2.4. Data Collection and Analysis

The ethics board approval and relevant institutional permissions were granted prior to the data collection process for the study. The PSTs to participate in the study were informed and their consent was obtained with an Informed Consent Form. Therefore, the PSTs participated in the study voluntarily. The data collection tools were applied to the PSTs via online means.

A packaged statistical software tool was employed to analyse the data obtained for the study. Initially, the scoring limits of the scales were set to identify the CT tendency levels of the PSTs participating in the study. For this reason, "4.20-5.00 very high, 3.40-4.19 high, 2.60-3.39 moderate, 1.80-2.59 little, 1.00-1.79 very little" ranges were taken into consideration in the evaluation of the average scores of the scale.

Two-way analysis of variance (two-way ANOVA) was used to examine whether the CT tendency levels of PSTs differ based on the variables gender, year, and academic achievement. Two-way ANOVA is a technique allowing researchers to analyse the main effect and the interaction effect of two independent variables on a dependent variable. In other words, this technique enables researchers to test both the impact of each independent variable on the dependent variable and any interaction effect (Pallant, 2015). In this study, the independent variables were "gender, year, and academic achievement" as well as the dependent variable was "CT tendency". The present study makes use of two-way ANOVA to test both the effect of the independent variables of gender, year, and academic achievement on the CT tendency levels of PSTs separately and the interaction effect of gender-year and gender-academic achievement collectively.

The assumptions were tested before applying two-way ANOVA: measuring level, observations independency, variance homogeneity, normal distribution. In terms of the measuring level assumption, the CT tendency scores, which constitute the dependent variable of this study, entails continuous measurement. The observations constituting the data (PSTs) are independent of one another. The assumption of variance homogeneity was tested using Levene's Test. Therefore, the Levene's Test significance levels dealing with the variables of gender-year and gender-academic achievement are .73 and .64, respectively. As the significance values obtained from Levene's Test are $p > .05$, the variance homogeneity assumption was not refuted.

Another assumption for the study was normal distribution. The normality of the data may be examined by means of skewness and kurtosis values as well as through formal normality tests (Pallant, 2015; Razali & Wah, 2011). For normal distribution; while the skewness and kurtosis levels being between ± 1 are considered to be perfect limits, the values ranging between ± 2 were deemed acceptable (George & Mallery, 2001). Furthermore, the Shapiro-Wilk Test (S-W) should be used in cases where the sample size is below 50 while the Kolmogorov-Smirnov Test (K-S) is recommended to be employed if the sample size is greater than 50 (Razali & Wah, 2011; Stevens, 2009). The statistically insignificant value obtained from the test results indicates the normal distribution of the data ($p > .05$). Table 2 shows the normality analysis results of the average CT tendency scores of PSTs according to the factors of the independent variables of gender-year and gender-academic achievement.

Table 2. *Normality analysis results of the average CT tendency scores according to factors of the independent variables*

Gender	Year	N	Mean	Sd	K-S	p	S-W	p	Skewness	Kurtosis
Female	2	38	3.68	.55	.12	.19	.96	.19	- .48	- .48
	3	25	3.79	.46	.11	.20	.98	.87	- .04	- .49
	4	24	4.02	.42	.08	.20	.99	.97	.19	- .04
Male	2	8	3.98	.56	.23	.20	.91	.36	- .76	- .42
	3	22	3.97	.52	.16	.18	.95	.28	.09	.01
	4	13	3.77	.56	.18	.20	.93	.34	.63	- .72
	Academic achievement									
Female	Low	24	3.84	.57	.12	.20	.95	.28	- .54	- .14
	Moderate	47	3.78	.45	.09	.20	.96	.14	- .64	.31
	High	16	3.81	.58	.14	.20	.98	.94	.02	- .07
Male	Low	21	3.77	.57	.12	.20	.97	.68	.35	- .63
	Moderate	14	3.98	.49	.15	.20	.97	.93	.05	.02
	High	8	4.16	.47	.16	.20	.97	.87	- .60	.00

An examination of Table 2 reveals that according to the K-S and S-W test results, the average points are suitable for normal distribution based on all factors of the independent variables of gender-year and gender-academic achievement ($p > .05$). Furthermore, all skewness and kurtosis coefficients for the average scores in terms of all factors of the indicated variables were within the range of ± 1, indicating fitness for normal distribution. Thus, the assumptions for the two-way ANOVA were deemed to be satisfied.

The study also involved the calculation of effect sizes. Effect size statistics inform the researcher about the extent of the differences between groups (Pallant, 2015). The partial eta squared ($\eta 2$) effect size statistic was used to compare the groups. The obtained eta squared values were interpreted as .01 = small effect, .06 = moderate level effect, .14 = big effect (Pallant, 2015). In the analysis of the study, the statistical significance level was accepted as .05.

3. Findings

Regarding the first sub-problem of the study, Table 3 shows the descriptive analysis findings concerning the identification of CT tendency levels of PSTs.

Table 3. *Descriptive statistics related to CT tendency of PSTs*

Sub-dimensions	N	$\overline{X}$	Sd	Level
Self-discipline	130	3.69	.64	High
Looking for innovation	130	3.84	.58	High
Courage	130	3.60	.74	High
Curiosity	130	4.10	.66	High
Doubting	130	4.05	.62	High
Flexibility	130	4.01	.62	High
Total	130	3.84	.52	High

An assessment of Table 3 reveals that the CT tendency scores of PSTs were close in terms of the sub-dimensions of the scale. In this respect, the PSTs opted for the answer "generally" for the items indicated in all sub-dimensions of the scale. The sub-dimension “curiosity” ($\overline{X}$ =4.10), produced the higher CT tendency scores of PSTs whereas “courage” had the lowest scores ($\overline{X}$ =3.60). The findings indicated that the CT tendency levels of PSTs were "high (generally)". This outcome may be construed as a promising sign in terms of the application of CT skills and fostering of CT environments for students by PSTs.

As far as the second and third sub-problems of the study are concerned, the two-way ANOVA was used to test both the main effect of each independent variable on the CT tendency levels of PSTs and the interaction effect of the two independent variables (gender-year and gender-academic achievement). Firstly, Table 4 shows the descriptive analysis results for the average CT tendency scores of PSTs based on the variables of gender, year, and academic achievement.

Table 4. *Descriptive statistics results of PSTs’ CT tendency scores according to gender, year, and academic achivement*

Variable	Subgroup	N	$\overline{X}$	Sd
Gender	Female	87	3.80	.50
	Male	43	3.91	.54
Year	2	46	3.73	.56
	3	47	3.87	.49
	4	37	3.93	.48
Academic achievement	Low	45	3.81	.56
	Moderate	61	3.83	.46
	High	24	3.93	.56

A review of Table 4 reveals that male PSTs ($\overline{X}$=3.91) had higher CT tendency scores when compared to their female colleagues ($\overline{X}$=3.80). In terms of year levels, 2nd-year PSTs had the lowest CT tendency scores ($\overline{X}$=3.73) while 4th-year PSTs obtained the highest average scores ($\overline{X}$=3.93). Additionally, it was also found that the average CT tendency scores increased along with the year level. Furthermore, highly successful PSTs were also found to have the highest CT tendency scores ($\overline{X}$=3.93). The average scores of the PSTs with moderate ($\overline{X}$=3.83) to low-level success rates ($\overline{X}$=3.81), on the other hand, were found to be close. Regarding the second sub-problem of the study, two-way ANOVA results regarding the main and interaction effects of gender and year level on CT tendency of the PSTs are presented in Table 5.

Table 5. *Two-way ANOVA results regarding the main and interaction effects of gender and year*

Variance source	Sum of squares	df	Mean square	F	p	η^2
Gender	.14	1	.14	.55	.46	.00
Year	.07	2	.04	.13	.87	.00
Gender*Year	1.39	2	.69	2.70	.07	.04
Error	31.84	124	.26			

The data given in Table 5 shows that the main effect of gender on CT tendency scores was not statistically significant [$F_{(1,124)}$= .55, p= .46> .05]. Neither did the year level have a statistically significant main effect on CT tendency scores of PSTs [$F_{(2,124)}$= .13, p= .87> .05]. As far as the effect size value calculated for both variables of gender and year level, the difference between the averages was negligible (η^2= .00). Additionally, the interaction effect between gender and year was found to be statistically insignificant [$F_{(2,124)}$= 2.70, p= .07> .05]. The impact size found was slightly below the medium level (η^2= .04).

Within the scope of the third sub-problem of the study, Table 6 presents the results of the two-way ANOVA test applied to test the main and interaction effects of the variables of gender-academic achievement.

Table 6. *Two-way ANOVA results regarding the main and interaction effects of gender and academic achievement*

Variance source	Sum of squares	df	Mean square	F	p	η^2
Gender	.58	1	.58	2.20	.14	.02
Academic achievement	.48	2	.24	.90	.41	.01
Gender*Academic achievement	.74	2	.37	1.39	.25	.02
Error	32.96	124	.27			

The information contained in Table 6 does not indicate statistical significance for the main effect of gender [$F_{(1,124)}$= 2.20, p= .14> .05] and academic achievement [$F_{(2,124)}$= .90, p= .41> .05] on the CT tendency score of PSTs. The impact sizes were small. The interaction effect of gender and academic achievement on the CT tendency levels of PSTs did not attain statistical significance [$F_{(2,124)}$= 1.39, p= .25> .05]. Besides, the impact size found was small (η^2= .02).

4. Discussion and Conclusion

PSTs' Creativity is one of the 21st-century skills students must acquire. Therefore, it is vital for teachers to hone their CT skills in the first place (Trilling & Fadel, 2009). The present study examined both the CT tendency levels of PSTs and the main and interaction effects of demographic variables (gender, year, and academic achievement) on CT tendency. The study reported high CT tendency levels of PSTs. This may be considered as a prerequisite for the fostering of the CT skill of students by teachers. In fact, the researchers emphasised that teachers must be able to think creatively so that they can encourage their students to think in the same manner (e.g., Aydın-Güç & Keskin, 2021; Leikin & Elgrably, 2020; Meintjes & Grosser, 2010). The results of the study are therefore consistent with the findings of previous research. The studies found high CT tendency levels of pre-service mathematics teachers (Aydoğdu & Yüksel, 2013; Cenberci, 2018; Çenberci & Yavuz, 2018), pre-service primary and or preschool teachers (Durnacı & Ültay, 2020; Tican, 2019), and teachers from different field of study (Kozikoğlu & Küçük, 2020). However, certain studies seem to have produced contrasting results with the outcomes of the present study. Erbas, Batdal-Karaduman, and Yavuz (2018) found the CT tendency levels of pre-service primary school teachers to be low whereas Yenice and Yavaşoğlu (2018) calculated medium-level scientific creativity characteristics of pre-service science teacher. According to the researchers, the study outcomes may vary depending on a variety of reasons such as the difference in the sample groups' field of study and the courses taken during undergraduate education.

Within the scope of the second sub-problem with two-way analysis of variance a) gender differences in CT tendency b) year level differences in CT tendency c) interaction effect of gender and year level variables on CT tendency were examined. Outcome of the study shows that there are no significant differences between the CT tendency levels of PSTs in terms of the gender variable. Therefore, female and male PSTs display similar CT tendency levels. This seems to be consistent with the results of other research studies claiming that the CT tendency levels of PSTs did not differ based on the gender variable (e.g., Aydoğdu & Yüksel, 2013; Cenberci, 2018; Durnacı & Ültay, 2020; Furnham & Nederstrom, 2010; Kozikoğlu & Küçük, 2020; Tican, 2019; Tsai, 2013; Yenice & Yavaşoğlu, 2018; Yenilmez & Yolcu, 2007). However, there are also studies that do not correspond with the findings presented in this particular study. For example, Kaufman (2006) reported a difference in favour of women in a study dealing with the correlation between creativity and gender. Similarly, some other studies found the CT tendency levels of female PSTs to be significantly higher when compared to those of their male colleagues (e.g., Gök & Erdoğan, 2011; Köse et al., 2016). In addition to these results, Stoltzfus et al. (2011) used The Torrance Tests of Creative Thinking, which is widely used to determine individuals' creative thinking skills, and found that men's creative thinking scores were significantly higher than women's. The gender factor is a widely recognised variable in studies on CT, as demonstrated in the study results. However, these outcomes are rather inconsistent. Therefore, it seems to be difficult to make a generalisation on the impact of the gender variable on CT and or tendency levels. Thus, it is evident that further detailed studies are required to reach a consensus.

The study results indicated no significant differences between the CT tendency levels of PSTs in terms of the year level variable. Furthermore, the interaction effect of gender and year level on the CT tendency levels of PSTs were not statistically significant. These findings are consistent with the results of other studies claiming that there are no differences in CT tendency levels in terms of year levels of PSTs (e.g., Durnacı & Ültay, 2020; Köse et al., 2016; Yenice & Yavaşoğlu, 2018). Similarly, Furnham and Nederstrom (2010) concluded that there is no statistically significant correlation between CT and education level. This finding is particularly interesting as a difference in favour of PSTs in their fourth year of university studies would be expected. The assumption would be that the prolonged education period would contribute to the development of CT tendency levels. A study by Lee (2013) supports this argument. Lee (2013) found that the increase of year, i.e. education levels of PSTs also resulted in a parallel increase in CT and creative behaviour. However, the present study produced differing results. The lack of a specific course on creativity and or CT in teacher training curricula might have contributed to this outcome. Another potential reason might be the teaching styles of academics employed at the university. This is because the strategies employed in learning environments play a role in the development of CT (Guilford, 1975; as cited in Fasko, 2001).

Pertaining to the third sub-problem with two-way analysis of variance, a) gender differences in CT tendency b) academic achievement level differences in CT tendency c) interaction effect of gender and academic achievement level variables on CT tendency were analyzed. The findings regarding the gender difference are discussed above. The study also found that highly successful PSTs had higher CT tendency scores than those with medium and lower academic achievement levels. However, the difference among the scores remained insignificant. Furthermore, statistical significance was not attained in terms of the interaction effect of gender and academic achievement level on the CT tendency scores of PSTs. These outcomes reinforce the conclusions of previous relational studies (e.g., Ai, 1999; Tong & Wo, 2002). Ai (1999) and Tong and Wo (2002) found that CT and mathematics academic achievement were not correlated. However, there are also studies claiming that there is a positive correlation between CT and academic achievement (e.g., Huang et al., 2017; Schoevers et al., 2018; Sebastian & Huang, 2016).

5. Limitations and Implications

There are certain limitations of the present study that may be remedied with further research. Firstly, the present study measured the CT tendency levels of PSTs at a single temporal point. Therefore, it provides a limited account for the developmental trajectory of CT. In this regard, the existing literature on the subject matter requires longitudinal studies to identify the development of CT tendency levels of PSTs. Longitudinal research may provide scholars with information regarding the impacts of undergraduate programmes on the CT tendency levels of PSTs. Therefore, longitudinal studies are considered to be guiding for curriculum developers in terms of programme formulation for teacher training purposes. Secondly, the variable of CT tendency relies on the self-report declarations of PSTs. Therefore, qualitative or multi-informant approaches may be adopted to obtain in-depth knowledge regarding CT in future studies. Thirdly, this study is limited to 130 PSTs studying at a state university in the Eastern Anatolia Region of Turkey. Future research may have larger sample groups including PSTs studying in different regions and at different universities.

These findings have certain implications for future research. Primarily, gender is a frequently examined variable in studies on CT (Baer & Kaufman, 2008; Kaufman, 2006). The findings of this study revealed that there are no significant differences between the CT tendency levels of PSTs in terms of gender. However, there are also studies reaching contradictory conclusions. Therefore, it seems to be difficult to make a generalization on the impact of gender on CT tendency levels. A meta-analysis study on the subject matter may make considerable contributions to existing literature. Besides, the present study found that the variable of academic achievement did not have significant main effect on CT tendency levels of PSTs. However, there are studies that contradict this result. Considering these contradictory outcomes, the intermediary role of variables like gender and year in the relationship between CT and academic achievement may be examined.

There are a plethora of factors affecting creativity and CT. The present study found that the variables of gender, year, and academic achievement did not have significant main and interaction effects on CT tendency levels of PSTs. Therefore, future studies may examine the effect of different variables such as familial factors (e.g., parent education level) on CT tendency. In fact, recent studies deal with the variables of familial or socio-economic and their effect on the CT tendency levels of students (e.g., Yang & Zhao, 2021).

Suggestions may also be provided within the context of educational implications. The study showed that the CT tendency levels of PSTs increased along with year levels. Therefore, one might argue that undergraduate classes affect CT tendency of PSTs. In this context, the study suggests the inclusion of theoretical and applied undergraduate courses covering models and strategies fostering CT thought of PSTs in departments of education. Moreover, collaboration and CT are 21st century skills (Lamb, Maire, & Doecke, 2017). Furthermore, the correlation of problem-posing applications with the development of CT in experimental and case studies is a topical subject (Leikin & Elgrably, 2020). Thus, the inclusion of applied course content requiring collaborative work in undergraduate curricula for encouraging CT of PSTs may be suggested. Additionally, courses including problem-solving and problem-posing workshops may be incorporated in subject-specific education courses.

Endnote

This article is generated based on the second author's master's thesis.

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