

Methods of forming the creative thinking and learning technology competencies of future biology teachers

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Abstract

The purpose of this research is to determine the creative thinking and learning technology competencies of biology teacher candidates and to get their opinions on the methods of creating these competencies. The mixed method, in which quantitative and qualitative methods are used together, was preferred as a research model. The study group of the quantitative part of the research consists of 482 biology teacher candidates studying at various universities in Kazakhstan in the 2021–2022 academic year, and the study group of the qualitative part consists of 25 biology teacher candidates. Two different measurement tools were used in the study. In collecting the quantitative data of the research, the scale of creative thinking and learning technology competencies, and a semi-structured interview form in collecting the qualitative data were prepared by the researchers. As a result of the research, the creative thinking and learning technology competencies of the biology teacher candidates participating in the research were found to be moderate. The creative thinking and learning technology competencies of the biology teacher candidates participating in the research did not show a significant difference according to the gender and the class they are studying in. Considering the qualitative findings of the research, the majority of biology teacher candidates mentioned the importance of giving importance to personal development and participating in creative thinking activities such as courses, seminars and conferences in order to develop creative thinking. Biology teacher candidates stated that in order to use learning technologies effectively in education, it is necessary to be interested in technology and to use technology in education. The vast majority of biology teacher candidates, on the methods of constructing creative thinking and learning technology competencies, suggested creating course content and organising creative thinking and technology seminars in universities.

Keywords: Creative thinking, learning technologies, biology teacher candidates;

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1. Introduction

Pre-service teachers take various courses in education faculties in order to gain the skills and behaviours required in their professional lives. These courses, on the one hand, enable them to have the necessary knowledge and competencies in their fields and, on the other hand, they help them gain high-level skills such as increasing their self-efficacy beliefs towards the teaching profession, developing a positive attitude towards the profession and the creativity and technology use skills required by the teaching profession.

1.1. Theoretical and conceptual framework

Creative thinking skills, which have been important since the existence of humanity at the beginning of the 21st century, are also seen as the trigger of economic systems. Florida (2006) describes this period as the 'age of creativity' because the key factor that can move the existing economic system forward is creativity. Creativity is also rewarded in economic, societal and global environments as it creates new business areas and is the starting point of socially and individually motivating innovation. When we want to define creativity, a complex phenomenon occurs in our minds that cannot fit into simple sentences. Creativity exists at every stage of life. Creativity is seen as a very important product that emerges as a result of learning and should be intertwined with education (McWilliam, 2009). In its most general sense, creativity is an innate disposition, the interaction between the process and the environment. With this interaction, the individual or group produces an original, useful and tangible product in the social context to which it belongs (Plucker, Beghetto, & Dow, 2004).

Schools equipped with the requirements of the age lead the development of the individual, but the quality of the teachers is also important at the point of using this equipment. For this reason, it is necessary to train creative teacher candidates who can use technology opportunities together with educational approaches and to update teacher competencies in accordance with the needs of the information society (Vanderlinde & Braak, 2011).

In parallel with the advances in new technologies, the support provided by these technologies to the design of biology courses and the creation of teaching environments has also begun to vary and become widespread. Today, both teachers and students can access up-to-date information on rapidly developing subjects, such as human biology, biotechnology and gene technology, and they can access various information from the websites of institutions that are difficult to access under normal conditions.

When the studies on the technology use proficiency of teachers and teacher candidates are examined, it is seen that the frequency and willingness to use these technologies increase as their positive attitudes and skills towards using instructional technologies increase. It is known that teachers' attitudes towards computers and their lesson planning skills are directly affected by their beliefs about technology integration (Lee & Lee, 2014). The intensive technology-based courses in higher education will enable pre-service teachers to graduate well-equipped in the use of technology. The role of educational technology in education and training is related to the fact that teacher candidates have the knowledge and skills to use technology. The choice of materials suitable for the purpose of the course affects the students' level of understanding of the course and the permanence of knowledge (Fisher, 2000).

1.2. Related research

When the literature is reviewed, it is seen that there are studies that examine the educational environments, which are formed depending on the level and use of creativity in education by teachers,

teacher candidates and students, in terms of various variables (Fairfield, 2010; Henriksen, 2011; Stricker, 2008). Jennings (2005) aimed to determine the attitudes, perceptions, awareness and basic knowledge levels of teachers and students towards creativity. As a result of the research, it has been determined that teachers and students have different perspectives on creativity. While teachers define creativity as a cognitive and problem-solving process, students try to define it through products. Teachers have stated that creativity can be developed in the classroom, but seeing creativity as a standard concept creates an obstacle for students.

Davies et al. (2012) discussed creative learning environments in education in their literature review. As a result of the findings of the researches discussed in the study, there are common features in environments where creativity is encouraged. Flexibility in the physical and pedagogical environment was expressed as students controlled their learning and ownership of the activity in a variety of physical environments at school and elsewhere, such as museums and flexible use of time, allowing students to work at their own pace without pressure.

Oliviant (2009) evaluated the experiences of teachers on the development of creativity and creative thinking in classroom environments where exams are important in his study titled 'A Study on Teacher Perceptions on the Role of Creativity on the Role of Creativity in Environments where Exams Determine Students' Futures'. As a result of the research, it was stated that the teachers had the view that students' learning while having fun is important for their creativity, but that exam expectations are an important obstacle in the development of creativity.

The use of technology in education and the development of teacher candidates in technological innovations provide convenience to teacher candidates in many ways. Studies indicate the importance and effects of technology use in education in many branches (Can, 2010; Crowe & van't Hooft, 2006). Hall (2006) aimed to develop a model for pre-service teachers' technology integration in line with the ideas of faculty members, teachers and administrators. At the end of the training, it was determined that the participants gained useful skills, such as creating a web page and making better use of educational software.

1.3. Purpose of the research

The purpose of this research is to determine the creative thinking and learning technology competencies of biology teacher candidates and to get their opinions on the methods of creating these competencies. In this direction, the following sub-objectives have been determined:

1. What is the distribution of creative thinking and learning technology competencies of biology teacher candidates by gender?
2. What is the distribution of creative thinking and learning technology competencies of biology teacher candidates according to the class variable?
3. What are the suggestions of biology teacher candidates regarding the methods of creating their creative thinking and learning technology competencies?

2. Method and materials

2.1. Research method

As a research model, the 'mixed methods research', in which quantitative and qualitative methods are used together, was preferred. Mixed method research is the use of data collected by different methods to confirm each other, and in this way, the credibility of the results is stronger. In this design, qualitative and quantitative data of equal importance are collected simultaneously, analysed separately, and in the final stage, quantitative and qualitative findings are compared and interpreted

in terms of similarities and differences between them, to reach a better understanding in line with the main purpose of the research (Harrison, Reilly, & Creswell, 2020). Accordingly, in this study, the creative thinking and learning technologies competencies of biology teacher candidates were discussed in accordance with the quantitative research method, and their views on the methods of creating these competencies were handled in accordance with the qualitative research method.

2.2. Participants

The study group of the quantitative part of the research consists of 482 biology teacher candidates studying at various universities in Kazakhstan in the 2021–2022 academic year. The study group of the qualitative part of the research consists of 25 biology teacher candidates studying at various universities in Kazakhstan in the 2021–2022 academic year. Pre-service teachers agreed to participate in the research voluntarily. Demographic information about the participants of the research are included in the findings section of the research.

2.3. Data collection tools

Two different measurement tools were used in the study. The scale of creative thinking and learning technologies competencies was prepared for collecting the quantitative data of the research, and a semi-structured interview form was prepared for collecting the qualitative data.

2.3.1. Creative thinking and learning technologies competencies scale

At the stage of collecting the quantitative data of the research, the creative thinking and learning technologies competency scale developed by the researchers was used. The development stages of the scale are given below:

While developing the scale of creative thinking and learning technologies competencies, a literature review was first conducted. Then, an item pool was created. The created item pool was presented to the expert opinion and their opinions on the use of the scale were taken. In line with the suggestions of 6 experts, 4 out of 15 items in the item pool were removed from the scale. A sample group to participate in the pilot application was formed. The sample group consisted of 237 biology teacher candidates who voluntarily agreed to participate in the pilot study. Of the biology teacher candidates, 110 are female and 127 are male. The 11-item draft scale was applied to 237 biology teacher candidates. Then, exploratory factor analysis was performed with the SPSS 20.0 programme. According to the Kaiser–Meyer–Olkin (KMO) coefficient and Bartlett's sphericity test results, the KMO value was found to be 0.924 and the Bartlett test was (0.000) <0.05. These values were determined to be high values. Eigenvalue and variance rates of the scale were examined. The cumulative distribution was found to be 87,281, and in the exploratory factor analysis, 2 factors with eigenvalues >1 were found. SPSS Amos 25.0 programme was used for confirmatory factor analysis. Goodness-of-fit index was found in confirmatory factor analysis. CMIN/df ($\chi^2/df < 5$) = 1.442, GFI (>0.90) = 1.402, CFI (>0.90) = 1.964, NFI-TLI (>0.80) = 1.971–0.93 and RMSA (<0.07) = 0.068. The results of the goodness-of-fit index of the scale show that it is applicable. After the factor analysis, the Cronbach alpha internal consistency coefficient of the scale was found. The internal consistency coefficient for the creative thinking sub-dimension of the scale was 0.88, and the internal consistency coefficient for the learning technologies competencies sub-dimension was 0.81. The Cronbach alpha internal consistency coefficient for the overall scale was found to be 0.86. On the 5-point Likert-type scale, 5 was rated as strongly agree, 4 as agree, 3 as partially agree, 2 as disagree and 1 as strongly disagree. Item score ranges were considered equal, 5.00–4.20 = very high, 4.19–3.40 = high, 3.39–2.60 = medium, 2.59–1.80 = low and 1.79–1.00 = very low. In Appendix A, the creative thinking and learning technologies competency scale developed by the researchers is given.

2.3.2. *Semi-structured interview form*

In order to collect the qualitative data of the research, a semi-structured interview form was developed to get the opinions of the biology teacher candidates on the methods of creating their creative thinking and learning technology competencies, which was developed by the researchers. The semi-structured interview form's development stages are given below.

After the relevant literature review, a semi-structured interview form consisting of three open-ended questions was created in order to get the opinions of biology teacher candidates. In the semi-structured interview form, there are also two demographic questions regarding the gender and class distribution of biology teacher candidates. The created form was presented to the opinion of four experts and they were asked to evaluate it in terms of construct validity. In line with the opinions of the experts, one item was rearranged. Before the study, questions were asked to two biology teacher candidates who were excluded from the study, and the parts that were not understood or found to be incomplete were rearranged. A semi-structured interview form developed by the researchers is given in Appendix B.

2.4. *Data collections process*

At the stage of collecting the research data, the scale of creative thinking and learning technologies competencies was delivered to the biology teacher candidates, who constituted the study group of the research, via Google Form. The prepared semi-structured interview form was applied to 25 biology teacher candidates through face-to-face interviews in order to collect the qualitative data of the research. The implementation process of the creative thinking and learning technologies competencies scale and semi-structured interview forms took approximately 6 weeks.

2.5. *Data collection analysis*

After the creative thinking and learning technologies competency scale was applied to the study group, the data obtained were analysed with the SPSS 20.0 programme. The Kolmogorov–Smirnov test was conducted with the SPSS 20.0 programme to determine whether the data were normally distributed or not. The result of Kolmogorov–Smirnov normality test was found to be $p > 0.05$, it was determined that the data set showed normal distribution and it was decided to perform parametric tests. Research findings, frequency, percentage and t-test results are given.

The content analysis method was applied for the analysis of the data collected by semi-structured interview form. Content analysis requires a more detailed examination of the collected data and reaching the concepts, categories and themes that explain this data. Content analysis focuses on collected data. Codes are extracted from the events and facts that are frequently repeated in the data set or that the participant emphasises heavily: From the codes to the categories and from the categories to the themes. In short, data (codes) that are found to be similar and related to each other are interpreted by bringing them together within the framework of certain concepts (categories) and themes (Bengtsson, 2016).

The data obtained from the semi-structured interview forms were first transferred to the Microsoft Excel programme by the researchers and read a few times to create coding categories. Then, within the framework of content and descriptive analysis, coding categories were converted to open coding. In order to determine reliability in content analysis, the consistency between two researchers (coders) was examined. Two researchers independently coded the answers given by the biology teacher candidates to the questions in the semi-structured interview form and compared the consistency between codings. The obtained findings are given by creating frequency and percentage tables.

3. Results

In this section, the analysis of the findings obtained from the creative thinking and learning technologies competency scale and semi-structured interview form is included.

3.1. Findings on the scale of creative thinking and learning technologies competencies

Table 1 contains information about the demographic characteristics of the biology teacher candidates participating in the research.

Table 1. Demographic characteristics of participants

Gender	F	%
Woman	213	44.2
Male	269	55.8
Total	482	100
Class of study	F	%
First and second year	225	46.7
Third and fourth year	257	53.3
Total	482	100

In Table 1, demographic characteristics of the biology teacher candidates participating in the research regarding the gender and class distribution are given. 44.2% of the biology teacher candidates are female and 55.8% are male. While 46.7% of the biology teacher candidates are studying in the first and second year and 53.3% of them are in the third and fourth year. A total of 482 biology teacher candidates participated in the study.

In Table 2, the sub-dimensions of the creative thinking and learning technologies competencies of the biology teacher candidates participating in the research and the average and standard results for the overall scale are given.

Table 2. Creative thinking and learning technologies competencies scale

	X	SS
Creative thinking sub-dimension	3.17	0.662
Learning technologies competencies sub-dimension	3.22	0.759
Overall scale	3.19	0.651

In Table 2, it has been determined that the biology teacher candidates participating in the research have moderate proficiency in the creative thinking sub-dimension ($X = 3.17$) and in the learning technology competencies sub-dimension ($X = 3.22$). In addition, it is seen that biology teacher candidates have moderate proficiency in the creative thinking and learning technologies scale ($X = 3.19$).

In Table 3, the *t*-test results of the biology teacher candidates participating in the research are given according to the creative thinking and learning technology competencies of the gender variable.

Table 3. *T*-test results of biology teacher candidates by gender variable

Gender	<i>N</i>	<i>X</i>	<i>SS</i>	<i>F</i>	<i>p</i>
Woman	225	3.17	0.528	11.554	0.218
Male	257	3.21	0.592		

In Table 3, the *t*-test results of the creative thinking and learning technologies competencies of the biology teacher candidates participating in the research are given according to the gender variable. When Table 3 is examined, it is seen that the creative thinking and learning technology competencies ($F = 11.554, p > 0.05$) of the biology teacher candidates participating in the research do not make a significant difference according to the gender variable.

In Table 4, the *t*-test results of the creative thinking and learning technology competencies of the biology teacher candidates participating in the research are given according to the class variable they study in.

Table 4. *T*-test results of biology teacher candidates by class variable

Their class of education	<i>N</i>	<i>X</i>	<i>SS</i>	<i>F</i>	<i>p</i>
First and second year	213	3.15	0.850	12.625	0.361
Third and fourth year	269	3.22	0.915		

In Table 4, the *t*-test results of the creative thinking and learning technology competencies of the biology teacher candidates participating in the research are given according to the class variable they study in. When Table 4 is examined, it is seen that the creative thinking and learning technology competencies ($F = 12.625, p > 0.05$) of the biology teacher candidates participating in the research do not make a significant difference according to the class variable.

3.2. Findings on the semi-structured interview form

In Table 5, the biology teacher candidates participating in the research asked the question ‘What should be done to develop creative thinking?’ Their answers to the question are evaluated.

Table 5. What should be done to develop creative thinking?

Teacher opinions	<i>F</i>	%
Giving importance to personal development	19	76
Participating in creative thinking activities such as courses, seminars and conferences	16	64
Being interested in the field and engaging in activities that increase interest	13	52
Willingness to come up with new and original ideas	9	36
Willingness to find solutions to problems	7	28
Thinking about the opinions of people around us	5	20
Being open to taking risks	2	8

In Table 5, in the semi-structured interview form, the biology teacher candidates participating in the research were asked ‘What should be done to develop creative thinking?’ The answers to the question are categorised. 76% of the biology teacher candidates attach importance to personal learning; 64% participate in creative thinking activities such as courses, seminars and conferences; 52% are interested in the field and engage in activities that increase interest; and 36% come up with new and original ideas. In addition, 28% of the biology teacher candidates answered that they are willing to

find solutions to problems, 20% of them think about the ideas of the people around them; and 8% are open to taking risks.

In Table 6, the biology teacher candidates participating in the research asked the question ‘What should be done to use learning technologies effectively in education?’ Their answers to the question are evaluated.

Table 6. What should be done to use learning technologies effectively in education?

Teacher opinions	F	%
Have an interest in technology	20	80
Adopting that the use of technology in education is a necessity	14	56
Improving the use of technological tools	11	44
Researching instructional technologies	8	32
Following innovations in learning technologies	6	24
Willingness to integrate learning technologies into the classroom	4	16
Attending courses and seminars on learning technologies	3	12

In Table 6, the biology teacher candidates participating in the research asked the question ‘What should be done to use learning technologies effectively in education?’ The answers to the question are categorised. 80% of the biology teacher candidates answered that they are interested in technology, 56% of them adopted the use of technology in education as a necessity, 44% of them developed the use of technological tools and 32% of them gave the answer of researching instructional technologies. In addition, 24% of the biology teacher candidates gave the answer of following the innovations in learning technologies, 16% were willing to integrate learning technologies into the course and 12% attended courses and seminars related to learning technologies.

In Table 7, the question ‘What are your suggestions about the methods of creating creative thinking and learning technology competencies?’ was asked to biology teacher candidates participating in the research. Their answers to the question are evaluated.

Table 7. What are your suggestions regarding the methods of building creative thinking and learning technologies competencies?

Teacher opinions	F	%
Course contents should be created in universities	17	68
Creative thinking seminars should be organised at universities	15	60
Technology seminars should be organised in universities	10	40
Creative thinking and technology education should be given from an early age.	6	24
The potential of the student should be revealed with different methods and techniques in universities.	3	12
Project development and use of technology in the field should be made compulsory for university students.	2	8

In Table 7, the question ‘What are your suggestions about the methods of creating creative thinking and learning technology competencies?’ was asked to biology teacher candidates participating in the research. The answers to the question are categorised. Of the biology teacher candidates, 68% answered that course content should be created at universities, 60% answered that creative thinking seminars should be organised at universities, 40% gave the answer that technology seminars should be held at universities and 24% answered that creative thinking and technology education should be given from an early age. In addition, 12% of the biology teacher candidates suggested that the

potential of the student should be revealed with different methods and techniques in universities and 8% of them suggested that project development and the use of technology in the field should be made compulsory for university students.

4. Discussion

The creative thinking and learning technology competencies of the biology teacher candidates participating in the research were found to be moderate in the creative thinking sub-dimension, the learning technologies sub-dimension and the overall scale. The creative thinking and learning technology competencies of the biology teacher candidates participating in the research did not show a significant difference according to the gender and the class they are studying in.

Considering the qualitative findings of the research, the majority of biology teacher candidates mentioned the importance of giving importance to personal development, participating in creative thinking activities such as courses, seminars, conferences and engaging in activities that increase interest in the field in order to develop creative thinking. Biology teacher candidates stated that in order to use learning technologies effectively in education, they should be interested in technology, adopt the use of technology in education as a necessity and improve the use of technological equipment. The vast majority of biology teacher candidates, on the methods of constructing creative thinking and learning technology competencies, suggested creating course contents, organising creative thinking seminars and technology seminars in universities.

When the researches in the field are examined, it is possible to say that the results of the study conducted by Borodina, Sibgatullina, & Gizatullina (2019) are similar to the results of this research. In their study, the researchers stated that only one-third of the future teachers who participated in the study had a high level of creative thinking. Shapka and Ferrari (2003), in their study, in which they investigated the attitudes and actions of pre-service teachers towards computers, stated that men are not superior to women in their attitudes towards computers and that men and women are equally competent in using technology. Tasci, Yaman, and Soran (2010) examined the biology teachers' use of new technologies in teaching in their study. As a result of the research, it has been seen that the rate of teachers never using new technologies in the teaching process is quite high, and the rate of using them very often is very low. In his study, Christensen (2002) revealed that the correct use of technology in education for the benefit of students can be achieved by developing a positive attitude towards technology by future teachers. Frye and Dornisch (2008) stated that science and mathematics are fields that are more closely related to the use of technology, that science and mathematics teachers use technology more than teachers of other fields and are more competent in this regard. Agyei and Voogt (2011) observed that in-service teachers are more advanced in terms of technology proficiency, while pre-service teachers are more concerned about technology use.

5. Conclusion

The requirements of the contemporary world have made it a necessity for today's individuals to have thinking skills. In the changing world with the developing technology, it is revealed that individuals with only knowledge will have difficulty in adapting to the contemporary world. Today, it is important not about how much information individuals have, but how effective they are in the process of accessing information. In addition, in the face of the impossibility of transferring the ever-increasing knowledge through education, the fact that teachers and pre-service teachers have to acquire knowledge and solve their own problems varies depending on the level of their creativity and technology use proficiency. Starting from here, in this research, it was aimed to determine the creative thinking and learning technology competencies of biology teacher candidates and to get their opinions on the methods of creating these competencies. As a result of the research, the creative thinking and learning technology competencies of the biology teacher candidates participating in the research were

found to be moderate. The creative thinking and learning technology competencies of the biology teacher candidates participating in the research do not show a significant difference according to the gender and the class they are studying in. Considering the qualitative findings of the research, the majority of biology teacher candidates mentioned giving importance to personal development and participating in creative thinking activities such as courses, seminars and conferences in order to develop creative thinking. Biology teacher candidates stated that in order to use learning technologies effectively in education, it is necessary to be interested in technology and to use technology in education. The vast majority of biology teacher candidates, on the methods of constructing creative thinking and learning technology competencies, suggested creating course content and organising creative thinking and technology seminars in universities.

6. Recommendations

The results obtained from the research reveal that the educational environments should be created in teacher education and the evaluations made in the lessons should be of a quality that will improve the creative thinking skills of the students. Moreover, for more effective use of computer technologies in education, it is necessary to organise comprehensive courses on computer applications for pre-service biology teachers. In addition, teacher candidates should be guided correctly in order to provide support for the integration of biology teaching and these applications, to support the use of the Internet for general and teaching purposes and to follow the developments and innovations in biology education and teaching methods.

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Appendix A

Yaratıcı düşünme ve öğrenme teknolojileri yetkinlikleri ölçeği

Cinsiyetiniz:					
Öğrenim Gördüğünüz Sınıf:					
Yaratıcı düşünme ve öğrenme teknolojileri yetkinlikleri ölçeği	Kesinlikle Katılıyorum	Katılıyorum	Kısmen Katılıyorum	Katılmıyorum	Kesinlikle Katılmıyorum
Yaratıcı Düşünme					
Öğrencilerin düşüncelerinde daha esnek olmaları konusunda onlara yardımcı olabilirim.					
Öğrencilerimin anlamlı akademik risk alma becerilerini zenginleştirebilirim					
Sınıftaki öğrencileri yaratıcı problem çözümleri için teşvik edebiliyorum					
Alanımla ilgili yaratıcı fikirler üretme konusunda yeterliyim					
Yaratıcı düşünceyi öğretmek güçlü yanlarımdan biridir.					
Alanımda yaratıcı düşünmenin gerekliliğine inanıyorum					
Öğrenme Teknolojileri Yeterlikleri					
Öğrenme teknolojilerini kullanma yeterliliğine sahibim					
Öğrenme teknolojilerini kullanarak ders verme yeterliliğine sahibim					
Öğrenme teknolojileri ile ilgili kendimi her zaman yenilerim					
Öğrenme teknolojilerinin eğitim öğretimde kullanılmasının gerekliliğine inanıyorum					
Öğrenme teknolojileri ile ders anlatma konusunda kendime güvenirim					

Appendix B

Yarı Yapılandırılmış Görüşme Formu

Cinsiyetiniz:
Öğrenim Gördüğünüz Sınıf:
Sorular
1. Yaratıcı düşünmenin geliştirilebilmesi için neler yapılmalıdır?
2. Öğrenme teknolojilerini eğitimde etkili kullanabilmek için neler yapılmalıdır?
3. Yaratıcı düşünme ve öğrenme teknolojileri yetkinliklerini oluşturma yöntemlerine ilişkin önerileriniz nelerdir?