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Development of the logical thinking of future mathematics teachers through the use of digital educational technologies

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Abstract

The purpose of this research is to get the opinions of future mathematics teachers on the development of logical thinking skills through the use of digital educational technologies. This research was created by using the qualitative research method. The participant group of the research consists of 50 teacher candidates studying in the mathematics teaching department of various universities in Kazakhstan in the 2021–2022 academic year. Research data were collected with a semi-structured interview form developed by the researchers. As a result of the research, it was determined that the majority of pre-service mathematics teachers had moderate logical thinking skills. The majority of pre-service mathematics teachers stated that they found the use of digital technologies effective in the development of logical thinking skills. The suggestions of the majority of pre-service mathematics teachers regarding the use of digital education technologies in the development of logical thinking skills are creating and developing logical thinking skills through digital education technologies, developing logical thinking skills through digital education technologies and providing complex problem-solving skills through digital education technologies. Effective course content should be created in order to enable pre-service mathematics teachers to gain logical thinking skills through digital education technologies.

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1. Introduction

It is a reality known by everyone that technological innovations develop day by day and take place in all areas of life. If an individual uses technology in a field he is interested in, he is among the pioneers of that field. Technology is increasingly taking place in the education system, which is one of the most important areas of social life. For this reason, starting from the first stage of education to higher education, many institutions and organisations include more technology and, in parallel, they create or restructure their education systems.

1.1. Theoretical and conceptual framework

In the digitalised world, the education and training system has undergone radical changes and the methods of accessing and sharing information have also changed, and raising individuals with this skill has become the main goal in order to achieve this (Duderstadt, 2001; Uzunboylu & Selcuk, 2016). The reason why information progresses exponentially is the availability of information with computers, the Internet and other online technologies, the disappearance of the border between those who want to access information and information sources and the rapid dissemination/distribution of new information (Toth & Graham, 2016). This situation shows that knowing and knowledge are not just cognitive processes as the knowledge produced is constantly collected, distributed and synthesised on online networks (Capurro & Hjorland, 2003).

Learning management systems, open learning resources, social networks, lecture videos, synchronous–asynchronous lectures and massive open online courses, which have been used for educational purposes in many higher education institutions, have been widely used (Harley, 2002). The logical thinking skill, which is one of the cognitive skills and has an important place in the success of students, is one of the most emphasised subjects in studies in the field of education. This skill is the ability of an individual to solve a problem by performing various mental operations or to reach principles and laws by making some abstractions and generalisations (Arifuddin, 2020; Maloney, 2007).

Logical thinking skill is a skill that should be acquired by teacher candidates. Individuals' attitudes towards the relevant subject are very important in acquiring and succeeding in this skill (Andayani, Muchtar, & Susanto, 2020; Egmir & Ocak, 2020; Han & Brown, 2013; Yuanita, Ibrahim, & Prahani, 2019). Logical thinking requires the individual to think decisively in order to reach a solution at the point of solution to the problems he encounters (Baserer, 2020; Gencel & Candan, 2014). Because logical thinking allows the individual to reach a conclusion by making logical decisions within the cause–effect relationships in the face of related problems or situations (Gentry, 2012; Khair, Hasnawati, Oktavianti, & Jufri, 2020). Logical thinking differs from other types of thinking. While correct thinking rules and forms are at the forefront in logical thinking, critical thinking can also attach importance to incorrect thinking styles (Topçul, 2019).

Logical thinking is based on sequential thinking. This feature means taking the ideas, facts and results about the problem and putting them in order in a chain (Tekbıyık & İpek, 2007). Individuals with logical thinking skills can determine the relationships between concepts by producing scientific solutions to the problems they encounter in daily life (Geçit & Akarsu, 2017; Ince, Çenberci, & Yavuz,

2018; Wagley, 2013;. In this way, they can evaluate their thoughts, knowledge and experiences by establishing cause–effect relationships. Solving the daily problems of individuals enables them to learn by taking them forward without realising it (Vadhan & Stander, 1994).

1.2. Related research

When the literature is examined, it is seen that various studies have been conducted on the evaluation and development of logical thinking skills. In the study conducted by Zarotiadou and Tsaparlis (2000), it was revealed that the logical thinking skill levels of male students were improved compared to females. Tuna, Biber, and Incikapi . (2013) investigated whether there is a significant difference between the logical thinking skill levels of pre-service mathematics teachers according to school type and grade level variables. As a result of the research, it was determined that there was a significant difference between the variables, while the gender variable did not create a significant difference.

In the study conducted by Morsanyi, McCormack, and O'Mahony (2018), the relationship between logical thinking skills and mathematical skills of university students was examined. The mathematical skills of students were measured with the mathematical fluency test to evaluate the mental number line and arithmetic skills. As a result of the research, it was seen that students' logical thinking skills and basic mathematics skills were related to each other, and this situation provided evidence for the relationship between logical thinking skills and number sense.

Some studies reveal the relationship between logical thinking skills and different variables, such as problem-solving, general academic achievement and success in mathematics, and support that logical thinking ability is a strong predictor of mathematics achievement (Evans, 2002; Jeotee, 2012). Inglis and Simpson (2009) examined the relationship between mathematical and situational reasoning skills. As a result of the research, it was concluded that mathematics undergraduate students performed better than matched art students in terms of intelligence level in questions requiring abstract situational inference.

Mansi (2003) reveals that mathematical reasoning skill requires harmony between making inferences by using mathematical facts and logical thinking. In the study, it was also stated that logical thinking and reasoning are an important and powerful part of the mathematics learning process. In the study conducted by Yaman and Yalcin (2005), the effect of problem-based learning on the development of logical thinking skills in science teaching was investigated. In this context, in the study, the experimental design was used, and it was stated that the gender of the students did not have a significant effect on their logical thinking skills, but a significant effect was observed only in terms of department preferences.

In another study by Attridge and Inglis (2013), the change in logical reasoning skills of students studying mathematics and English literature was investigated. No difference was observed in the reasoning performances of the students immediately after enrolling in the relevant departments. But unlike literature students, math students' reasoning skills improved throughout the year.

1.3. Purpose of the research

The purpose of this research is to get the opinions of future mathematics teachers on the development of logical thinking skills through the use of digital educational technologies. For this purpose, the following sub-objectives have been established:

1. What are the opinions of future mathematics teachers on their logical thinking skills?

2. What are the opinions of future mathematics teachers on the use of digital education technologies in the development of logical thinking skills?

3. What are the suggestions of future mathematics teachers regarding the use of digital education technologies in the development of logical thinking skills?

2. Method and materials

2.1. Research method

This research was created by using the qualitative research method. Qualitative research is one of the forms of knowledge production developed by people to understand their own potential, to solve their secrets and to explore the depths of the social structures and systems they have built with their efforts. There is an effort to reach a deep perception about the investigated event or phenomenon in the studies designed with the qualitative method. Qualitative data collection techniques, such as observation, interview, document and speech analyses, are generally used in qualitative research. In addition, qualitative research, in which perceptions and events related to human beings are examined in depth in social reality and natural environment, also has a holistic perspective that combines different disciplines (Golafshani, 2003). In this direction, the opinions of future mathematics teachers on the development of logical thinking through the use of digital education technologies were evaluated in accordance with the qualitative research method.

2.2. Participants

The participant group of the research consists of 50 teacher candidates studying in the mathematics teaching department of various universities in Kazakhstan in the 2021–2022 academic year. Demographic information of prospective mathematics teachers participating in the research is given in Table 1. The participant group of the research consists of volunteer mathematics teacher candidates.

Table 1

Demographic Characteristics of the Pre-Service Mathematics Teachers

Gender	*F*	%
Female	22	44
Male	28	56
Sum	50	100
Class		
1.Class	7	14
2.Class	14	28
3.Class	20	40
4.Class	9	18
Sum	50	100

In Table 1, the gender and class distributions of the pre-service mathematics teachers participating in the research are given. Of the pre-service mathematics teachers, 22 are female and 28 are male. Seven -service mathematics teachers are studying in the first grade, 2 in the second grade, 20 in the third grade and 9 in the fourth grade. A total of 50 pre-service mathematics teachers participated in the study.

2.3. Data collection tools

Research data were collected with a semi-structured interview form. Before the semi-structured interview form was developed, a literature review was conducted in accordance with the research purpose. In this direction, an interview form consisting of two closed-ended and one open-ended questions was created, in addition to the demographic questions in order to get the opinions of the prospective mathematics teachers participating in the research on the development of their logical thinking skills through the use of digital education technologies. The prepared interview form was presented to the opinion of two experts. In line with expert opinions, the semi-structured interview form was given its final form. The questions in the semi-structured interview form are as follows:

1. What are your views on your level of logical thinking skills?

2. What are your views on the use of digital education technologies in the development of logical thinking skills?

3. What are your suggestions regarding the use of digital education technologies in the development of logical thinking skills?

2.4. Data collection process

During the data collection process, pre-service mathematics teachers were contacted via email in order to provide preliminary information. Information about the purpose and scope of the research, data collection method, data analysis and ethical principles were conveyed to the teacher candidates via email. The pre-service teachers who agreed to participate in the research were asked to respond to the email and state that they agreed to participate in the research. In the second stage, appointments were made with the teacher candidates who returned to the researchers. Face-to-face interviews were conducted with prospective teachers in a quiet environment where they could fill in semi-structured interview forms in the university environment. It took about 5 weeks to conduct face-to-face interviews with 50 teacher candidates.

2.5. Data collection analysis

Research data were analysed by the content analysis method. Naming the meaningful parts (such as a word, sentence or paragraph) among the data by the researcher is expressed as coding. The coding process is necessary to segment, examine, compare, conceptualise and relate the obtained data. The meanings given to meaningful parts (such as a word, sentence or paragraph) and events in the data are defined as concepts. Concepts form the basic analysis unit of content analysis. Classification of the concepts obtained in content analysis in a certain relationship with each other is expressed as categorisation. Categories are grouped under a theme. As a result of examining the categories, their relationships with each other are revealed and when these relationships require a higher level grouping, themes are mentioned. Themes are more abstract and general than the concepts obtained in content analysis and are important in terms of showing the dimensions of the

research problem (Merriam & Grenier, 2019). The opinions of prospective mathematics teachers were converted into findings according to the content analysis method. Teacher opinions are given in tables with frequency and percentage values.

3. Results

In Table 2, the opinions of the pre-service mathematics teachers participating in the research on their logical thinking skills are evaluated.

Table 2

Opinions of Pre-Service Mathematics Teachers on Their Logical Thinking Skills

Teachers' opinions	***F***	**%**
I have high-level logical thinking skills	14	28
I have moderate logical thinking skills	26	52
I have low logical thinking skills	10	20
I do not have logical thinking skills	-	-
Sum	50	100

In Table 2, the views of pre-service mathematics teachers who participated in the research on their logical thinking skills are categorised. 28% of the pre-service teachers who participated in the research stated that they had high-level logical thinking skills. 52% of the pre-service teachers stated that they have moderate logical thinking skills. 20% of the pre-service teachers stated that they have low level logical thinking skills. It was determined that among the pre-service mathematics teachers who participated in the study, there was no pre-service teacher who did not have logical thinking skills.

In Table 3, the views on the use of digital education technologies in the development of logical thinking skills of pre-service mathematics teachers are evaluated.

Table 3

Opinions of Pre-Service Mathematics Teachers on the Use of Digital Education Technologies in the Development of Logical Thinking Skills

Teachers' opinions	***F***	**%**
I find the use of digital technologies very effective in the development of logical thinking skills.	7	17
I find the use of digital technologies effective in the development of logical thinking skills.	28	56
I find the use of digital technologies somewhat effective in the development of logical thinking skills.	10	20
I find the use of digital technologies ineffective in the development of logical thinking skills.	4	8
I find the use of digital technologies very ineffective in developing logical thinking skills.	1	2
Sum	50	100

In Table 3, the views of pre-service mathematics teachers participating in the research on the use of digital education technologies in the development of logical thinking skills are categorised. 17% of the pre-service teachers answered that they find the use of digital technologies very effective in the development of logical thinking skills. 56% of the teacher candidates stated that they found the use of digital technologies effective in the development of logical thinking skills. 20% of the pre-service teachers stated that they found the use of digital technologies somewhat effective in the development of logical thinking skills. 8% of teacher candidates stated that they found the use of digital technologies ineffective in developing logical thinking skills. Finally, 2% of the pre-service teachers answered that they found the use of digital technologies very ineffective in developing logical thinking skills.

In Table 4, the suggestions of prospective mathematics teachers regarding the use of digital education technologies in the development of their logical thinking skills are evaluated.

Table 4

Recommendations for the Use of Digital Education Technologies in the Development of Logical Thinking Skills of Pre-Service Mathematics Teachers

Teachers' opinions	***F***	**%**
Building logical thinking skills through digital education technologies	44	88
Developing logical thinking skills through digital education technologies	41	82
Developing logical thinking ability through digital education technologies	32	64
Gaining complex problem-solving skills through digital education technologies	27	54
To be able to determine the relationships between concepts and terms through digital education technologies.	23	46
Eliminating occupational stress by gaining logical thinking skills through digital education technologies	16	32
Teaching questions involving logic and their analysis methods through digital education technologies	11	22
Developing logical thinking skills with appropriate method selection through digital education technologies	8	16
Gaining the ability to hypothesise and generalise through digital education technologies	5	10
Gaining the ability to use and categorise numbers effectively through digital education technologies	2	4

In Table 4, the suggestions of prospective mathematics teachers regarding the use of digital education technologies in the development of their logical thinking skills are categorised. 88% of the pre-service teachers suggested developing logical thinking skills through digital education technologies, and 82% of them suggested developing logical thinking skills through digital education technologies. 64% of the pre-service teachers suggested developing logical thinking skills through digital education technologies, and 54% suggested gaining complex problem-solving skills through digital education technologies. 46% of the pre-service teachers suggested detecting the relationships between concepts and terms through digital education technologies, and 32% of them suggested eliminating the stress related to the profession by gaining logical thinking skills through digital

education technologies. 22% of the pre-service teachers wanted to teach questions involving logic and their analysis methods through digital education technologies, 16% wanted to develop logical thinking skills with appropriate method selection through digital education technologies and 10% wanted to develop hypotheses and solutions through digital education technologies. They suggested that they gain the ability to make generalisations. Finally, 4% of the teachers suggested that they gain the ability to use and categorise numbers effectively through digital education technologies.

4. Discussion

Majority of the pre-service mathematics teachers who participated in the study stated that they had moderate logical thinking skills. In his research, Fettahlıoğlu (2018) analysed the logical thinking skills of teacher candidates according to their learning styles. As a result of the research, it was determined that the logical thinking skills of the teacher candidates are at a moderate level. A study was conducted by İncikapı et al. (2013) to determine the logical thinking levels of primary school mathematics teacher candidates. While the researchers observed the logical thinking levels of primary school mathematics teacher candidates at a low level, they did not find a statistical difference according to gender.

Al-Zoubi and Al-Salam (2009) also stated in their study that there was no significant difference between male and female students in terms of logical thinking levels, and stated that students' logical thinking levels were moderate. The majority of pre-service mathematics teachers stated that they found the use of digital technologies effective in the development of logical thinking skills. Liu and Niess (2006) revealed in their study that the majority of students associate logical thinking with the ways of solving problems and finding answers.

The suggestions of the majority of pre-service mathematics teachers regarding the use of digital education technologies in the development of logical thinking skill are; creating and developing logical thinking skills through digital education technologies, developing logical thinking skills through digital education technologies and providing complex problem-solving skills through digital education technologies. In addition, they have developed suggestions for determining the relationships between concepts and terms through digital education technologies, eliminating the stress related to the profession by gaining logical thinking skills and teaching questions involving logic and their analysis methods. They proposed to develop logical thinking skills, to develop hypotheses and generalisations, to use numbers effectively and to categorise them, through digital education technologies, with appropriate method selection.

In some studies conducted in the field, it has been revealed that the acquisition of logical thinking skills by research participants is based on problem-solving (Cai, 2002; Nunokawa, 2005). Kilic and Saglam (2009) investigated whether students' logical thinking level was affected by gender, age and school type variables in their study named 'Examination of Students' Logical Thinking Skills in Terms of Some Variables'. In the study, it was concluded that female students' scores in the logical thinking ability test were significantly higher than male students, the age variable did not affect the scores and the school type affected the scores. As a result of their study, Gerber, Cavallo, and Marek (1997) revealed that different learning environments and teaching methods lead to differences in students' logical thinking abilities. In their studies, they stated that students' experiences, cognitive conflicts and social interactions affect their logical thinking abilities.

4. Conclusion

Mathematics education in developed countries focuses on the development of cognitive and logical thinking skills. Logical thinking covers theoretical, statistical and causal hypotheses and the skills necessary to understand and evaluate scientific knowledge. The ability to use logical thinking and thinking skills plays an important role in students' academic success, understanding scientific concepts and the nature of science. Therefore, this research aimed to get the opinions of future mathematics teachers on the development of logical thinking skills through the use of digital education technologies. As a result of the research, it was determined that the majority of pre-service mathematics teachers had moderate logical thinking skills. The majority of pre-service mathematics teachers stated that they found the use of digital technologies effective in the development of logical thinking skills. The suggestions of the majority of pre-service mathematics teachers regarding the use of digital education technologies in the development of logical thinking skills are creating and developing logical thinking skills through digital education technologies, developing logical thinking skills through digital education technologies and providing complex problem-solving skills through digital education technologies.

6. Recommendations

In line with the results obtained from the research, suggestions have been developed for the development of pre-service mathematics teachers' logical thinking skills through digital education technologies.

1. Effective course content should be created in order to enable pre-service mathematics teachers to gain logical thinking skills through digital education technologies.

2. Blended learning environments should be created to enable pre-service mathematics teachers to gain logical thinking skills.

3. Digital education technologies training should be given to prospective mathematics teachers.

4. Regarding the acquisition of logical thinking skills through digital education technologies, it should be evaluated by taking the views of not only the students studying in the mathematics teaching department, but also the students studying in the entire education faculty.

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