The impact of digital educational resources on enhancing logical thinking skills of future mathematics teachers

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ABSTRACT: The aim of this study was to investigate the impact of digital educational resources, specifically interactive simulations and visualisations, on enhancing the logical thinking skills of future mathematics teachers. The research was motivated by the need to modernise mathematics education and equip prospective teachers with the skills required in a technology-driven educational landscape. In the course of experimental studies with 80 participants and subsequent tests to determine the level of logical thinking (group assessment of logical thinking) and a survey, a significant improvement in logical thinking skills was noted among those who used digital resources. The findings underscore the effectiveness of interactive simulations and visualisations in developing an intuitive understanding of abstract mathematical concepts and enhancing problem-solving abilities, which are constituent parts of logical thinking. These results are crucial for informing the design and implementation of mathematics teacher training programmes, highlighting the importance of integrating digital educational resources to improve the quality of mathematics education and better prepare future educators for the challenges of the 21st century.

Keywords: Digital resources, logical thinking, mathematics education, future mathematics teachers

INTRODUCTION

The importance of integrating digital educational resources (DERs) in mathematics education cannot be overstated in the modern educational landscape. As the world continues to evolve towards a more technologically advanced society, the traditional methods of teaching mathematics are increasingly becoming obsolete. The need for educators to adapt and embrace digital tools and resources is more critical than ever to ensure that students are equipped with the necessary skills to thrive in the 21st century.

Scholars continuously investigate ways of enhancing thinking abilities, such as systems thinking [1], coding and computational thinking [2], and design thinking [3]. Authors' opinions coincide on this issue, and as Avsec summed up developing thinking skills allows to establish prerequisites for *meaningful learning experiences that influence a pedagogical shift* [3].

The role of digital resources in mathematics education has been extensively studied, highlighting their potential to enhance students' engagement, motivation and learning outcomes. However, the effectiveness of these resources is contingent upon the teachers' ability to integrate them into their teaching practices effectively. This underscores the importance of providing adequate support and training for teachers to harness the full potential of DERs.

Despite the recognised benefits of the use of interactive simulations and visualisations in education, there remains a gap in the literature regarding the specific impact of these tools on the development of logical thinking skills of future educators. Given the significance of preparing future mathematics teachers with the skills to navigate and utilise digital resources effectively, research in this area is of paramount importance. It is essential to understand how interactive simulations and visualisations can be integrated into teacher training programmes to improve the quality of mathematics education. Therefore, studies dedicated to developing and evaluating the use of DERs in mathematics teacher education are both timely and necessary.

In conclusion, the investigation into the use of DERs, particularly interactive simulations and visualisations, in mathematics education is a critical and relevant area of research. The findings from such studies have the potential to significantly enhance the quality of education, making this line of inquiry highly pertinent in the contemporary educational context.

LITERATURE REVIEW AND PROBLEM STATEMENT

The integration of technology in education is a topic of ongoing debate, where proponents argue that digital tools enhance learning outcomes, facilitate interactive learning and prepare students for modern educational environments. Studies have shown that blended learning, which combines traditional narrative instruction and integration of technology, produces positive effects on learning effectiveness [4][5]. Mobile learning (m-learning) also facilitates deeper engagement with content, with many studies reporting positive outcomes [6-8]. Additionally, digital tools can bridge the gap between theoretical knowledge and practical application, aligning learning with current technological advancements [9][10].

However, critics highlight potential drawbacks, such as over-reliance on technology, which may undermine foundational teaching skills [11][12]. There are also significant concerns about inequities in access to technological resources, which can lead to disparities in educational outcomes [13][14]. Furthermore, digital devices can be distracting, negatively impacting concentration and academic performance [15].

The effectiveness of DERs in mathematics education has been a focus of scholarly investigation. Studies by Zainuddin and Perera demonstrate the potential of DERs to enhance student engagement, motivation and learning outcomes, yet they do not specifically address the impact on logical thinking skills among future mathematics teachers [16][17].

Research by other authors has shown that DERs promote active learning, problem-solving skills and critical thinking, but there remains a gap in understanding their contribution to developing logical thinking skills in prospective mathematics teachers [16-18]. Furthermore, while DERs are praised for creating personalised learning experiences and accommodating diverse learning styles, the challenge of selecting and integrating appropriate resources effectively into teaching practices remains underexplored.

Successful integration of DERs in mathematics education requires teachers to possess adequate pedagogical and technical skills. Scholars like Kunene and Havenga [2], and Yessingeldinov et al [19] argue that these skills must be complemented by sufficient thinking skills, highlighting the need for further investigation into the training and professional development of future mathematics teachers to use DERs effectively [2][19].

Additionally, studies have indicated that teachers' attitudes and self-efficacy significantly influence the integration of DERs [19][20]. However, the literature lacks a comprehensive analysis of how these factors affect the enhancement of logical thinking skills among future mathematics teachers.

Given these gaps in the literature, there is a clear need for empirical research to investigate the impact of digital educational resources - particularly interactive simulations, visualisations and other digital tools - on enhancing the logical thinking skills of future mathematics teachers. This research aims to address this gap by comparing traditional and digital methods to evaluate their effectiveness in developing logical thinking abilities, as discussed in previous sections.

THE AIM AND OBJECTIVES OF THE STUDY

The aim of the study is to empirically investigate the impact of digital educational resources on enhancing logical thinking skills of future mathematics teachers, with a focus on interactive simulations, visualisations and other digital tools.

To achieve this aim, the following objectives need to be accomplished:

1. Conducting experimental studies to assess the impact of various digital educational resources on the logical thinking skills of future mathematics teachers. This involves pre-test and post-test assessments to measure changes in logical thinking skills.
2. Analysing specific contributions of interactive simulations and visualisations and quantifying the improvement in logical thinking skills. Determining the magnitude of improvement in logical thinking skills among participants after exposure to digital educational resources to provide empirical evidence of the effectiveness of these resources.
3. Exploring participants' perceptions and experience through survey and questionnaire to gather deep qualitative insights regarding the use of digital educational resources.

To accomplish the mentioned aim and objectives, the research design described in the following section has been used.

MATERIALS AND METHODS

The present section focuses on the methodology employed to investigate the effectiveness of interactive simulations and visualisations as digital educational resources in enhancing the logical thinking skills of prospective mathematics teachers. The study consisted of three main stages as illustrated in Figure 1.

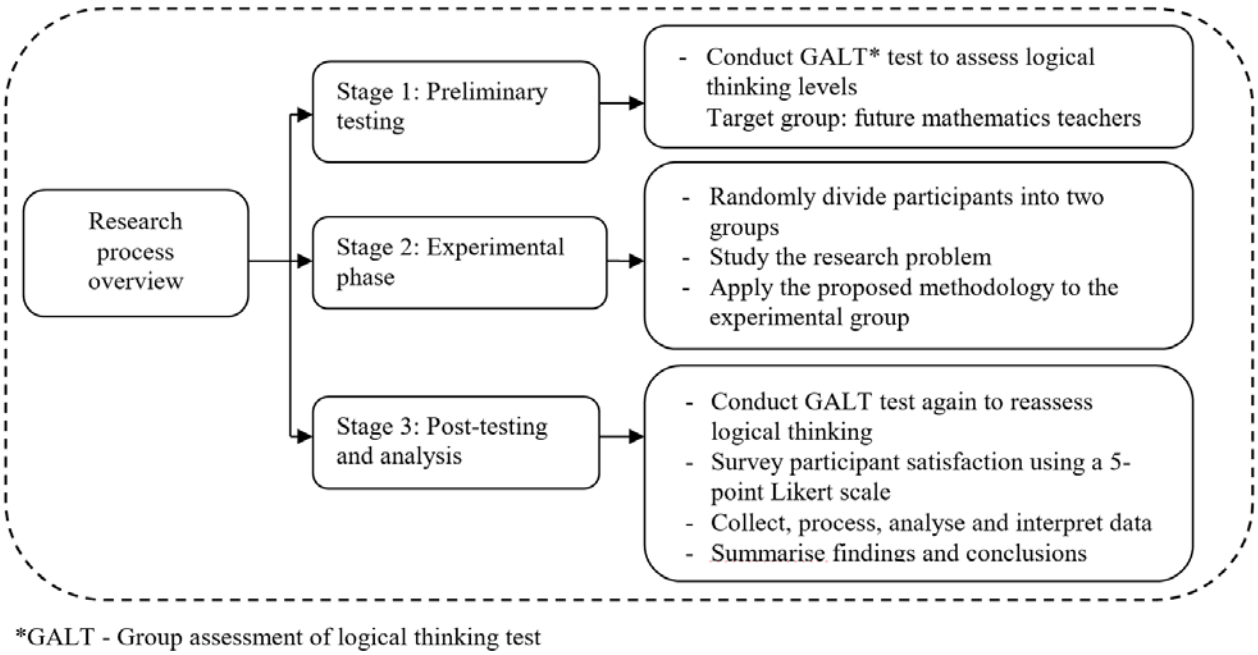

Figure 1: Research process overview.

The first stage was pre-testing which aimed to identify the level of logical thinking of students - future teachers of mathematics with the GALT test developed by Vantipa Roadrangka [21].

The second stage involved random division of participants into two groups (experimental group, control group), studying the research problem and application of the proposed methodology to the experimental group.

In the third stage, all of the participants took the GALT test again and shared their experiences and opinions of the learning process in the questionnaire.

Research Context

The research was conducted on the *Methods of solving non-standard problems in mathematics* module which lasted 15 weeks and consisted of 45 academic hours: 15 lectures and 30 practical seminars, 50 minutes each.

Table 1: Curriculum and DERs employed in the experimental group.

Name of the discipline modules	Duration	Skills being formed	Experimental group			
			DER type	Training format	Duration	
					Lecture	Seminar
Module 1. Non-standard methods for solving algebraic equations	5 weeks 5 lectures 10 seminars	Evaluation, analysis, synthesis, abstract thinking, logical reasoning	PhET Interactive Simulations	Individually	2	4
			MathCad	In pairs	2	4
			MS Excel	In pairs	1	2
			Photomath	Individually	Not limited	Not limited
Module 2. Equations and inequalities containing radicals, degrees and modules	7 weeks 7 lectures 14 seminars	Analytical thinking, deductive thinking, inductive thinking, logical reasoning	Wolfram Alpha	Individually	3	6
			Khan Academy	In groups	2	4
			MS Excel	In pairs	2	4
			Photomath	Individually	Not limited	Not limited
Module 3. Solving equations and inequalities using the properties of the functions included in them	3 weeks 3 lectures 6 seminars	Combinatorial thinking, critical thinking, abstract thinking	Desmos	In groups	2	4
			Microsoft Math Solver	In pairs	1	2
			Photomath	Individually	Not limited	Not limited

In the experimental group, lectures were conducted in a collaborative format, where participants engaged with non-standard problem formats designed to enhance logical thinking and reasoning. These sessions utilised digital tools incorporating elements of data visualisation to facilitate understanding. During practical seminars, interactive digital

simulators and mathematical platforms were employed to support independent problem solving, as well as problem formulation in individual, paired and group settings, as illustrated in Table 1.

Conversely, the control group followed a traditional instructional approach, relying on conventional tools, such as the blackboard, notebooks and textbooks. The curriculum adhered strictly to the general syllabus, with classes conducted in a standard classroom-lesson format, devoid of innovative technologies and contemporary teaching methods.

Sample

The research involved 80 students (n = 22.27% males and n = 58.72.5% females) of the Faculty of Natural Science of pedagogical specialties, studying in educational programmes 6B01501 - Mathematics and 6B01502 - Mathematics-Computer Science at *I. Zhansugurov* Zhetysu State University, Taldykorgan, Republic of Kazakhstan. All of the participants were in their last year pursuing education to become future teachers of mathematics. The research covered the 2022/2023 academic year. The research covered two semesters, where 42 students of educational programme 6B01501 - Mathematics (52.5%) took part in the research in the first semester and 38 students of educational programme 6B01502 - Mathematics-Computer Science (47.5%) in the second semester, respectively. The average age of participants was 19.7 years (Table 2). The study was conducted in the research laboratories of the University. Ethical approval was obtained from the University Ethics Committee and all participants provided written informed consent.

Table 2: Demographics of the participants.

Educational programme	Gender		Year of study (4th year)	Age			Control group	Experimental group
	Fem	Male		18y	19y	20y		
6B01501 Mathematics	29	13	42	2	9	31	21	21
6B01502 Mathematics-Computer Science	27	11	38	1	7	30	19	19
Overall	58	22	80	3	16	61	40	40
	72.5%	27.5%	100%	3.75%	20%	76.5%	50%	50%

Research Tools

The logical thinking of future mathematics teachers before and after training was assessed using the diagnostic GALT test, which consists of 40 non-standardised questions and assesses the level of logical thinking in six reasoning skills. Figure 2 illustrates these six skills, with a brief description and a sample task for each of them.

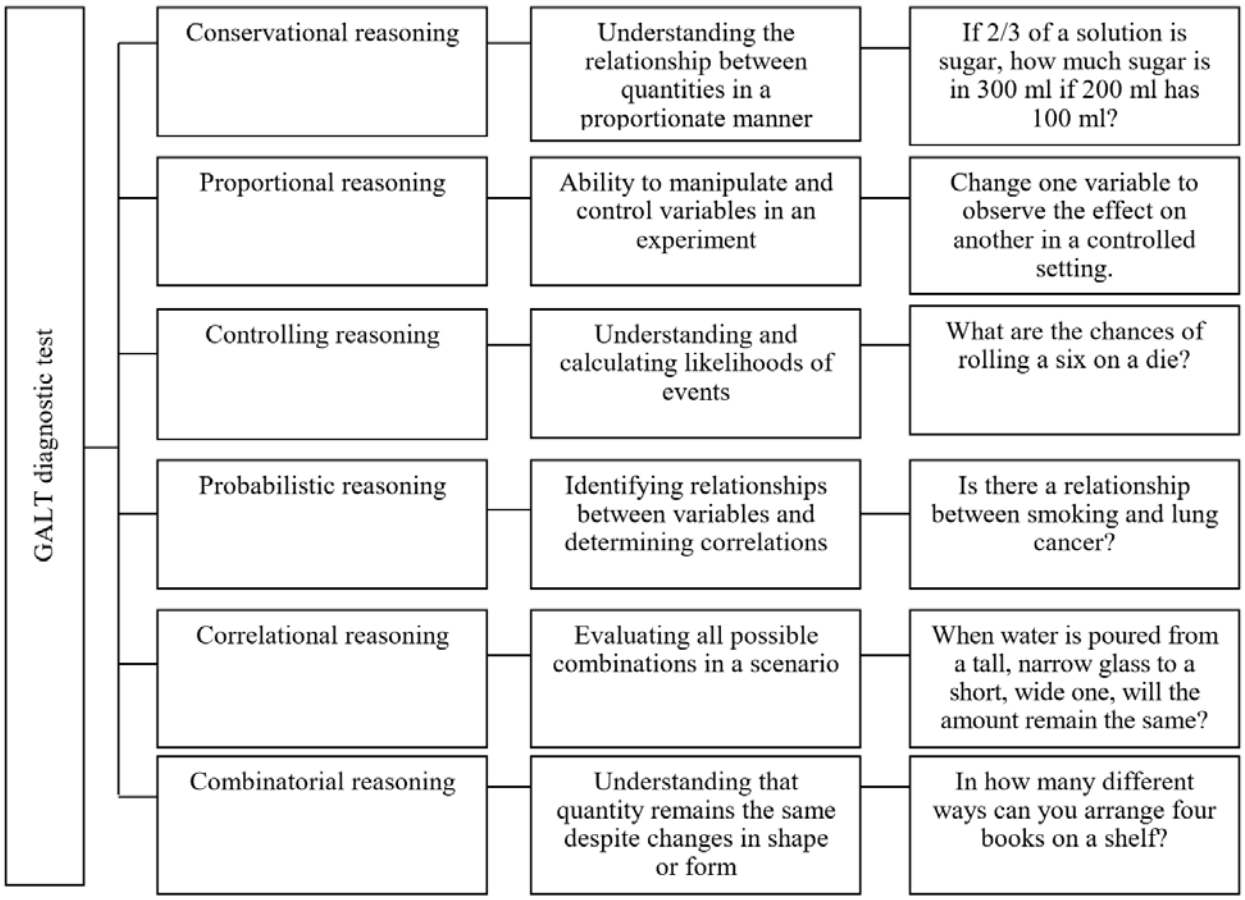

Figure 2: Types of reasoning, thinking skills and examples used in testing participants.

In addition to GALT testing, participants were surveyed and given the opportunity to express their opinions and satisfaction rate using a 5-point Likert scale (where 0 was totally disagree and 5 was totally agree). The validity checks of the questionnaire showed that the mean value of Cronbach's α equalled to 0.86.

Empirical Referents for Transformative Learning

Building on the GALT test, the following thinking skills were identified as referents for learning during the application of digital resources in the experiential learning: increased abstract thinking, improved deductive reasoning skills, ability to analyse complex problems, evaluate reasoning, improved memory and attention, quick and accurate solution of logical problems, development and testing of hypotheses, and increased satisfaction and engagement.

These skills affect the ability to understand material in depth, analyse and evaluate information, increase motivation to learn, and implement projects and practical tasks, leading to effective mathematics learning and thinking skills.

Procedure and Data Analysis

A diagnostic GALT test was prepared in Google Forms, with 40 open and closed questions of theoretical and practical nature, for each correct answer students received 0.5 points, which resulted in a maximum of 20 points. The pre-test was sent out in the group chats of the university e-journal and was taken by both experimental and control group students one week before the start of the study, and the result was recorded as pre-test in an Excel dataset. At the end of the relevant semester, the control and experimental groups took the GALT test again with a different set of questions and the data collected was recorded as post-test. The student satisfaction questionnaire was administered to the students one week after course completion.

The collected data was analysed in SmartPLS 4 software, where standard deviation (SD), mean ($\bar{x}$), variance (s^2) and margin of error (confidence interval) ($s\bar{x}$) were calculated, which made it possible to identify and confirm the distribution of pre-test results within each group, to determine changes in the variability of post-test results after the application of digital tools in the teaching process, and to compare the consistency of improvements between the control and experimental groups. Additionally, a *t*-test for independent samples was employed to compare populations based on quantitative attributes. This statistical method was utilised to assess the significance of changes in the development of logical thinking among future mathematics teachers facilitated by the use of digital resources. By applying this rigorous statistical analysis, the authors aimed to provide a comprehensive evaluation of the impact of digital tools on enhancing logical reasoning skills.

RESULTS

The results of this study provide empirical evidence of the effectiveness of digital educational resources in enhancing the logical thinking skills of future mathematics teachers, as demonstrated through experimental studies, analysis of specific contributions of interactive simulations and visualisations, and exploration of participants' perceptions and experiences.

The level of logical thinking among final-year students in pedagogical mathematics and mathematics-computer science was assessed using the GALT diagnostic test. This test comprises 40 questions evaluating six core logical thinking skills (Table 3), with each question valued at 0.5 points. In the pre-test, future mathematics teachers in both the control and experimental groups demonstrated an average score of 11.80 out of a possible 20 points, equating to 59%. This baseline measurement indicates that, on average, students exhibited a moderate level of logical thinking skills prior to the intervention (Table 3).

Table 3: Pre-test and post-test results of the control and experimental group.

		Pre-test				Post-test				Differ.
Logical thinking component	Maximum value	M ($\bar{x}$)	SD	ME ($s\bar{x}$)	V (s^2)	M ($\bar{x}$)	SD	ME ($s\bar{x}$)	V (s^2)	Mpost-test - Mpre-test
Control group										
Conservation thinking	4	2.10	0.38	0.06	0.15	2.45	0.40	0.06	0.16	0.35
Proportional thinking	4	2.40	0.39	0.06	0.15	2.93	0.39	0.06	0.15	0.53
Controlling thinking	3	1.75	0.33	0.05	0.11	2.00	0.29	0.04	0.08	0.25
Probabilistic thinking	3	1.80	0.22	0.05	0.03	2.28	0.25	0.06	0.03	0.48
Correlation thinking	3	1.90	0.32	0.05	0.10	2.28	0.25	0.06	0.03	0.38
Combinatorial thinking	3	1.72	0.39	0.06	0.15	1.95	0.15	0.02	0.02	0.23
Total score		11.80	0.86	0.13	0.74	14.00	1.55	0.24	2.42	2.20

Experimental group										
Conservation thinking	4	2.00	0.45	0.07	0.20	3.40	0.48	0.07	0.23	1.40
Proportional thinking	4	1.86	0.51	0.08	0.26	3.62	0.37	0.05	0.13	1.76
Controlling thinking	3	1.76	0.35	0.05	0.12	2.47	0.39	0.06	0.15	0.71
Probabilistic thinking	3	2.00	0.34	0.05	0.12	2.70	0.29	0.04	0.08	0.70
Correlation thinking	3	1.90	0.36	0.05	0.13	2.75	0.25	0.04	0.06	0.85
Combinatorial thinking	3	2.00	0.29	0.04	0.08	2.50	0.40	0.06	0.16	0.50
Total score		11.80	0.98	0.15	0.97	17.50	2.03	0.32	4.14	5.70

The post-test results, following the application of digital tools in teaching the experimental group through non-standard contextual problems, revealed an average score of 14.0 points in the control group and 17.5 points in the experimental group. A visual comparison of pre- and post-test results underscores the effectiveness of incorporating digital tools in teaching future mathematics teachers, particularly in enhancing their ability to solve practical tasks that develop higher-order thinking abilities, including logical thinking and reasoning (Table 3).

A detailed analysis of the standard deviation alongside the mean further substantiates these findings. The post-test results indicated a mean score of 14.00 with a standard deviation of 1.55 in the control group, and a mean score of 17.50 with a standard deviation of 2.03 in the experimental group. This analysis demonstrates a significant improvement in logical thinking skills across six areas in the experimental group, evidenced by a post-test increase of 5.70 points from the pre-test scores. In contrast, the control group exhibited a more modest increase of only 2.20 points. This statistical analysis validates the effectiveness of the teaching methodology in enhancing the logical thinking skills of students (Table 3).

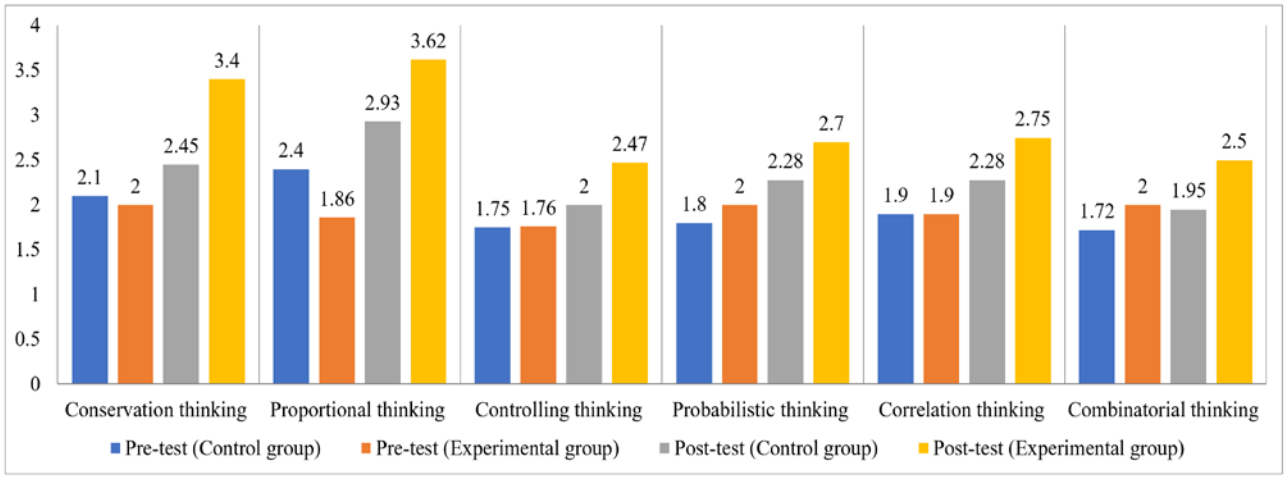

Figure 3: Pre-test and post-test results of the participants divided by the type of thinking.

Figure 3 shows the detailed dynamics of the development of logical thinking of future teachers of mathematics for each type of thinking process in the control and experimental group before and after the experiment. According to the results of the study (Table 3, Figure 3), regular and systematic solving of non-standard problems contributed to the increase in the development of logical thinking skills. But nevertheless, according to this diagram one can observe how DERs in the experimental group significantly increased the effectiveness of this process, compared to the traditional method that was applied in the control group.

In order to calculate significant differences in mean values between pre- and post-test results, the *t*-test of independent samples was used. This test was conducted with the help of Python programming language, using statistical modules (Table 4).

Table 4: Values of *t*-test and *p*-test.

Pre-test		Post-test	
t-statistics	*p*-value	*t*-statistics	*p*-value
-0.49	0.63	-11.73	6.65e-19

The analysis of these data reveals no statistically significant difference in the pre-test results between the control group and the experimental group, as indicated by a *p*-value greater than 0.05 ($p > 0.05$). This suggests that before the experiment, the logical thinking levels were equivalent in both groups, establishing comparable initial conditions.

However, the post-test results reveal a significant difference, with the *p*-value much lower than the standard threshold of $p < 0.05$, indicating statistically significant differences between the control and experimental groups. This finding substantiates that the use of DERs in the experimental group positively influenced the development of logical thinking skills among future mathematics teachers. Changes in the six targeted thinking skills are illustrated in Figure 3.

To further assess and measure satisfaction with the teaching process, a questionnaire using a 5-point Likert scale was developed and administered. The scale ranged from 0 (totally disagree) to 5 (totally agree). The questionnaire encompassed six main components of the learning process: quality of content, teaching methodology, involvement and interaction, practical implementation, support and resources, and educational environment, with five questions for each component (Table 5).

Table 5: Results of the questionnaire.

Component	Quality of content	Method of teaching	Involvement and interaction	Practical implementation	Support and resources	Educational environment	Overall satisfaction
Mean score (Contr. gr.)	3.50	3.00	3.10	3.40	3.30	3.60	3.20
Mean score (Exp. gr.)	4.70	4.80	4.90	4.50	4.60	4.70	4.60

According to the questionnaire results, students in the control group gave an average course rating of 3.20 points on the Likert scale, indicating moderate satisfaction. The questionnaire highlighted specific areas for improvement, such as teaching methods (3.0) and involvement and interaction (3.10).

Conversely, the experimental group rated the course at an average of 4.60 points, reflecting high satisfaction. Despite the similar course content and tasks for both groups, the use of DERs in the experimental group's teaching process positively impacted satisfaction across all aspects of the learning process. This is evidenced by high scores in teaching methodology (4.80) and learner engagement (4.90), demonstrating that the integration of DERs enhances teaching effectiveness and student engagement.

DISCUSSION

The discussion section begins by examining the results obtained from the study in the context of enhancing logical thinking skills among future mathematics teachers through the use of digital educational resources. It seeks to explore the underlying reasons for the observed outcomes, compare the proposed method with existing approaches, and identify the limitations and potential areas for further development. This analysis is grounded in the empirical evidence provided by the experimental studies, surveys and comparative analyses conducted as part of the research. The obtained results can be explained by the effective integration of digital educational resources in the mathematics teacher training programme.

The significant improvements in logical thinking skills among participants (as shown in the results section) are supported by the literature indicating that interactive simulations, visualisations and gamification can enhance learning outcomes, engagement and motivation in mathematics education [7][8][18]. The positive feedback from participants regarding the quality of content, method of teaching, involvement and interaction, practical implementation, support and resources, educational environment (as indicated in the survey results) aligns with previous research that highlights the importance of user-friendly and relevant digital resources in education [10][11].

The proposed method of incorporating DERs, particularly interactive simulations and visualisations, into mathematics teacher training programmes, differs from traditional approaches that rely heavily on textbook-based instruction. Compared to existing methods, the use of DERs offers a more dynamic and interactive learning experience, which is in line with the current trend of using technology to enhance learning outcomes [1][3]. This approach addresses the challenges of updating the curriculum content to meet the demands of the modern economy, as highlighted in the introduction.

The study has several limitations, including the relatively small sample size of 80 participants, which may not be representative of all future mathematics teachers in Kazakhstan. The study's focus on specific types of DERs (interactive simulations and visualisations) may limit the generalisability of the findings to other digital resources. Additionally, the study was conducted in a controlled experimental setting, which may not fully replicate the complexities of real-world classroom environments.

The development of this research could involve exploring the long-term effects of using DERs on the professional development of mathematics teachers and their impact on student learning outcomes. Future studies could also investigate the integration of other types of digital resources, such as adaptive learning algorithms and collaborative learning platforms, into teacher training programmes. Challenges that may be encountered include the need for more

extensive training and support for teachers, ensuring equitable access to digital resources and addressing the diverse needs of learners.

CONCLUSIONS

In conclusion, this study has addressed the objectives set forth regarding the impact of digital educational resources on enhancing the logical thinking skills of future mathematics teachers. The use of interactive simulations and visualisations has proven to be a valuable tool in developing an intuitive understanding of abstract mathematical concepts and enhancing problem-solving skills. The experimental studies demonstrated statistically significant improvements in logical thinking skills among participants, indicating the effectiveness of these resources.

Furthermore, the study provided insights into the perceptions and experiences of participants through a survey of satisfaction with the educational process. The feedback indicated a high level of satisfaction and the effectiveness of the digital tools was appreciated by the experimental group, underscoring the importance of incorporating digital educational resources into mathematics teacher training programmes.

It is also important to acknowledge the limitations of this study, including the small sample size and the controlled laboratory setting. These factors may limit the generalisability of the findings. Additionally, the focus on interactive simulations and visualisations means that other types of digital educational resources were not explored. Future research could expand on these findings by investigating the long-term effects of these resources on the professional development of mathematics teachers and the overall quality of mathematics education.

The potential of digital educational resources in mathematics education is vast, and it is crucial to continue exploring their applications to provide high-quality and engaging mathematics education for all students.

In conclusion, the findings of this study underscore the effectiveness of interactive simulations and visualisations in developing an intuitive understanding of abstract mathematical concepts and enhancing problem-solving abilities, which are crucial components of logical thinking. These results highlight the importance of integrating digital educational resources into mathematics teacher training programmes to improve the logical thinking skills of future educators.

The use of innovative tools in education not only supports the modernisation of teaching practices, but also ensures that prospective teachers are well-equipped to foster a deeper understanding of mathematics in their students. Therefore, the incorporation of interactive simulations and visualisations into the curriculum is essential for enhancing the quality of mathematics education and preparing future teachers to meet the challenges of a technology-driven educational landscape.

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REFERENCES

1. Gero, A., Systems thinking of secondary and post-secondary students majoring in engineering. *Global J. of Engng. Educ.*, 25, **3**, 195-199 (2023).
2. Kunene, N. and Havenga, M., Coding and computational thinking: Foundation Phase mathematics students' experiences and reflections. *Global J. of Engng. Educ.*, 26, **1**, 42-48 (2024).
3. Avsec, S., Design thinking to enhance transformative learning. *Global J. of Engng. Educ.*, 23, **3**, 169-175 (2021).
4. Lazar, I.M., Panisoara, G. and Panisoara, I.O., Digital technology adoption scale in the blended learning context in higher education: Development, validation and testing of a specific tool. *PloS one*, 15, **7**, e0235957 (2020).
5. Gerasimova, I.G., Pushmina S.A. and Carter E.V., A fresh look at blended learning: boosting motivation and language acquisition in an ESP course for engineering students. *Global J. of Engng. Educ.*, 24, **1**, 52-59 (2022).
6. Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O. and Kerres, M., Mapping research in student engagement and educational technology in higher education: a systematic evidence map. *Inter. J. of Educational Technol. in Higher Educ.*, 17, 1-30 (2020).
7. Mystakidis, S., Berki, E. and Valtanen, J.P., Deep and meaningful e-learning with social virtual reality environments in higher education: a systematic literature review. *Applied Sciences*, 11, **5**, 2412 (2021).
8. Tsai, T.P. and Lin, J., eBook-based mobile action learning to enhance learning effects in flipped classrooms. *Global J. of Engng. Educ.*, 23, **3**, 252-259 (2021).
9. Castro, R., Blended learning in higher education: trends and capabilities. *Educ. and Inform. Technol.*, 24, **4**, 2523-2546 (2019).

10. Guzik, A., Tomczak, M.T.and Gawrycka M., What is the future of digital education in the higher education sector? An overview of trends with example applications at Gdańsk Tech, Poland. *Global J. of Engng. Educ.*, 26, **2**, 95-100 (2024).
11. Knox, J., What does the *postdigital* mean for education? Three critical perspectives on the digital, with implications for educational research and practice. *Postdigital Science and Educ.*, 1, **2**, 357-370 (2019).
12. Anderson, V., A digital pedagogy pivot: re-thinking higher education practice from an HRD perspective. *Human Resource Develop. Inter.*, 23, **4**, 452-467 (2020).
13. Gonzales, A.L., McCrory Calarco, J. and Lynch, T., Technology problems and student achievement gaps: a validation and extension of the technology maintenance construct. *Communication Research*, 47, **5**, 750-770, (2020).
14. Kaddoura, S. and Al Husseiny, F., An approach to reinforce active learning in higher education for IT students *Global J. of Engng. Educ.*, 23, **1**, 43-48 (2021).
15. Vargas, P.R. and Romaní, C.C., Digital learning: distraction or default for the future. *Digital Educ. Review*, 37, 1-16 (2020).
16. Osiurak, F. and Reynaud, E., The elephant in the room: what matters cognitively in cumulative technological culture. *Behavioral and Brain Sciences*, 43, e156 (2020).
17. Lesh, R.A., Sriraman, B. and English, L., Theories of learning mathematics. *Encyclopedia of Mathematics Educ.*, 861-869 (2020).
18. Sinclair, N. and Robutti, O., Teaching practices in digital environments. *Encyclopedia of Mathematics Educ.*, 845-849 (2020).
19. Yessingeldinov, B., Rakhymbayeva, Z., Zhapparova, A. and Tursynova, L., Utilising a differentiated assessment method in mathematics class: computer adaptive testing for tracking student progress. *Global J. of Engng. Educ.*, 25, **1**, 29-34 (2023).
20. Bostan, İ. and Moseley, R., Mathematics teachers' use of digital resources and students' achievement: a comparative analysis of the EU countries. *Inter. J. of Educational Technol. in Higher Educ.*, 16, **1**, 1-20 (2019).
21. Roadrangka, V., The construction of a group assessment of logical thinking (GALT). *Kasetsart J. of Social Sciences*, 12, **2**, 148-154, (1991).

BIOGRAPHIES

Aiym Yesseikyzy obtained her Bachelor degree in pedagogical informatics in 2014 and her Master degree in informatics in 2018 from *I. Zhansugurov* Zhetysu State University, Taldykorgan, Kazakhstan. Since 2018, she has been engaged in both teaching and research activities at this University, initially as an assistant lecturer and subsequently as a senior lecturer. From 2019 to 2022, she pursued her doctoral studies in mathematics, and conducted research focusing on cognitive skills, particularly logical reasoning, argumentation and problem-solving skills among future mathematics teachers. In addition to her academic endeavours, she has participated in numerous research projects and has authored over 20 publications covering various topics related to mathematical education, educational technology, cognitive skills, logical thinking and diverse teaching methods. Furthermore, she has been the recipient of grants from various competitions supporting research activities for young scholars.

Yesengali Smagulov's academic career began at the Taldykorgan Pedagogical Institute, Kazakhstan, from 1975 to 1979, where he specialised in mathematics education. Later, he commenced a postgraduate course at *Abai* Kazakh Pedagogical Institute, Almaty, Kazakhstan. In 1992, he received a PhD in physics and mathematics with a degree in mathematical modelling. During his career, Yesengali Smagulov has frequently received significant awards, including state grants in the nomination *Best University Teacher* and prestigious medals. He was promoted to associate professor in 1996 and professor in 2018. His research contributions, comprising more than 80 scientific publications, cover a wide range of specialised fields in educational technology, mathematical analysis and mathematical literacy. He is the author of educational materials and methodological manuals, as well as monographs aimed at improving mathematical education.

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