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Technology of formation of students' skills of educational and cognitive activity through mathematical modelling

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Abstract

The study was examined, the technology for creating students' educational and cognitive activity skills through mathematical modelling was aimed and designed. As a model, this study was helped by the quantitative research model, and the research was carried out in the fall term of 2022–2023. 172 volunteer students who continue their education in high schools participated in the research. In the study, 3 weeks of online training was given to the students. The data collection tool was delivered to high school students by online method and collected. The analysis of the data was added to the research by tabulating the findings from the participants. When the results dimension of the study was examined comprehensively, it was concluded that the cognitive activity levels of the students were high through mathematical modelling. While this situation was determined as good for education, it was concluded that it was used by reflecting the mathematics and technology systems in the course.

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1. Introduction

It is known that mathematical modelling, which takes place during the educational period, is the time to create a physical, symbolic or abstract model of a real-life situation (Mafakheri, 2017). It is known that the modelling process can be complicated for students, emphasising that mathematical modelling in education is an event that involves much more than creating a model to explain a problem situation (Ferdosipour & Mojaveri, 2022). All the mental tools that educators and students use in the mathematical modelling process are external representations of mental structures that provide a mathematical interpretation and solution of real-life problem situations as mental models. In other words, the mathematical modelling process is a process that requires the mental modelling process (Xu, Lu, Yang, & Bao, 2022). In our developing world every day, the need for people who can understand mathematics and use their mathematical knowledge and skills in daily life is increasing, and it is inevitable that individuals with these competencies will take a more active role in shaping the future (Moghimi, 2022). In this context, he suggests that students are individuals with advanced problem-solving skills outside of school and in their future lives.

He conducts important research on mathematical modelling, which involves finding solutions to non-routine real-life situations. In this study, different perspectives on the mathematical modelling process and its components, which have an important place in mathematics teaching, are included (Muradova, Shafiyev, & To'xtayeva, 2022). According to these definitions, it is tried to give a comprehensive answer about how a richer environment can be created in the modelling process and what mathematical skills this process can help students develop or reveal. Accordingly, important studies have been conducted in the literature in this study (Jawarneh & AL-Momani, 2022). Approaches to the modeling process and some other studies that describe the structure of the process. Finally, it is seen that the theory is explained, which provides a detailed explanation of the cognitive structure of the mathematical modelling process in a technology-supported environment (Riyanto, 2022). In order for students to be able to model, they need to use their modelling competencies. Mathematical competence refers to the ability to understand, judge, apply and use mathematics in various mathematical contexts and situations in which mathematics plays or may play a role, and, accordingly, competencies include not only abilities and skills, but also their use, which is reflected in life and the willingness to put these skills and abilities into action (Essien & Adelekan, 2021). Modelling competencies can be defined as the skills and abilities to willingly complete the modelling process in a purposeful manner (Martins & Gresse Von Wangenheim, 2022).

Modelling competencies are explained as transferring real-life problems to a model and being able to see whether the solution obtained from the model is suitable for a real-life problem (Oschepkov et al., 2022). As can be seen, modelling competencies are related to the modelling process. The modelling steps overlap with the modelling competencies (Geiger et al., 2022). For this reason, many researchers have explained their modelling competencies along with the modelling process. It is known that cognitive modelling competencies are modelling competencies (Stytsyuk et al., 2022). In addition, understanding the real problem and reality that is based on a model after creating the actual model from mathematical modelling, mathematical model and solving the real situation then interpret mathematical results and finally the solution expressed in the form of validation (Alwattar, 2022).

1.1. Related studies

Lavrov, Logvinenko, Siryk, and Kyzenko (2021) in the year they have done in the articles, instructional technology revolutionary transformations in attempts to explain the cognitive activity of the students that arise due to the wakeup problem, and as a result of e-learning environments to significantly improve the use of their academic performance and students ' independent studies in the mathematical field they achieved a decrease in the frequency of rejection and getting stronger.

Shcherbatykh and Lykova (2022) deciphered information and technology, interdisciplinary, system and efficiency approaches by developing the structural components of a stochastic worldview, for example, motivational value relations, intuitive figurative perception and rational logical acceptance (10 and 11). The students in the class to determine the most effective way to investigate the properties of mathematics was undertaken to complete and as a result methodological and methodical approaches in mathematics education and is also known with the technology, ideas, methodological tools empowered with the technology they have achieved.

Chamberlin, Payne, and Kettler (2022) in the year the work they have done in attempts to explain aspects of mathematical modelling related to the taxonomy of mathematical problem solving, mathematical modelling, and the result is the main focal point of the detailed problem and the types of the structural properties and values that they can enjoy their products so that readers have arrived at the possible side, and side products such positive emotional outcomes, a tendency to affect the creative process and the product in a positive way, and they could be achieved in defining mathematics conceptual learning.

In this section, as can be seen in the given research is primarily in research and technology of the combination of mathematics in their lives and future educational achievements of students identified by the individual, they would be more successful using this model, it is obvious that, in this context, this research also while waiting for the same condition through mathematical modelling students' educational and cognitive activity takes place between the technology to build the skills of the formation of expectations.

1.2. Purpose of the study

In this research, which you have read and examined, the technology of creating students' educational and cognitive activity skills through mathematical modelling was aimed. In order to reach the problem situation in the research, answers to some questions were sought:

1. What is the level of mathematical modelling readiness of the students participating in the research?

2. Is there a significant difference in the mathematical modelling readiness of the students participating in the study according to gender variables?

3. According to the activities of the students participating in the research, is there a significant difference in the cognitive activity skills formation technologies according to gender variables?

4. What are the opinions of the students who participated in the research about the post-study period?

2. Method

When the method part and part of the study are discussed, it will be seen that the information about the participants participating in the research, data analysis, application dimension will be included and explained in this section.

2.1. Research model

It is seen that quantitative research methods are supported and benefited from in the research, and this model is designed to collect objective and irrefutable facts, namely numerical data. Quantitative data, which are structured and statistical, are known to be used to assist when you need to draw general conclusions from your research (Valdebenito Zambrano, Duran Gisbert, & Uzunboylu, 2021). In this research, on the technology of forming students' educational and cognitive activity skills through mathematical modelling, through quantitative research method; were described according to the variables of gender, educational status, and duration of education.

2.2. Working group/participants

The research was carried out on a voluntary basis and was carried out on 172 participants who continued their education in high schools in Kazakhstan over the 2022–2023 fall academic year and wanted to participate voluntarily. The data collection tool used in the study was applied to 172 participants and accepted.

2.2.1. Gender

In this part of the study, the gender data of the participants who were included in the study voluntarily were separated and each detailed data is given in Table 1.

Table 1. Distribution of high school students included in the study by gender

Gender	Boy		Girl	
	F	%	*F*	%
Variable	90	52.33	82	47.67

As seen in this part of the research, it is seen that the gender data and the digitised data are added to Table 1, it is seen that 52.33% (90 people) of the participant groups included in the research are male students, while 47.67% (82 people) are female students. In the gender section, the findings reflect the actual gender distribution.

2.2.2. Cognitive activity use cases

In this part of the study, cognitive activity activities were given to high school students during the study and they were asked to follow them, their use cases during the day were examined in order to improve their cognitive activity and mathematical status, and detailed information is given in Table 2.

Table 2. Cognitive activity usage status of the students participating in the research during the day

Cognitive activity use	1–3 hours		4–6 hours		7 or more hours	
	F	%	*F*	%	*F*	%
Variable	8	4.65	49	28.49	115	66.86

As seen in Table 2, the cognitive activity usage status of the participant groups included in the study during the day was examined and within the scope of the findings, 4.65% (8 people) stated that they preferred it between 1 and 3 hours, 28.49% (49 people) stated that they preferred it between 4 and 6 hours and 66.86% (115 people) stated that they used 7 hours or more of cognitive activity. In this context, it can be said based on Table 2 that the most preferred time period is 7 hours and above. In the section of cognitive activity use cases during the day, the findings reflect the true distribution.

2.2.3. Class status

When the class status section of the study is examined, detailed information according to the class distinction of the participant groups included in the research is given in Table 3.

Table 3. Distribution of the participants participating in the research according to their class status

Class	Second grade		Third grade		Fourth grade	
	F	%	*F*	%	*F*	%
Variable	49	28.49	55	31.98	68	39.53

As seen in Table 3, it is seen that the class characteristics of the students participating in the study are included. In this context, it is seen that 28.49% (49 people) are in the second grade, 31.98% (55 people) are in the third grade and 39.53% (68 people) were in the fourth grade. They stated that they were educated in the classroom. In the class situations section, the findings reflect the actual distribution.

2.3. Data collection tools

It is seen that the data collection tool used in the research was created by the people who were created to add the study to the literature and developed by the experts in the field, it is seen that two parts are emphasised in the data collection tool part, it is seen that there are mathematical modelling and cognitive activity and the use of technology in this part.

1. First form: Some information was given in this form and the participants were asked about information gender, class etc.

2. Second form: When the name of the data collection tool was examined, ‘Mathematical Skills Building Skills’ was arranged and compiled by the researchers as a data collection tool. In the data collection tool, 19 items of the measurement tool consisting of 25 items were used and 6 items were extracted from the measurement tool thanks to expert opinion. The views of the participant groups were sought from two factorial dimensions, namely ‘mathematical modelling’ and ‘use of cognitive activity skills’ of the students participating in the research. The Cronbach alpha reliability coefficient

of the data collection tool was calculated as 0.93. The measuring tool was in the range of 'strongly disagree' (1), 'disagree' (2), 'undecided' (3), 'agree' (4) and 'strongly agree' (5). The measurement tool was also collected from the participant groups participating in the research in the form of an online environment.

2.4. Application

It is seen that training will be given to the participant groups as a whole and existence in the application dimension in the research. For the students who continue their education in high schools in Kazakhstan, the application environment was prepared and designed for these 172 volunteer participants. The online education environment was organised by showing the environment of mathematical modelling and cognitive activity and technology creation activities to experts in the field, after the training part of the research, it was planned to show permanent memory techniques for mathematical modelling development and cognitive activity technologies for students. During the 3-week training, information such as 'mathematical modelling', 'cognitive activity skills', 'formation of models with technology' etc., were transferred to the participant groups in the form of live activities. After the 3-week training, the data collection tool and information form were applied to the participant groups participating in the research, and the data were given in tables in the findings section. Two sections were determined through the Adobe Connect application programme, which is preferred by most schools and preferred by other people, and each section is distributed over weeks to be limited to a maximum of 90 students. The data collection tool applied to the participant groups participating in the research was collected through an online questionnaire with the help of their families and transferred to the Statistical Package for the Social Sciences programme by coding them in the computing software environment.

2.5. Analysis of the data

The data obtained from the high school students participating in the study were analysed in the Statistics programme using frequency (f), percentage (%), mean (M), standard deviation (SD) and *t*-test. The data obtained from the programme are given in the findings section accompanied by tables and comments.

3. Findings

In this section, it is seen that the answers to the problem status questions are sought and added. In addition, various interpretations were given in line with each finding.

3.1. Mathematical modelling readiness of the students participating in the research

In this section, the mathematical modelling readiness status of the students participating in the research under two headings was investigated and information about these findings was added to Table 4.

Table 4. Mathematical modelling readiness status of the participants participating in the research

Cognitive activity	*N*	*M*	SS
Cognitive activity Yatkın Olma	172	4.32	0.342
Cognitive activity Ortamı	172	2.36	0.542

When Table 4 is examined, the research groups that are included in the mathematical modeling of participant readiness cases have been investigated and results is observed to occur, accordingly, being inclined and readiness in cognitive activity score (*M* = 4.32), no signs were found of that, I also examined the scores of cognitive activity in Table 4, using the environment (*M* = 2.36), it is observed that. According to these values, the related table shows that the groups of participants participating in the study have high cognitive activity readiness and are able to use the environment.

3.2. Distribution of mathematical modelling readiness of the students participating in the research according to gender variables

It is seen that the *t*-test was applied and added to find out that the mathematical modelling readiness of the participants participating in the study on Table 5 is not a negative difference for the gender criterion.

Table 5. Distribution of mathematical modelling readiness of the students participating in the research according to gender variables

Groups of participants included in the study	Gender	*N*	*M*	SS	SD	*t*	*p*
Mathematical modelling	Boy	90	4.36	0.419	172	−2.076	0.021*
	Girl	82	4.12	0.438			

According to Table 5, when the findings were considered, it was concluded that the difference in the gender variable dimension of the mathematical modelling readiness scores of the participant groups included in the study according to the *t*-test result was significant [$t(172) = -2.076$, $p < 0.05$]. When the arithmetic averages of mathematical modelling readiness are examined, it is seen that the average of male students is (*M* = 4.36), the arithmetic mean of mathematical modelling readiness status of female students is (*M* = 4.12) and the scores of male students are higher than female students. Accordingly, it can be said that male students are more prone than female students.

3.3. Distribution of cognitive activity skills creation technologies status of high *school students participating in the study according to gender variables*

As seen in Table 6, the t-test was applied to find out whether there is no gender difference in the cognitive activity skills generation technologies status of the high school students participating in the research according to the activities performed.

Table 6.

Distribution of cognitive activity skills generation technologies status of high school students participating in the research according to gender variables

High school students participating in the	Gender	*N*	*M*	SS	SD	*t*	*p*
Technologies for building cognitive activity skills	Boy	90	4.33	0.375	172	−2.328	0.020*
	Girl	82	4.26	0.428			

According to the *t*-test findings applied according to Table 6, it was concluded that there was a significant difference in the gender variable dimension of the cognitive activity skills creation technologies status and scores of the students participating in the research [$t(172) = -2.328$, $p < 0.05$]. When the arithmetic averages in the dimension of technologies for creating cognitive activity skills are examined, it is seen that male participants have an average score of $M = 4.33$, while female students have a high score of technologies for creating cognitive activity skills ($M = 4.26$) and male students have high scores. Accordingly, it can be said that male participants are more prone to cognitive activity skills generation technologies than female participants.

3.4. Opinions of the students who participated in the study after the study

In this section, the opinions of the students who participated in the research after the study were taken and detailed information is given in Table 7.

Table 7.

Opinions of the students who participated in the study after the study

No	Opinions of participants who participated in the study after the study	*M*	*S*
1	Live lessons, which are explained and processed with mathematical modelling, are more effective	4.38	0.86
2	Receiving live events in cognitive activity environments provides the opportunity to devote more time to my social life.	4.32	0.72
3	Instant correspondence and asking questions with the teacher who teaches the lesson with mathematical modelling is a very effective method for mathematical formulas.	4.29	0.88
4	Reaching the recording of the lesson taught with cognitive activity and technology. it is more effective in reinforcing the lesson	4.37	0.86
5	Cognitive activity is an advantage for me to be able to learn technology and information whenever and wherever I want.	4.25	0.71
6	I don't experience any disconnection during the live lesson with mathematical modelling.	4.33	0.73
7	I have the opportunity to learn how information technologies are used by taking a math lesson with cognitive activity.	4.37	0.82
8	It gives me pleasure to chat with my friends while taking lessons in a cognitive activity environment.	4.31	0.92
9	In the cognitive activity environment, I can watch the course video recordings when they are uploaded.	4.38	0.83
10	I can download mathematical videos processed with cognitive activity from the system whenever I want.	4.32	0.85
11	I find cognitive activity effective and beneficial	4.36	0.81
12	It gives me pleasure to be in the system as an online participant while the live lesson is being taught with cognitive activity.	4.35	0.71
13	It raises hands in cognitive activity and makes me feel like I am in a formal education environment.	4.33	0.82
14	I think that mathematical modelling and technology are very effective for my communication.	4.37	0.84
15	I believe that mathematical modelling in general is very	4.34	0.88

	useful and effective for me.		
16	Being in sync with my teacher with mathematical modelling increases my interest in the live lesson.	4.32	0.91
17	Materials using mathematical modelling help me better understand the subject	4.31	0.82
18	Sharing files in the cognitive activity environment allows me to get feedback from other students while preparing my lecture presentations.	4.32	0.83
19	Using mathematical modelling and cognitive activity, I saw that I understood the lesson better with technology.	4.39	0.88
	Overall Average	4.33	0.82

As can be seen in Table 7, the surveyed groups of study participants after made reference to the opinion and opinions can be seen in Table 7 that is high, even the highest one of each expression is a significant difference in the expressions 'the course of cognitive activity in the environment of the video records are loaded when you watch' *M* = 4.38 finding is reached, it is seen that that was the main views being examined another value when it is 'Cognitive system being alive with activity during the processing of the online course as a participant in it gives me joy', *M* = 4.35 finding that has been reached, although there was a significant difference in each expression, another finding was found to be 'I have the opportunity to learn how to use information technologies to take a math lesson with cognitive activity' *M* = 4.37.

Mathematical modelling and cognitive activity is observed to occur with the state of the technology, while the other one finding when considering the cognitive activity of students to be included in the study when I wanted to download the video processed with mathematical system I '*M* = 4.32' another value when it is seen that 'mathematical modelling provides a better understanding of the subject materials' *M* = 4.31, and 'mathematical modelling and cognitive activity using technology to better the lesson that I understand', I saw *M* = 4.39 is, in this context, since all the values in Table 7 have a positive meaning, it can be said based on the findings that the students included in the study were positive in their lessons with technology using mathematical modelling and cognitive activity.

4. Discussion

In the work of Rakhimova et al. (2020), it was aimed to consider an original educational development model that allows decoupling, formalisation and multi-criteria optimisation of the learning process, as well as increasing its efficiency and effectiveness. As a result of their research, they came to the conclusion that it was formulated based on the use of mathematical modelling methods, design methodology and is a successful solution to the problem of improving educational optimisation. When this value is combined with the results of the research, it is seen that the results of the study group students are very well predisposed to mathematical modelling subjects. In this context, it can be said in the discussion section that the mathematical aspect of these two studies within the research is strong and benefits the field.

Djumaboev, Usmonov, and Ergashev (2021) in the year of the work they have done and earned competencies acquired by the students in the study formulated in mathematical computer modelling is in need of further development and research by addressing the main aim of this topic and, as a result, on the principles of adequacy and at the same time, the disciplines of mathematics and Computer Science Education interdisciplinary connections of this approach, it is observed that achieves the results that contributed to the formation of research. In this context, when this value is combined with the results of the research, it is seen that the results of the students' scores are high in response to the answer that I saw that I understood the lesson better with technology using mathematical modelling and cognitive activity. Based on these two examples, it can be said in the discussion part of the research that mathematics and numerical fields will be combined with technology.

Soboleva et al. (2022) in their graduation studies, interactive math instructional model to improve the quality of educational outcomes through the development of a personalised novels sought to investigate the characteristics of, and as a result develop ideas for the personalisation of digital learning at school, in business studies, and mathematics education at all levels of training and instruction for the inclusion of interactive digital tools allow to be used for the justification of the need they achieved. In this context, when this result is combined with the values of the research, it is seen that the results of high arithmetic averages in the dimension of cognitive activity and mathematical modelling skills creation technologies are reached. It can be said in the discussion part of the research that the cognitive field benefits other fields with all values.

It seems that each value processed by cognitive activity and technology benefits the study. As a result, a separate and distinct purpose in math

Mathematical modelling research in education online the value was expected to bring in a better position for success on the participants in both intended and designed, in this context, the research is of benefit to each value in the study of the judiciary, and while it is known that, this research is expected to provide benefit and benefit the students in this direction.

5. Conclusion

Partial results of the research discussed as the first time, are among the number of participants the number of participants, the research problem is known to affect the status of an incident in perspective against such as to affect, in this context, the results of the research that had been included in the research between high school pupils in Kazakhstan and 172 of these students continue their education, it is seen that the results that have been achieved. Another important result of the study, the participating groups included in the study were examined in the days of cognitive activity and cognitive activity during the day as a result of the use cases the use cases in Section 7 hours and it is seen that desirable results have been achieved. When another value of the research is considered, the mathematical modelling readiness status of the participant groups included in the research is examined, and as a result, it is seen that the results of the participant groups participating in the research are high in cognitive activity readiness and they can use the environment.

Another value of the research is that it seems that it has been concluded that the difference in the size of the gender variable in the scores of the groups of participants included in the research on the mathematical modeling readiness of students is significant. In addition, according to the results, it was found that male students are more prone to their condition than female students.

Another value of the research is that it was concluded that the difference in the gender variable dimension of the cognitive activity skills creation technologies status and scores of the students participating in the research is significant. In addition, it is also seen that the values of male participants are more prone to cognitive activity skills creation technologies than female participants. When the final value of the research is considered, it is seen that the opinions of the groups of participants participating in the research were applied after the study and the results that the opinions examined were high were reached. Also in the environment of cognitive activity video recordings of the course are loaded, they expressed that observe and cognitive alive with activity as a participant in the system while processing the online course and they expressed them pleasure to be found, and mathematics cognitive activity they are finding an opportunity to take a course to learn how to use information technologies, cognitive activity to the videos can be downloaded anytime from the system processed with mathematical modelling, they provide a better understanding about the materials used, mathematical modelling and cognitive activity, expressed a better understanding of the lesson with using technology, in this context, the views of research participants by moving the meaning of each value of the research can be said to be positive.

According to the results obtained from the research, it has been concluded that the students' cognitive activity levels are high through mathematical modelling. While this situation was determined to be good for education, it was concluded that mathematics and technology systems were reflected and used in the course.

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