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The impact of integrated technology on students' logical thought in mathematics: A case study of Kazakhstan

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Abstract

This study aims to assess the impact of integrative technology on the improvement of the logical thinking of students in mathematics, their goals and the appropriate technological process. The study used mixed research methods. Participants included third-grade students attending elementary schools No. 12 and Ataturk in Kentau (Kazakhstan) during 2019-2022. The results indicated that primary school teachers do not pay attention to the improvement of the logical thinking of lower-grade students in mathematics. The research findings suggest that integrative technology improved logical thought in lower-grade students in the experimental group in mathematics. Finally, the study offers suggestions to improve the work of primary school teachers in developing the logical thinking of children in mathematics in Kazakhstan to increase the effectiveness of this process without increasing the burden on students or changing the curriculum.

Keywords: Case, Impact, improvement, Integrated technology, Logical thought, Students', Study

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Contents

Contribution of this paper to the literature
This study contributes to the existing literature by assessing the impact of integrative technology on the improvement of the logical thought of students in mathematics, their goals and how support for the improvement of their logical thought and the appropriate technological process take place.

1. Introduction

1.1. Math Education in Kazakhstan

An intensive exchange of advanced experience in the functioning, continuity and integration of various educational systems in the 21st century is necessary to identify effective methods, forms and technologies for teaching mathematics, determine their optimal content and develop the personalities and cultures of full-fledged members of the world community (Darling-Hammond, Flook, Cook-Harvey, Barron, & Osher, 2020; Zhang, Tao, & Zheng, 2021). The updated content of education, the transition carried out in the Republic of Kazakhstan since 2016 and its implementation in educational and methodological complexes are now some of the most discussed topics in school education (Nagima et al., 2023; Ospankulov, Zhumabayeva, & Nurgaliyeva, 2023; Zhumash et al., 2021; Zhussupbayev et al., 2023). The main tasks in the process of teaching (in particular, mathematics) are to identify and develop productive, heuristic, creative, divergent and creative thinking, the formation of sustainable motivation for learning and self-improvement, teaching the skills of self-education and research work and the formation of an internal need for continuous self-improvement (Gunawan, Kartono, Wardono, & Kharisudin, 2022; Nufus & Duskri, 2018; Sukestiyarno, Mashitoh, & Wardono, 2021; Toheri, Winarso, & Haqq, 2019). These tasks of teaching mathematics correspond to the social order of society and the identification of contradictions and difficulties that are encountered in mass practice (Gutiérrez, 2018; Wiriyaudomsatean & Thinwiangthong, 2019; Yi, Ying, & Wijaya, 2019). In mathematics, students must master the general methods of action, exercising step-by-step control and self-assessment of activities (Abd Alganı, 2019; Maass, Cobb, Krainer, & Potari, 2019; Yeh, Cheng, Chen, Liao, & Chan, 2019). At this point, the foundations of children's mental development are being laid and the conditions are being set up for the preparation of an independently thinking person who can compare, propose various solutions to a problem, assess them, select the most logical one, highlight the crucial elements, draw generalizations and apply the knowledge acquired in practice (Cunhua, Ying, Qunzhuang, & Wijaya, 2019; Huang et al., 2020; Lin, Zhou, & Wijaya, 2020). In recent years, Kazakhstan has seen a slight decline in the mathematical training of graduates of mathematical profiles at pedagogical universities (Sharzadin et al., 2019). Experts are sure that in the modern world, someone who is mathematically illiterate could be taken advantage of by someone more advanced in a subject such as financial trading (Chen, Zhou, Wijaya, & Tamur, 2021; Norqvist, 2018; Sevgi & Orman, 2022). A person must have the skills of mathematical thinking and logic to be able to correlate data and examine the information received from gadgets and computers (Fan, Qi, Liu, Wang, & Lin, 2017; Jäder, Lithner, & Sidenvall, 2020; Wijaya, Tang, Li, & Purnama, 2021).

According to experts, the main problem with mathematics education in schools in Kazakhstan is detachment from life (Abylkassymova & Tuyakov, 2018; Rysbekova, Rysbekov, & Shintimirova, 2017). Kazakh school children keep winning the most prestigious international Olympiads, yet their performance in functional math literacy is low. In the Program for International Student Assessment (PISA) 2018 ranking, Kazakhstan scored 423 points in mathematics (53rd), 387 points in reading (69th) 397 points in science (68th) and many students failed functional literacy tasks in the national exam. Updating the content of mathematical education at school is one of the main problems with the theory and method of teaching mathematics. The Kazakh mathematical community is facing the task of carefully selecting such content from the accumulated mathematical heritage of the Soviet school that would meet not only the requirements of modernity but also students' thinking abilities.

1.2. Math Education and Logical Thinking

The development of students' logical reasoning is an essential task in teaching mathematics (Algani & Jmal, 2020; Bronkhorst, Roorda, Suhre, & Goedhart, 2021). The connection between mathematicsand logic is determined by the history of their emergence and development and by the current subjects of their study. This relationship is reflected both in the processes of purposeful teaching of mathematics and logic as independent disciplines and in the improvement of mathematical thinking in studying logic and in the improvement of logical thought in teaching mathematics. On the other hand, the certainty and consistency of the studied mathematical theories make mathematics an effective tool for mastering logical constructions. The student is characterized by the level of physiologic and mental primarily intellectual development that provides the opportunity to learn (Febriana, Amin, & Wijayanti, 2019; Kim, 2020). The logical thinking of students can be seen in any mental operation they perform. Comparison is the basis of any subsequent grouping, classification and systematization of objects (Gravemeijer, 2020; Quintana & Correnti, 2019) and plays a crucial role. Students in grades 1-3 can already successfully compare objects by presentation and then abstract concepts. Solving these problems requires a high level of mathematical training (Li, Wang, Xiao, Froyd, & Nite, 2020; Zhao, Van Den Heuvel-Panhuizen, & Veldhuis, 2016). One of the fundamental principles of pedagogy is violated. Teaching new complex logical theories takes place in mathematics. As a result, teachers are deprived of the teaching material necessary for students' logical perceptions of universal educational behavior. Solving the problem requires searching and sorting through various options; children use empirical research using the "sampling" method (Aspers & Corte, 2019). Therefore, it is impossible to develop a theoretical level of logical literacy without developing empirical and conceptual forms of thinking. It is the expansion and deepening of mathematical knowledge that develops logical abilities (Su, Ricci, & Mnatsakanian, 2016). This process is also typical for younger students. Based on previously known knowledge, the student obtains new knowledge in the form of a rule or a statement. Therefore, the selected tasks in terms of their content and mathematical structure should evoke an emotional experience in the child and push him to mental activity. Thus, the solution to a textual problem consists of multiple stages in which students perform specific cognitive tasks. Consequently, a solution algorithm is determined and the student has to answer specific questions related to the functional dependencies between the quantities described in the text of the problem. Analytical, synthetic, inductive and deductive analysis of problems are used to determine solutions (Gurat, 2018; Nowell, Norris, White, & Moules, 2017). Teaching mathematics to younger students is a multifunctional process that involves the enrichment of mathematical knowledge to form and develop students' mathematical speech. In mathematical speech, there is an element of logic (Rochman, Nasudin, & Rokayah, 2019). Mathematical concepts in elementary school are mostly defined intuitively. The scientific definition of the concept occurs under the guidance of the teacher. The study of mathematical concepts (as logical material) in elementary grades requires a special methodological approach. When teaching mathematics to lower-grade students, both natural and spoken language are used. Students are first exposed to the language of mathematics in elementary school. Hence, special attention should be paid to working with its signs (Robertson & Graven, 2020; Ruef, Jacob, Walker, & Beavert, 2020).

Thus, an analysis of the skills that ensure the development of mathematical speech suggests that the main attention in the initial teaching of mathematics should be focused on:

- On the understanding by younger students of the meaning of mathematical concepts.
- The formation of skills to establish semantic relationships between concepts, terms and symbols, translate life situations into the language of mathematics and represent this situation in various mathematical models.

One of the initial stages is to create positive motivation to learn math. Tasks that help children develop a critical perception of their own and other people's speeches as well as a sense of communicative expediency play a special role in this process. Deductive and inductive statements have a special place in mathematics. Teaching children to use these statements correctly is one of the main tasks of the teacher and the ability to build such statements is an indicator of a conscious and deep understanding of the mathematical content. The ability of students to build deductive and inductive statements is an integral part of the logical part of mathematics.

The issue of organizing the improvement of logical thought in the schools of Kazakhstan has not yet found an unambiguous and generally accepted solution. One of the most important conditions for solving this problem is a specially developed system of tasks focused on teaching younger students the methods of logical thinking. School teaching practices in Kazakhstan demonstrate that school teachers suggest that all the necessary thinking skills will develop independently in children of primary school age. The growing volume and complexity of scientific knowledge have made it impossible for schools of general education to fully disseminate it.

1.3. The Goal of the Research

This research examined the impact of integrative technology on the improvement of the logical thinking of students in mathematics in Kazakhstan. The presentation included the following sub-problems:

(1) What is the developmental level of motivation to learn of third-grade students?
(2) What is the student's level of cognitive interest in mathematics?
(3) What is the level of intelligence development of 3rd-grade students?
(4) What is the level of improvement in logical thought among students in mathematics?

2. Method

2.1. Participants

The study group participants included third-grade students attending elementary schools No. 12 and Ataturk elementary schools in Kentau (Kazakhstan) during 2021-2022. An experimental group (hereinafter EG) (3 "A," 3 "B," 3 "C" 76 students) and a control group (hereinafter CG) (3 "A," 3 "B," 3 "C" 74 students) were chosen at random from three classes from these schools. 76 students participated in the experimental group (34 females, 42 males) and 74 students in the control group (41 females, 33 males).

The following are the justifications for using third-grade students:

- The third-grade students were homogeneous in age.
- The study focused on teaching younger students the academic discipline "Mathematics."
- A distinctive feature of the 3rd-grade program is that the material is not distributed over the semesters. Several difficult topics are covered in elementary school.
- Third-grade math involves significant sophistication over previous material, particularly as children learn to use multiplication tables, division and multiplication outside tables, learn fractions and solve more complex examples and problems.

Tasks and examples in mathematics grade 3 require the student to concentrate for a long time and develop logical abilities.

2.2. Procedures and Instruments for Collecting Data

The experiment took place at the beginning of 2021-2022.

A 16-week course on the use of integrated technology in mathematics lessons was conducted in an experimental class. During the formative experiments, the intermediate section is conducted periodically to assess the formative process of the student's logical operations. Students completed small independent assignments (10-15 minutes) every 1.5-2 months. The works were evaluated on a regular scale to make the results understandable to the students.

The study used the following five collections to gather data: (1) a questionnaire to determine the developmental level of motivation to learn, (2) a survey for identifying cognitive interest based on mathematics tasks, (3) a test to study the characteristics of children's thinking, (4) a test to assess students level of intelligence development, (5) a test for the diagnosis of logical thought.

2.3. Questionnaire to Determine the Developmental Level of Motivation to Learn

The questionnaire is designed to identify motivational preferences in educational activities and contains 10 questions reflecting the student's attitude towards school. According to their level of motivation, for each question, points are put down and summed up to distribute children.

High level of school motivation (25 – 30 points): Students are characterized by high cognitive motivation and a desire to successfully meet all school requirements.

Average level of school motivation (20 - 24 points): Students who successfully coped with educational activities had similar indicators. Such children rely less on strict standards and norms when answering questions. This level of motivation is average.

Low motivation (10 - 19 points): Students are reluctant to attend school, experience difficulties in learning activities and have an unstable adaptation to school.

According to this technique, there are several levels of cognitive motivation: high, good, positive, low and negative. Surveys are conducted in small groups.

2.3.1. A Survey to Determine the Student's Interest in the Subject Being Studied and the Tasks Given in the Textbook

The survey consisted of written answers and was designed in such a way that students assessed their satisfaction with the subjects taught through 3 statements.

Question 1: Do you enjoy studying math?

Question 2: What advice would you give to a math teacher if you were interested in the lesson?

Question 3: Are you interested in doing the tasks given in the textbook?

The survey will provide material from which various connections can be made between students' cognitive interests and their attitudes towards mathematics.

2.3.2. Diagnostic Test of the Intelligence Development Level of Primary School Students

The test (school tests for intelligence development) was developed by employees of the USSR Union of Soviet Socialist Republics. The institute of General Educational Psychology consists of 6 subtests, each containing 15-25 tasks. To conduct a proper test, follow the instructions exactly, time the subtests (use a stopwatch) and not help the test subject complete the task (see Table 1).

Table 1. The test includes six sets of tasks (subtests).

Subtest number	Number of tasks in the subtest	Execution time in min
1. Awareness (1)	20	8
2. Awareness (2)	20	4
3. Analogies	25	10
4. Classifications	20	7
5. Generalizations	19	8
6. Number series	15	7

The test involves the participation of two researchers. The first researcher created the right attitude among test-takers, explaining the purpose of what happened, giving instructions and controlling the time frame over which the test was administered. The second researcher supervises the students to ensure all rules are followed during their studies. It comes in two forms: A and B. If something is not clear, students are allowed to ask a question to clarify. The survey itself is conducted separately for each of the subtests. The researcher explains what students need to do in the first subtest, he turns on the stopwatch and the students complete the task.

2.3.2.1. Results Processing

Tests (individual and group) are conducted with quantitative and qualitative methods. The individual indicator for each specific task (except for subtest 5) is equal to 1 point. In subtest 5, the quality of generalization is assessed, scores range from 0 to 2. The researchers use a table that lists the answers corresponding to each score. More detailed is the list of words corresponding to a score of 2 points. Adding together all the points received is a single metric. The test result shows the level of intellectual development of the student as a whole.

2.3.3. Test for the Diagnostic Logical Thought of the Student's

Purpose: To investigate the ability of elementary school students to identify a series of numbers and evaluate numbers according to established standards.

A system of specialized tasks was created and implemented including the following assignments:

- Selection of features from one or more objects.
- Direct distribution of signs.
- Distribution using the negation of some of the signs.
- Change of signs.
- Selection, distribution and change of features transform into another graphic form: matrices (rectangular tables).
- Search for the missing figure, designed as an incomplete matrix.
- The use of an algorithmic scheme.

2.4. Data Analysis

The effectiveness of integrated technology to improve students' logical thinking was determined by comparing the data obtained from the tests.

3. Findings and Discussion

Table 2 shows the motivational preferences of third grade students in educational activities.

Table 2. The findings of the questionnaire "determining the educational motivation of students".

Group	Levels					
	High level		Average level		Low level	
	n	%	n	%	n	%
CG	13	18	32	43	29	39
EG	12	16	33	44	31	40

Table 2 shows that only 12% of the participants (EG) demonstrated a high level compared to 13% of the control group's students. The average level of intrinsic motivation was attained by 43% of the participants (CG) while 44% of the participants (EG) demonstrated an average level. Unfortunately, the survey's findings revealed that 39% of the participants (CG) and 40% of the participants (EG) had difficulty adjusting and had unfavorable attitudes towards learning. Figure 1 depicts the findings of the participants (CG) and (EG) about "determining the learning motivation of students."

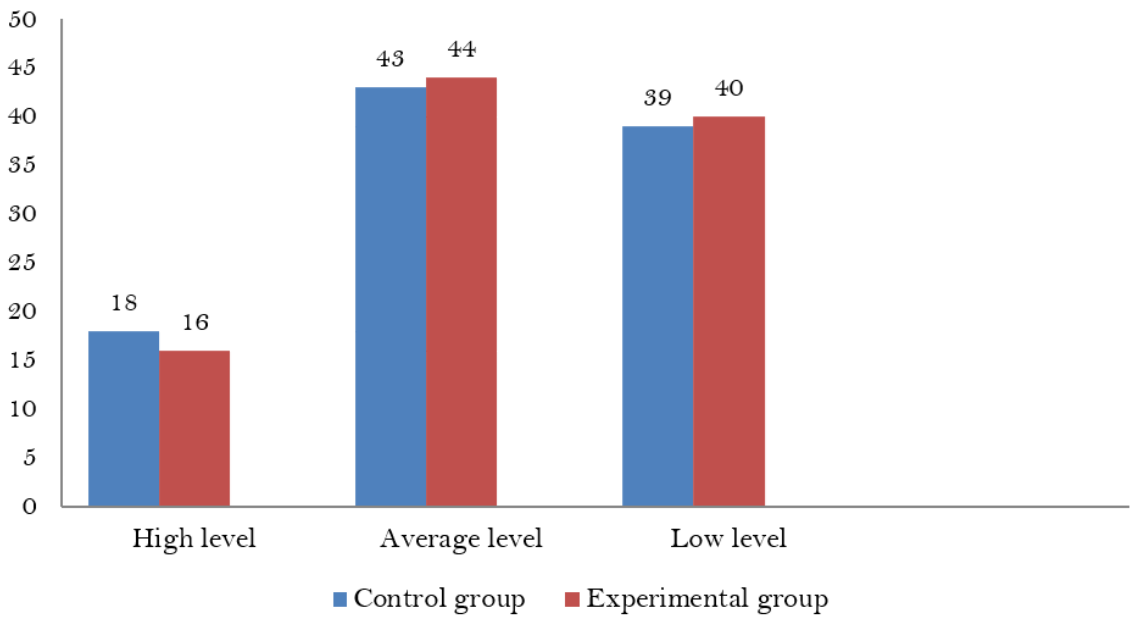

Figure 1. The results from the "determining the learning motivation of students" control and experimental groups.

The data obtained indicates the motivation of younger students for learning activities. To develop the motivation of younger students for learning activities, the teacher makes sure that the tasks performed in the lesson are aimed at the formation of logical operations and also from the point of view of their correspondence to the peculiarities of thinking of children of primary school age. Some tasks assume that the child has formed logical operations. In addition, all tasks in textbooks are presented in the form of word problems which makes it difficult for the child to solve them since the thinking of younger students is still visual-figurative. Most of them contain tasks aimed at developing logical thinking but they are not systemic, they are used as optional material. In this regard, the author's survey to determine the students' interest in the subject being studied and the tasks given in the textbook was conducted to determine what types of tasks allow primary school students to actively participate in the subject and tasks.

According to an analysis of the results, 76 (3rd grade) students from the school participated in the survey as members of the experimental group while 74 (3rd grade) students participated as members of the control group. The first question in the survey is, "Do you like studying math?" In the experimental group, 17 students (21%) said they disliked teaching mathematics compared with 19 students (26%) in the control group.

The percentage of students who enjoy math is 2% higher among participants in (CG). Therefore, it is 47 percent (35 of the participants). Moreover, 6 (8%) of the participants in the experimental group could not say anything about their interest in mathematics compared to 3% of the participants in the control group.

Table 3. The survey findings on "determining students' interest in the subject being studied and types of tasks".

No.	Questions	Answers	Number of students who answered questions	
			Experimental group	Control group
1	Do you enjoy studying math?	I don't like.	17	21
		Satisfactorily	19	16
		Like	34	35
		I can't answer.	6	2
2	What advice would you give to a math teacher if you are interested in the lesson?	Use game tasks	39	41
		It would be interesting if there were tasks using a computer.	21	30
		More interesting tasks (Logical tasks)	16	3
		I can't answer.	0	0
3	Are you interested in doing the tasks given in the textbook?	There should be more entertaining exercises.	52	49
		If the textbooks had colorful pictures, it would be interesting to complete tasks in them.	24	25
		Possibly, but not taught	0	0
		I can't answer.	0	0

What advice would you give to a math teacher? The experimental group had 39 students (45%) respond to the second question, "There should be game tasks," while the control group had 41 students (55%) respond with the same response. Students who responded "it would be interesting if they had computer tasks" made up 28% of participants (EG) and 40% of participants (CG). Sixteen (21%) of participants (EG) thought that there should be more interesting (logical) tasks than game tasks and computer games as did 4% of participants (CG).

The best thing about this question is that not a single student from either the experimental or control group answered it with "I can't say." Thus, game tasks, computer game tasks and interesting tasks (logical tasks) are liked by primary school students. This made it possible to determine that their interest in the subject can be increased by developing special tasks while maintaining internal motivation.

The survey's final question was "Are you interested in completing the assignments in the textbook?" In the experimental group, 68 percent (52 students) of the students responded, "There should be more entertaining exercises," whereas 66 percent of participants (CG) did so (49 of participants). In the experimental group, there were 24 students (32%) who responded in this manner to "If the textbooks had colorful pictures, it would be interesting to complete tasks" compared to 25 participants (34%) in the CG.

The results of the survey made it possible to determine that most of the younger school children included in the study like mathematics including the fact that they prefer performing game tasks, tasks with colorful pictures, and interesting tasks (see Figure 2).

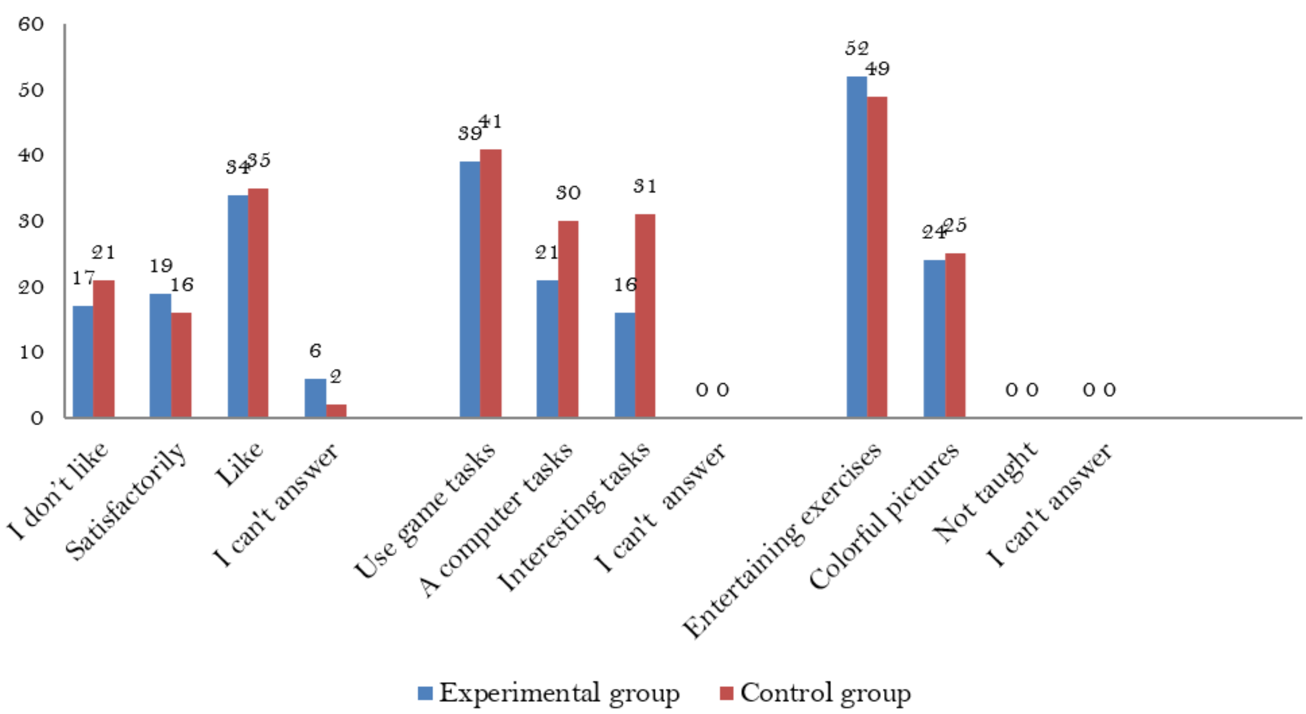

Figure 2. The survey findings on "determining the student's interest in the subject being studied and the tasks given in the textbook".

Table 4. Quantitative results of the author's survey.

No.	Assessment level	EG		CG	
1	High level	10	13%	11	14%
2	Average level	27	36%	28	39%
3	Low level	39	51%	35	47%
	Total	76	100%	74	100%

We took these findings into account when developing specialized tasks to improve logical thinking in elementary school students.

When students actively participate in the learning process and are highly motivated to learn and enjoy the process of achieving a specific result (see Table 5).

Table 5. The results of the test of the intelligence development level of students.

No.	Assessment level	EG		CG	
1	High	10	13%	9	12%
2	Good	23	30%	24	32.5%
3	Average	43	57%	41	55.5%
	Total	76	100%	74	100%

After an analysis of the data, it was discovered that 10 students (13%) from the experimental group had achieved excellent results, 23 students (30%) had achieved good results, 43 students (57%) had achieved poor results and 9 students (12%) had achieved good results from the control group. 24 students (32.5%) performed well while 41 students (55.5%) performed poorly. This graph illustrates how the intelligence levels of the participants in the groups differed (see Figure 3).

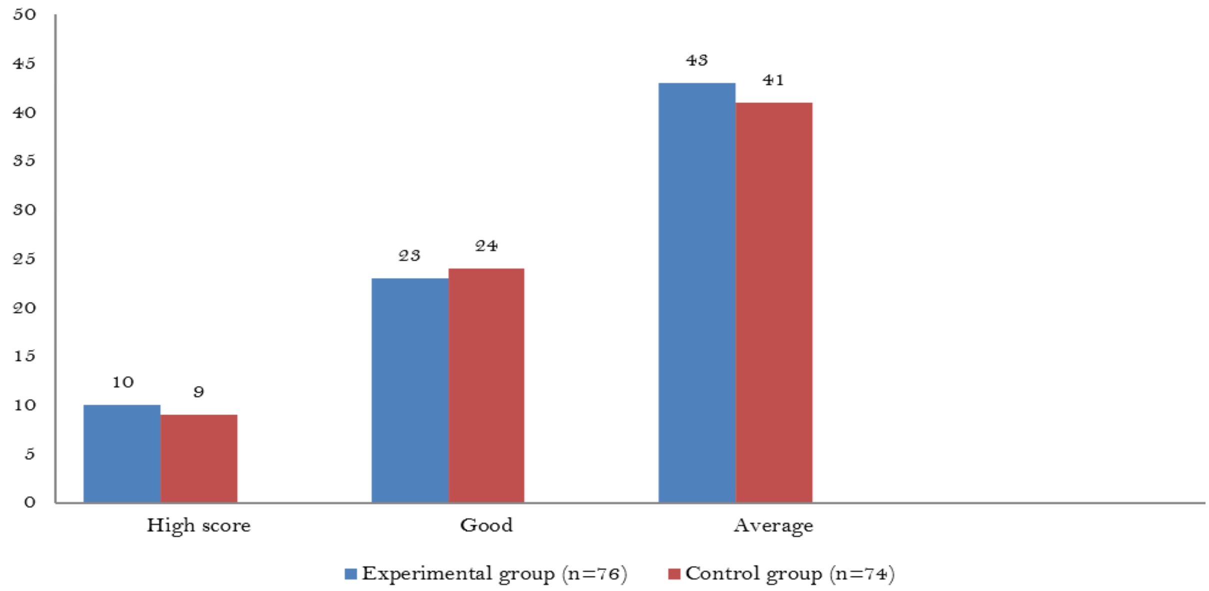

Figure 3. Investigation results on the intelligence level of the students.

Table 6 displays the results of a diagnosis of students' abilities to identify number sequences, summarize and set up logical laws and judge numbers by predetermined standards.

Table 6. The results of the test of the diagnosis logically thought the students.

No.	Assessment level	EG		CG	
1	High	8	11%	10	14%
2	Good	19	25%	15	20%
3	Average	49	64%	49	66%
	Total	76	100%	74	100%

Analysis of the data revealed that 10 students (14%) from the control group performed well on the task, 15 students (20%) performed averagely, 49 students (66%) performed poorly and 8 students (11%) from the experimental group performed well on the task, 19 students (25%) performed averagely and 49 students (64%) performed poorly (see Figure 4).

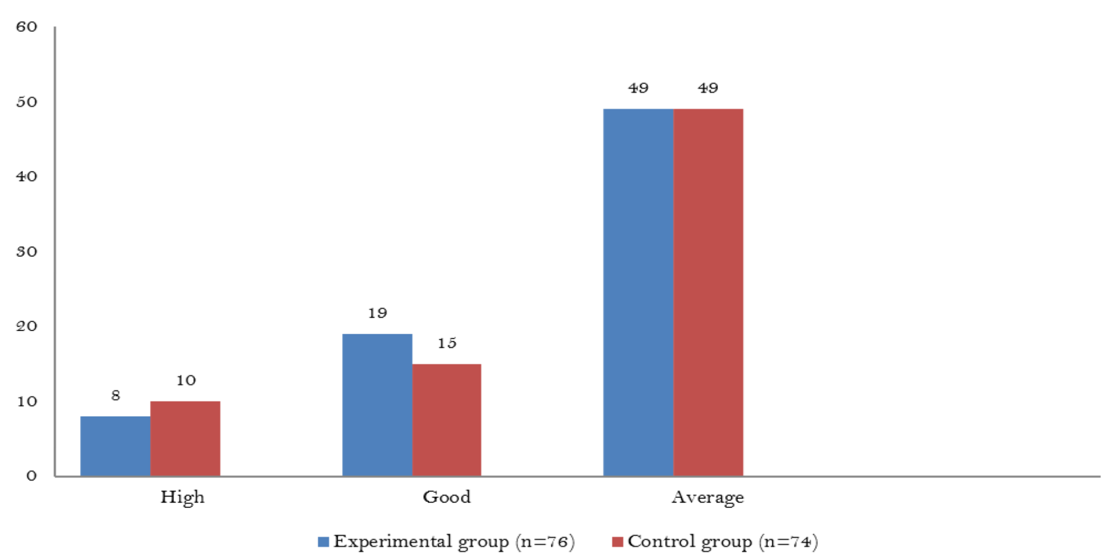

Figure 4. The results of the diagnosis were logically thought of by the students.

In this regard, primary school teachers should assign additional work to aid students in the development of their logical reasoning skills which is particularly important. These features of children's thinking can form and develop through systematic, intentional learning (and not just any kind of learning but learning aimed at developing logical thinking).

An experimental program was developed at the prognostic stage of the study to test integrative technology that would resolve the identified problem and include the developed system of didactic tools in teaching mathematics to younger students in the experimental class. To develop an integrative technology for the development of logical thinking using mathematics, we have developed a single methodological line.

The developed integrative technology was implemented into educational practice without altering the basic curricula or increasing the load on students (introducing stages into the structure of the lesson that allow the teacher to intensify the activity of developing logical thinking, wide use of specially selected tasks and reliance on visual-effectual and game teaching methods).

We proposed incorporating the following steps into the traditional structure of a mathematics lesson to implement this technology:

1) Activation of attention and perception processes. 2) The carrying out of a logical operation through memory, perception and representation (on mathematical content). 3) Acquiring a comprehensive understanding of the mathematical object under consideration. 4) The discovery of an algorithm for solving a mathematical problem. 5) Restoration of materials. 6) The control of acquired knowledge.

Table 7 depicts the dynamics of changes in indicators compared to the initial diagnosis using these methods.

Table 7. Results of the questionnaire "determining the educational motivation of students".

Group	Levels					
	High level		Average level		Low level	
	Before experiment	After experiment	Before experiment	After experiment	Before experiment	After experiment
Control group	13	15	32	38	29	21
Experimental group	12	42	33	22	31	12

The upper level (CG) increased by 3% while in the experimental group after the formative period, this level increased by 39%. The average motivation was present in 51% of participants in the control group but it decreased to only 29% (EG) after the formative period (16%).

The results of this survey obtained during the control experiment showed that participants do not adapt well to school and have a negative attitude towards it. In the experimental group, the proportion of such participants after the formative period decreased (16%) while in the control group, 39% of the students had low levels of adaptation and a negative attitude towards school.

Consequently, there is a discrepancy between the participant's (EG) formative period and their control stage results. The graph shows that the experimental group's cognitive motivation significantly increased (see Figure 5).

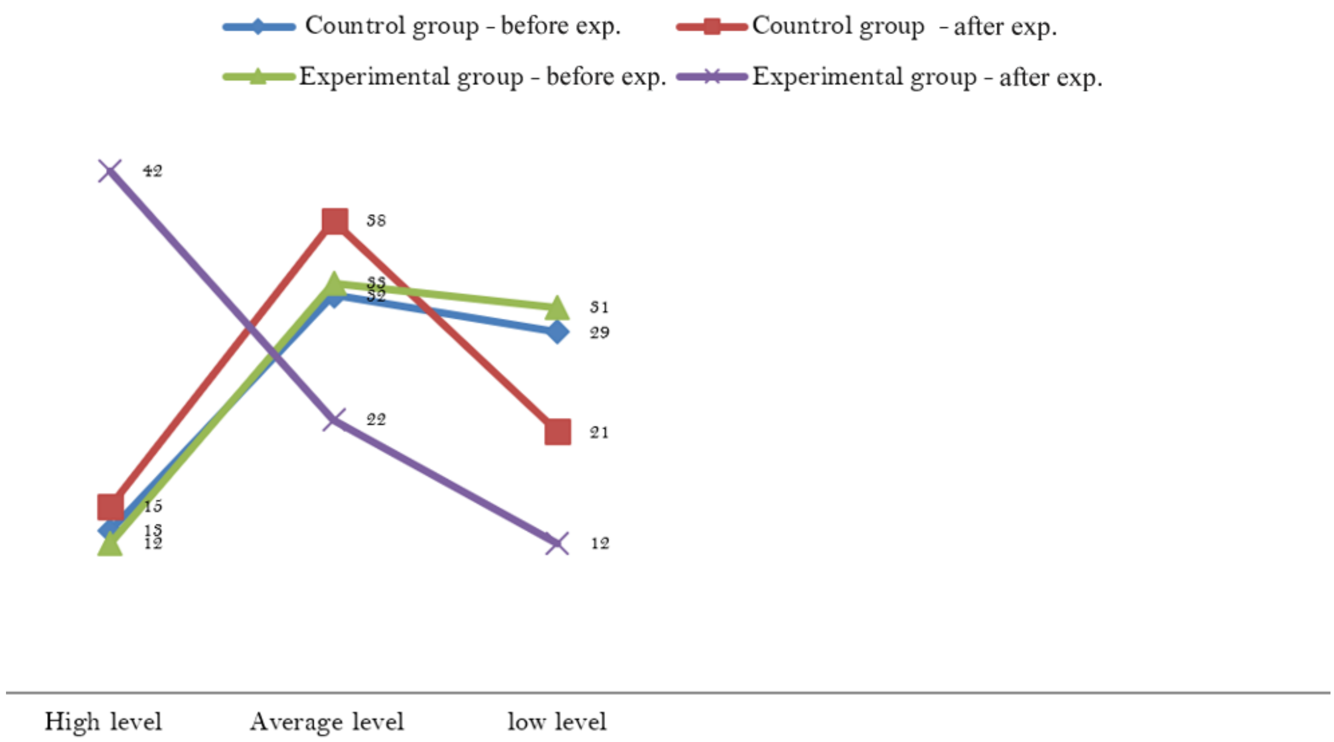

Figure 5. The results from the "determining the learning motivation of students" control and experimental groups (Dynamics of changes in the results for the entire period of the study).

Following the author's survey to ascertain the students' interest in the subject being studied and the tasks provided in the textbook, there are differences between the mean knowledge in the groups (see Table 8).

Table 8. Comparative results of the author's survey "Determination of students' interest in the subject being studied and types of tasks".

No.	Questions	Answers	Number of students who answered questions			
			Experimental group		Control group	
			Before experiment	After experiment	Before experiment	After experiment
1	Do you enjoy studying math?	I don't like	17	10	21	22
		Satisfactorily	19	20	16	16
		Like	34	44	35	36
		I can't answer	6	2	2	1
2	What advice would you give to a math teacher if you are interested in the lesson?	Use game tasks	39	41	41	42
		It would be interesting if there were tasks using a computer.	21	13	30	29
		More interesting tasks (Logical tasks).	16	23	3	3
		I can't answer	0	0	0	0
3	Are you interested in doing the tasks given in the textbook?	There should be more entertaining exercises.	52	61	49	43
		if the textbooks had colorful pictures, it would be interesting to complete tasks in them.	24	15	25	31
		Possibly, but not taught	0	0	0	0
		I can't answer.	0	0	0	0

According to an analysis of the results, after the use of integrative technology, the experimental group's students' interest in mathematics and aptitude for logical tasks both increased. Students who responded, "I don't like," decreased from 17 to 10. The number of students who marked "satisfactorily" increased from 19 to 20 in the experimental group. At the beginning of the experiment, the answer to the second question of the questionnaire was 39 (45%) which increased to 41 (54%) after the introduction of integration technology. 28% (21 students) of students who answered the questionnaire said that "It would be interesting if there were tasks using a computer" at the beginning of the experiment and 17% (13 students) after the experiment introduced integrative technology. The decrease is 11 percent.

There were 16 participants (21%) at the beginning of the experiment who believed that there should be more interesting tasks (logical tasks) than games and computer games and after the experiment, their number increased to 23 (29%).

The last question of the survey was "Are you interested in doing the tasks given in the math textbook?" 68 percent (52 students) of students in the experimental group answered: "There should be more entertaining exercises" in the test period while in the control period, this percentage of students was 80 percent (61 students). Participants who answered "if the textbooks had colorful pictures, it would be interesting to complete tasks in them" were 24 students (32% EG) while in the control group, there were 15 students (20%). The survey's findings show that students' interest in mathematics and engaging in interesting (logical) tasks have significantly increased since the introduction of integrative technology.

Table 9 shows the level of the results of the intelligence development of the participants after introducing integrative technology.

Table 9. Comparative numerical results of the author's survey "Determination of students' interest in the subject being studied and types of tasks".

No.	Assessment level	EG		CG	
		Before	After	Before	After
1	High	10	23	11	15
2	Good	27	41	29	31
3	Average	39	12	34	28
	Total	76	76	74	74

Table 10 shows the level of the results of the intelligence development of the participants after introducing integrative technology.

Table 10. The results of the test of intelligence development level of students.

No.	Assessment level	EG		CG	
		Before	After	Before	After
1	High	10	28	9	11
2	Good	23	39	24	29
3	Average	43	9	41	34
	Total	76	76	74	74

Analysis of the results shows the level of analysis, summation and comparison between students in the experimental class increased significantly. The number of students who answered at the highest level increased from 10 to 28(37 percent), the number of students who answered at the average level increased from 23 to 39 (51 percent) and the number of students who answered at the lower level decreased from 43 to 9 (12 percent). In the control class, there is only a slight increase in the level of analysis, summation and comparison. The participants who answered at the highest level increased from 9 to 11 (15 percent). The number of students who answered at the average level increased from 24 to 29 (39 percent) and the participants who answered at the lowest level decreased from 41 to 34 (46 percent) (see Figure 6).

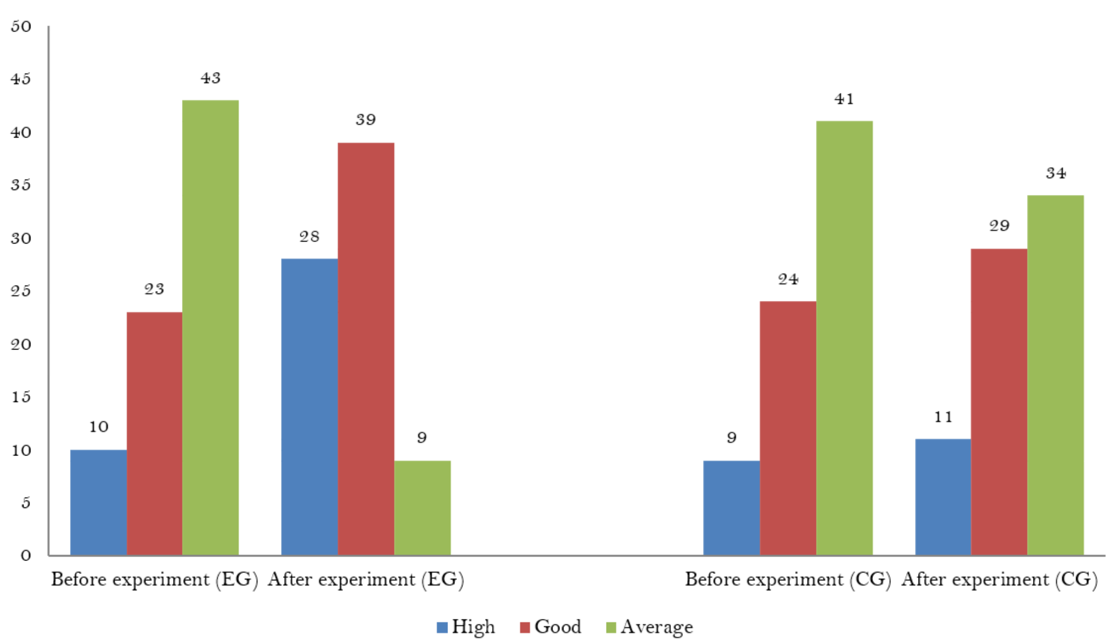

Figure 6. Comparison index of the results of primary school students' intelligence development level.

Table 11 the analysis of the improvement of logical thought of the students in the CG and the EG at the end of the experiment after the introduction of the integrated technology.

Table 11. The results of the test of the improvement of logical thought of the of the participants.

No.	Assessment level	Experimental group		Control group	
		Before experiment	After experiment	Before experiment	After experiment
1	High	8	29	10	15
2	Good	19	35	15	19
3	Average	49	12	49	40
	Total	76	76	74	74

When analyzing the results obtained, the level of analysis, summation and comparison among the participants increased significantly. The participants who answered at the highest level increased from 8 to 29 which is 37% of the participants; the participants who answered at the average level increased from 23 to 39 which is 51 percent of the participants; the participants who answered at the lower level decreased from 43 to 9 representing 12 percent of the participants. In the control class, there is only a slight increase in the level of analysis, summation and comparison. The participants who answered at the highest level increased from 9 to 11(15%), the participants who answered at the average level increased from 24 to 29 (39%) and the participants who answered at the lowest level decreased from 41 to 34 representing 46 percent of the participants. These results are presented below in the form of a diagram (see Figure 7).

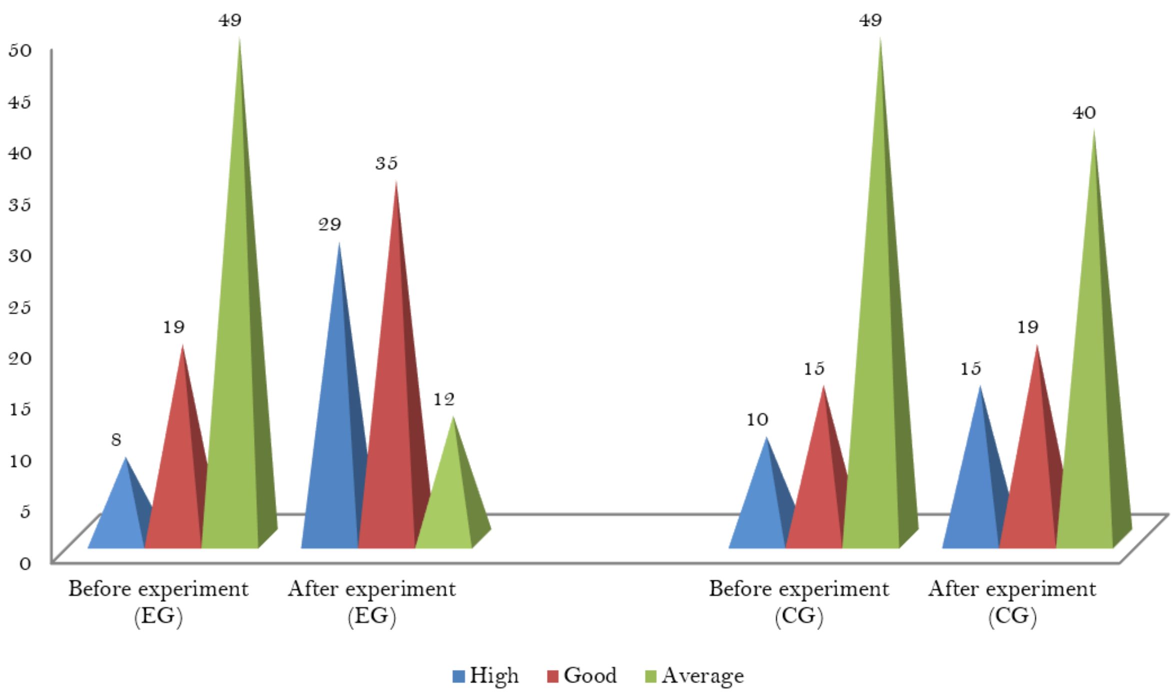

Figure 7. Comparative indicators of the results of the test on the improvement of logical thought among the participants.

"Logical tasks" are performed by logical methods at the control stage. The comparative results of the obtained test results are shown in Table 12.

Table 12. Comparative results of students' fulfillment of "logical tasks".

No.	Assessment level	EG		CG	
		Before	After	Before	After
1	High	11	30	9	12
2	Good	21	32	18	20
3	Average	44	14	47	42
	Total	76	76	74	74

Significant performance in this task was shown by 39 percent of participants (EG) which is 25 percent higher than the previous results. In the control group, the score at this level was even lower at 16 percent, an increase of 4 percent. 42% of participants (EG) showed an average level which was significantly higher than the previous indicator of 14%. Only 24 percent of participants (CG) showed an average at the start of the experiment compared to 27 percent thereafter. Nineteen percent of students in the experimental group showed low levels compared with 57 percent of participants (CG). This metric decreased by 39% of participants (EG) and by 7% of participants (CG) (see Figure 8).

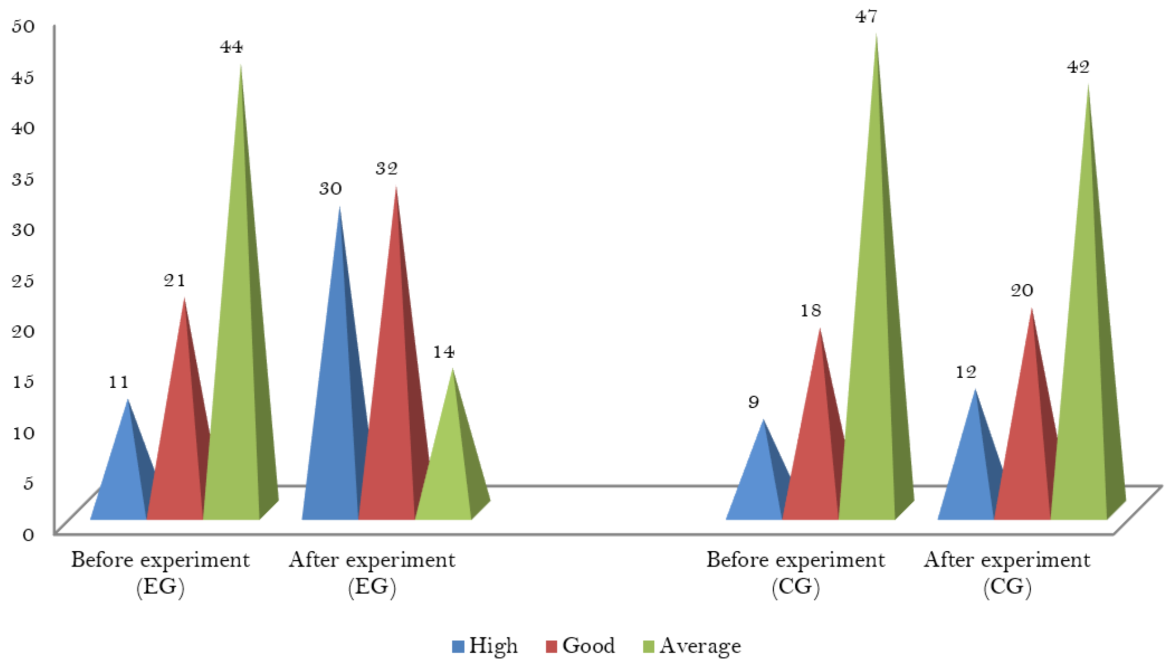

Figure 8. Comparative indicators of the results of the test on the implementation of "logical tasks" of the participants.

The next task in statistical analysis is to perform a joint analysis of multiple samples. The question of whether there were differences between the samples is the most crucial one that comes up when analyzing two samples.

The control group handled the task of 62 students and the experimental group handled the logic task of 74 students. In the first case, the percentages are 62/74 × 100%= 83%. In the second case, the percentage is 74/76 × 100%= 97%. Is this percentage of received data sufficient for N1 and N2? This is 83% higher than the 97% but based on the data, the N1 and N2 percentages are not enough. In this regard, we are interested in how efficiently the group completes the logic task.

To compare the sample according to the frequency of the occurrence of signs (high level of severity of logical thinking), a multifunctional statistical criterion - Fisher's angular transformation (φ* Fisher's criterion).

By reducing the data to an alternative scale, "there is an effect or there is no effect." The named criteria allow you to compare samples according to the frequency of the occurrence of a trait evaluating the reliability of differences between the percentages of the sample.

Let us agree to consider that "there is an effect" if the level of manifestation of the student's logical thinking takes high values and there is no "effect" if the level of manifestation takes low values (Table 13).

Table 13. Data for calculating the empirical value φ* of the Fisher criteria when comparing groups of third-grade students by the percentage of manifestations of a high level of logical thinking.

Sample	There is an effect. A high level of manifestation		No effect: Low level of manifestation		Sums
	Number of test subjects	%	Number of test subjects	%	
i. Experimental group (76)	76	97	2	3	74
ii. Control group (74)	74	83	12	16	62
Sums	150	-	14	-	136

Null hypothesis H0: High levels of logical thinking are not more prevalent in the first group of participants than they are in the second.

Alternative hypothesis H1: In the first group, there were more participants with higher levels of logical thinking than in the second group.

Define the values of φ appropriating to the percentages in each of the groups according to the table, " the value of the angle φ (in radians) for different percentages." Fisher's angular transform gives.

$$\varphi 1(60\%) = 1{,}6672$$
$$\varphi 2(40\%) = 1{,}499$$

Empirical value of the criterion φ*:

$$\varphi^* = (\varphi 1 - \varphi 2)^* \sqrt{\frac{n_1 \cdot n_2}{n_1 + n_2}}$$

Where φ1 is the angle advising the larger % share;

φ2 is the angle corresponding to the smaller percentage; n1 is the number of observations in sample 1; n2 is the number of observations in sample 2.

In this case: $\varphi^*_{emp} = (1{,}6672 - 1{,}499) \times \sqrt{\frac{76 \cdot 74}{76 + 74}} = 0{,}1682 \cdot \sqrt{37{,}49} = 10.29$

Critical values of the criterion φ*: $\varphi^*_{cr} = 1.74$ ($p \le 0, 05$) and $\varphi^*_{cr} = 2.38$ ($p \le 0, 01$). Since φ*: φ^*_{cr} i.e. H0 is rejected while H1 is accepted.

4. Conclusion

Studying the practice of developing logical thinking in school children in Kazakhstan confirmed the existing problem in the current system of educating students and the need for its accentuation on the improvement of logical thought as a basic factor in successful learning activities in the future, the needs of practice in the widespread use by elementary school teachers of the established forms, methods and means of improvement of logical thought of children that allow intensifying and optimizing this work without changing the content of curricula and recommendations on the organization without increasing the teaching load on younger school children. This confirmed the need to develop an integrative technology using mathematics and its implementation in the course of the educational process of an elementary school to improve the logical thinking of students. The experimental results revealed the effectiveness of integrative technology in improving the logical thinking of younger students.

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