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The influence of learning technology on the formation of research skills in primary school students: Action research

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Abstract

This study aims to determine the effectiveness of the author's teaching technology in developing schoolchildren's research skills, the challenges an elementary school faces, and how the entire process of developing research skills works. Quantitative and qualitative research techniques were used. Participants were from No.15, No.1, No.46, and No.16 schools in Ust-Kamenogorsk (East Kazakhstan). A random selection was made of an EG comprising 176 students and a CG comprising 173 students. To test the hypothesis that the author's teaching technology in studying natural science fosters the effectiveness of generating research skills, the research methodology employed an experimental pretest-posttest learning CG and EG study. As a result of the introduction of the developed technology in the EG, the levels of formation of these skills among students from the CG and the EG differ significantly. Finally, the developed technology can be used in the practical activities of teachers in elementary schools and serve as the basis for creating methodological materials that perform the developing function of teaching "Natural Science."

Keywords: Action research, Effectiveness, Formation, Influence, Learning technology, Primary school students, Research skills.

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Contents

Contribution of this paper to the literature

This study contributes to the existing literature by determining the effectiveness of the author's teaching technology in developing schoolchildren's research skills, the challenges an elementary school faces, and how the entire process of developing research skills works.

1. Introduction

Research activities and research skills are now at the forefront of educational development. Research skills are regarded as complex skills because they require the concurrent application of numerous psychological and theoretical perspectives (Dawadi, Shrestha, & Giri, 2021; DeJonckheere & Vaughn, 2019).

Considering the concept of "research skills," it is impossible to define it clearly. The components of this definition and the full description of research skills are multifaceted and functional and do not have one specific point of view (Tunç, 2022; Vieno, Rogers, & Campbell, 2022). Research skills are the ability of a subject to carry out mental and practical actions in line with research activities and adhere to the logic of scientific research based on the knowledge and skills gained while studying the science fundamentals (Aktepe & Ulu, 2023; Maddens, Depaepe, Raes, & Elen, 2023). Research skills are the ability to make independent observations, experiments, and searches acquired while solving research problems (Castillo-Martínez & Ramírez-Montoya, 2021; Polat & Kutlu, 2022). Research output is based on applying knowledge and experience, recognizing objectives, conditions, and means of activity, paying attention to research, clarifying processes, facts, and developments, and preparing for research activities (Gerbin & Drnovsek, 2020; Igbokwe, Benson, & Enem, 2019).

Updating the content of primary education in Kazakhstan focuses on creating conditions and opportunities for young students to participate in active research activities (Alì et al., 2021; Sarmurzin, Amanzhol, Toleubayeva, Zhunusova, & Amanova, 2021). In this regard, developing schoolchildren's research skills is relevant to Kazakhstan's primary education system.

It is essential to start forming this group of skills in schoolchildren early, during active development and the formation of the child's cognitive abilities (Bidzan-Bluma & Lipowska, 2018; Gizzonio et al., 2022). Modern students are increasingly engaged in search and creative activities, which can be achieved through research skills that begin in primary school. During this phase, the cognitive domain of the child undergoes significant development, accompanied by a shift in the predominant mode of devotion and an enhanced need to express themselves. A child begins to acquire ways of thinking between the ages of 6 and 11 that ensure the continued assimilation of a body of scientific knowledge and the growth of scientific, theoretical thinking. At this age, a child also establishes the foundations for independent learning, forms an understanding of the outside world, and develops research skills (Boykova, 2021; Darling-Hammond, Flook, Cook-Harvey, Barron, & Osher, 2019).

However, there is opposition to traditional formal and research education in schools in our country (Ontuganova, Zhumabayeva, Abilkhairova, Akzholova, & Zhunusbekova, 2023). Lack of consideration for interest in schoolchildren's learning, emotional discomfort, and logically formalized, mechanical teaching are the main features of this approach (Zhussupbayev et al., 2023). As before, formal education is not based on independent, creative research methods but on reproductive activities aimed at assimilating ready-made, someone-acquired truths (Nagima et al., 2023; Ospankulov, Zhumabayeva, & Nurgaliyeva, 2023; Zhumash et al., 2021).

Our preliminary study confirms that in our country, 56% of junior high school students have low research ability, 43% have productive capacity, and only 1% have creative power. These indicators reflect the acute problems of primary school: the low level of academic motivation and cognitive initiative of the student, the inability to regulate educational and research activities, insufficiently formed general cognitive and logical actions, and, as a result, school maladjustment. Our research shows that primary teachers in educational institutions need to exploit the full potential of learning activities to develop research skills in young students due to insufficient research on this issue.

Thus, it has been established that there are contradictions between the requirements of the modern education paradigm, which gives priority to primary school students' research activities and the demands of contemporary society, and the orientation of teachers towards developing the formal knowledge and skills of students.

RQ. How effective are the content and methods of studying the academic discipline "Natural Science" in developing research skills and creating the conditions for research learning in elementary school children?

The hypothesis is that using the author's teaching methods in the study of "Natural Science" is supposed to improve the efficiency of forming research skills and set up favorable conditions for schoolchildren's research education.

2. Literature Review

A fundamental methodological task of teaching is to set up the conditions for students' research activities in the natural sciences, then move on to teach them the fundamentals of the physics, chemical, and biological sciences (Matos et al., 2023).

We will consider the concept of "skill" as a person's readiness for specific actions and operations based on their existing knowledge and skills. Research skills are categorized as experimental skills, i.e., research skills are the skills in which students work independently on the research element, conduct search experiments, formulate hypotheses, and demonstrate the methods by which they test the validity of those hypotheses (Lachance, Heustis, Loparo, & Venkatesh, 2020).

The investigation of one's surroundings, also known as exploratory behavior, is a fundamental aspect of a child's understanding of the world. The innate urge of a child to independently explore his environment is the foundation of research-based learning (Ahmetoglu, 2019; Jirout, 2020; Shah, Weeks, Richards, & Kaciroti, 2018).

Our country still needs to establish an overall teaching system conducive to educational institutions' search and research activities, mainly because search and research activities have yet to be introduced into its practice in a targeted manner. At the same time, its application requirements are essential for secondary and primary schools, as a person acquires knowledge and cognitive skills, including research skills, during childhood. The most important feature of research activity is that it arises in a specific case and makes the child aware of the problem that has

occurred, formulates hypotheses, and tests them in the course of mental and practical operations. Younger students use children's experiments in various contexts in a complex way that satisfies their thirst for new information, fresh perspectives, and, most importantly, new experiences. Conducting research with children helps them develop their intellectual abilities, research skills, and creativity; on this basis, they have active, competent, and creative personalities. In addition, the benefit of using research is its strong persuasion abilities (Bezerra, Alves, & Azoni, 2022; Gryazeva-Dobshinskaya, Dmitrieva, Korobova, & Glukhova, 2020; Lassig, 2020).

According to many researchers, using innovative methods and technologies in teaching the discipline "Natural Science" is highly effective for deepening students' interest in cognitive and creative activities and for forming their relevant knowledge, skills, and research position in the perception and understanding of the world (Allcoat et al., 2021; Çetin & Türkan, 2021; Kossybayeva, Shaldykova, Akhmanova, & Kulanina, 2022; Melnikov, Gustomesov, Tsymbalist, & Knysh, 2020).

When teaching the natural sciences lesson, it is recommended to single out three sets of skills in particular:

1. Theoretical (define the purpose of the experiment and formulate the research problem); select equipment; use tables, reference books, educational, and technical literature; analyze the results and draw conclusions from the work; modeling skills.
2. Technological (to assemble experimental installations; the ability to conduct observation; work with natural objects; master the technique of conducting the experiment; make experiments).
3. Organizational (plan work; organize a workplace; keep records and make sketches; report on the work; rationalize workplace use; exercise self-control over work performance; cooperate).

Based on his research, such educational and cognitive activities for schoolchildren, can significantly expand the possibilities for developing research skills in them. In addition, it must be pointed out that the knowledge and skills acquired by schoolchildren in independent research activities are universal and can be used to study any subject and meet various educational needs. Moreover, mastery of schoolchildren's research activities allows them to complete an individual learning path.

3. Method

3.1. Participants

Participants included younger students attending elementary schools No15, No1, No46, and No16 in Ust-Kamenogorsk (East Kazakhstan) during the 2021–2022. A random selection was made of an experimental group (EG) comprising 176 students and a control group (CG) comprising 173 students from four classes.

Reasons for the study of elementary school students:

(1) Continuation of the versatile development of the child's personality, beginning in the family and a preschool educational institution.

(2) Continual development of a comprehensive understanding of the world in younger students; familiarization with the various connections between human life and the environment; equipping younger students with information about things, events, and patterns in their environment as well as means of understanding them.

(3) Fostering in students a caring attitude towards all living things on the Earth, a conscious attitude towards their health, a love for nature, the formation of their research skills, and environmentally literate ethical behavior in nature, nature, and society.

(4) A more varied and intensive search activity helps children get new information, leading to more intensive development.

3.2. Procedures and Instruments for Collecting Data

The subject of research: forming research skills in primary school pupils in natural science lessons. The primary objective is to foster self-sufficiency in younger pupils for tackling non-conventional educational tasks. This necessitated an update of the current approach to teaching natural sciences, which previously focused mainly on rote learning of fundamental concepts and improving individual competencies. The students' search-related activities combined the teaching strategies, which were the best blend of verbal (storytelling, conversation) and visual (excursion, demonstration of experiments). Hence, a system of tasks was also developed to form theoretical knowledge in natural science. In addition, students develop the ability to discover questions, formulate hypotheses, compare facts, and draw conclusions through exercises and tasks. When performing research, students work out the entire composition of the structural elements, ensuring they must be completed in the identified sequence. At the same time, they are given almost complete independence.

The effectiveness of the assimilation process of educational material was judged by comparing several indicators characterizing the quality of its result. Such indicators were the amount of knowledge acquired by students, their consistency and meaningfulness, and the speed at which the students completed the task during the final control period. In order to determine the outcomes of the experiment, the following procedures were executed: The methodology employed in this study involved recording the duration of time taken by each student to complete the control test tasks, tallying the number of correct responses provided by each student during the knowledge assessment phase, evaluating the responses provided by the students, conducting a qualitative analysis of the errors made by the students while performing the test tasks, and conducting a comprehensive analysis of the experimental data obtained.

3.3. Data Analysis

The data collected through the tests was compared to determine the impact of the author's technology on the efficient development of research skills and creating conditions for the research education of schoolchildren.

4. Results and Discussion

Table 1 displays the levels of the personality-motivational structure of the research skills.

Table 1. The levels of the personality-motivational structure of research skills.

Components	Levels	EG (N = 172)		CG (N = 173)	
		Quantity	%	Quantity	%
1	2	3	4	5	6
The student's interest in learning new things. educational and cognitive desire	High	33	19.2	34	19.7
	Average	97	56.4	98	56.6
	Low	42	24.4	41	23.7
	General indicator	172	100	173	100
The desire to independently predict the solution to research problems and conduct research activities	High	21	12.2	19	10.9
	Average	86	50	88	50.9
	Low	65	37.8	66	38.2
	General indicator	172	100	173	100
Desire to work on a creative team	High	59	34.3	60	34.7
	Average	64	37.2	70	40.5
	Low	49	28.5	43	24.8
	General indicator	172	100	173	100
Attempts to predict and generate ideas identify problems conduct experiments evaluate results	High	23	13.4	27	15.02
	Average	53	29.7	60	34.68
	Low	96	56.9	86	50.3
	General indicator	172	100	173	100

Table 2 displays the levels of the cognitive structure of the research skills of students.

Table 2. The levels of the cognitive structure of the research skills of students.

Components	Levels	EG (N = 172)		CG (N = 173)	
		Quantity	%	Quantity	%
Organization of creative searches by students	High	23	13.4	26	15
	Average	63	36.6	74	42.8
	Low	86	50	73	42.20
	General indicator	172	100	173	100
Knowledge of research methods	High	34	19.8	36	20.8
	Average	86	50	91	52.6
	Low	52	30.2	46	26.6
	General indicator	172	100	173	100
Ability to set goals, plan, and evaluate results	High	24	14	23	13.3
	Average	63	36.6	54	31.2
	Low	85	49.4	96	55.5
	General indicator	172	100	173	100
Knowledge and use of research methods	High	36	20.9	37	21.4
	Average	51	29.7	49	28.3
	Low	85	49.4	87	50.3
	General indicator	172	100	173	100
Working with information sources	High	56	32.5	53	30.64
	Average	51	29.7	57	32.94
	Low	65	37.8	63	36.42
	General indicator	172	100	173	100
Ability to conduct research	High	43	24.4	47	27.2
	Average	64	36.6	53	31.8
	Low	65	39	73	41
	General indicator	172	100	173	100

Table 3 shows the levels of the activity structure of the research skills of students.

Table 3. The levels of the activity structure of the research skills of students.

Components	Levels	EG (N = 172)		CG (N = 173)	
		Quantity	%	Quantity	%
Actively engaged in research	High	31	18.02	29	16.8
	Average	54	31.4	63	36.4
	Low	87	50.58	81	46.8
	General indicator	172	100	173	100
Plan research activities. Determine the goal. Objectives and topic make forecasts and predict research	High	33	19.2	38	22
	Average	87	50.6	86	49.7
	Low	52	30.2	49	28.3
	General indicator	172	100	173	100
Analysis, comparison, and evaluation of research results	High	28	16.3	29	16.8
	Average	78	45.3	75	43.3
	Low	66	38.4	69	39.9
	General indicator	172	100	173	100
Expressing your point of view and criticism	High	41	23.84	39	22.5
	Average	67	38.95	61	35.3
	Low	64	37.21	73	42.2
	General indicator	172	100	173	100
Ability to reflect	High	32	18	35	20.23
	Average	69	41.9	75	43.93
	Low	71	40.1	63	35.84
	General indicator	172	100	173	100

We collected the above data in Table 4, 5.

Table 4. The results of the generalized data of the EG.

Structures	Indicators	EG (N = 172)					
		High %		Average %		Low %	
		Quantity	%	Quantity	%	Quantity	%
Personality-motivational	Student interest in doing research	34	19.8	75	43.3	63	36.9
Cognitive	Students' knowledge of research structures, methods, and forms of conduct	36	20.83	63	36.53	73	42.64
Activity	Students' ability to research, defend, and reflect	33	19.07	71	41.63	68	39.30
Research skills of elementary school students		34	19.8	70	40.6	68	39.6

Table 5. The results of the generalized data of control group.

Structures	Indicators	CG (N = 173)					
		High %		Average %		Low %	
		Quantity	%	Quantity	%	Quantity	%
Personality-motivational	Student interest in doing research	35	20.09	79	45.66	59	34.25
Cognitive	Students' knowledge of research structures, methods, and forms of conduct	37	21.4	63	36.6	73	42
Activity	Students' ability to research, defend, and reflect	34	19.7	72	41.7	67	38.6
Research skills of elementary school students		35	20.4	72	41.3	66	38.3

To prove the absence of differences we summarized the data of these groups in Table 6.

Table 6. The proportion of students developing research skill levels.

Group type	Quantity	Levels					
		High		Average		Low	
		19.8	20.4	41.3	40.6	39.6	38.3
EG	172	34			70	68	
CG	173		35	72			66

Using Pearson χ^2 criterion, we compared the students' research skills between the groups.

$$\chi^2 = \frac{1}{n_1 n_2} \sum \frac{(n_1 Q_{2i} - n_2 Q_{1i})^2}{Q_{1i} + Q_{2i}}$$

n_1 and n_2 the number of respondents who took part in the experiment.

Q_{1i}, Q_{2i} - 1 – sign frequency, i – number of signs.

$$\chi^2 = \frac{1}{172 \cdot 173}\left[\frac{(172 \cdot 35 - 173 \cdot 34)^2}{69} + \frac{(172 \cdot 72 - 173 \cdot 70)^2}{142} + \frac{(172 \cdot 66 - 173 \cdot 68)^2}{134}\right] =$$

$$= \frac{2071{,}4}{29929} \approx 0{,}069$$

$\chi_1^2 \approx 0{,}069$

$\chi_2^2 = 5{,}99$. $\chi_1^2 < \chi_2^2$. $0{,}069 < 5{,}99$

Taking into account the analysis of the data obtained and the state of teaching science in the primary grades of the schools where the experiment was conducted, it was stated that:

- The formation of these skills is not carried out (and if it is carried out, it is not convincing enough).
- Students do not form elements of research skills, which are based on analysis, synthesis, comparison, abstraction, classification, generalization, etc.

These findings indicate the need to develop methodological recommendations for primary school teachers: include additional exercises and tasks; transform assignments and exercises from traditional teaching aids into research activities and research projects.

The survey revealed that the teachers' typical difficulty in organizing research activities for schoolchildren is the need for more knowledge and skills.

Many teachers believe that research activities are only possible with special equipment, which schools still need to have. Obviously, in the school of methodical literature, more gear is needed. In general, however, it can be said that some faculty do not seek to organize research work with their students.

The survey data show that about half of the teachers know the minimum research skills that every student should possess (48%). 13% of teachers have a fragile idea of the minimum research skills. These results reveal a rather urgent problem: a modern teacher is only sometimes unambiguously sure what skills should be taught to

schoolchildren. In many ways, this problem is because some teachers need to be more familiar with the documents regulating the research activities of students.

We analyzed the attitudes of teachers toward why students need to engage in research activities. It was found out that the importance of a student's research activity, according to teachers, lies, first of all, in the fact that it helps him realize his potential (54%), the personal growth of the student (40%), and only ten people (12%) believe that research activities contribute to the development of student achievement. Nevertheless, the obtained data give grounds to say that teachers are aware that research activities, of course, help the students develop research skills. These skills include goal-setting, formulating and testing hypotheses, planning research work, analyzing the results obtained, preparing conclusions, etc. The main thing is that teachers understand that research activities are essential for the students and that research skills may be required in the future. So, the data obtained during the study convinced us of the need to increase teachers' readiness levels to organize student research activities.

The next stage of the study was to formulate requirements for the selection of material and, on their basis, test the author's teaching technology in the study of the academic discipline "Natural Science" for objective and evidence-based confirmation of the hypothesis put forward (see Table 7).

Table 7. Technological foundations author's teaching methods in the study of "Natural science."

Structure of research skills	Tasks	Methods and techniques	Forms
Personality-motivational	Competitions; Competition "Best project."	Problem learning; Hypothesis method; Explanatory and illustrative method; Techniques "team building"; Techniques "Same but different"; Method "Boomerang"; method "true and false statements" or "do you believe ?"	Forms of classroom and out-of-school education: Science lesson; Research lesson; Olympics; Club work; Thematic weeks, decades, months; Excursion; Competition Exhibitions; Attractions (museum, library); Collection.
Cognitive	Training "Young researcher"; Memo on the organization of research activities with elementary school students.	Definition of concepts; Method "Graphic reading"; Filford method; "Live radio" strategy; critical thinking; essay writing; Comparison method; Reception "Thin and Thick questions"; Description.	
Activity	Workbook "I will learn how to write a project"; Creation of projects on natural science topics.	Method of projects; Control; Research method; Game "intellectual goal"; "Cluster" approach; "Insert" form; "Sinkwine"; Experiment.	

The formation of research skills is carried out simultaneously with the assimilation of knowledge. Therefore, methodological recommendations have been developed for using the developed system of educational tasks in preparing students for the academic discipline of "Natural Science."

At the end of the experiment, the survey was used to determine the interest and desire of the pupil for the formation of research skills (see Table 8).

Table 8. The levels of interest and desire of students for research activities, as well as the formation of research skills of pupils.

Indicators	CG (N = 173)			EG (N = 172)		
	High	Average	Low	High	Average	Low
Student interest in doing research	27%	44%	29%	67%	29%	4%
Students' knowledge of research methods and the forms of their conduct	25%	43%	32%	73%	25%	2%
Students' ability to research, defend, and reflect	26%	46%	28%	69%	25%	6%

Comparative data are depicted in Figure 1.

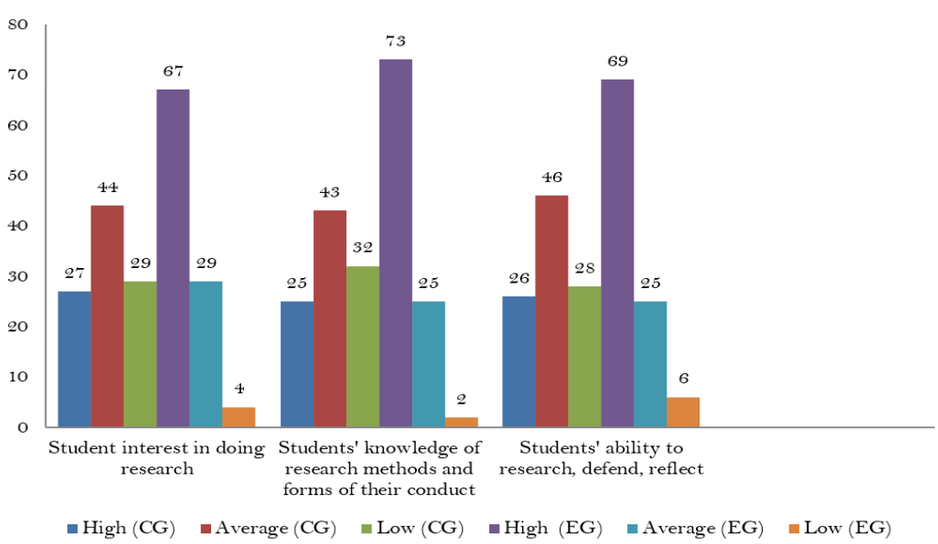

Figure 1. Distribution of junior schoolchildren by levels of the formation of research skills at the ascertaining and control stages of the study.

We also carried out a comparative analysis of indicators of research skills (see Table 9) and figure (see Figure 2).

Table 9. The ratio of research skill formation levels at the start and end of experimental work.

Structure of research skills	Indicators	EG (N = 172)	
		Before	After
Personality-motivational	Student interest in doing research	63%	96%
Cognitive	Students' knowledge of research methods and forms of their conduct	57%	98%
Activity	Students' ability to research, defend, reflect	61%	94%

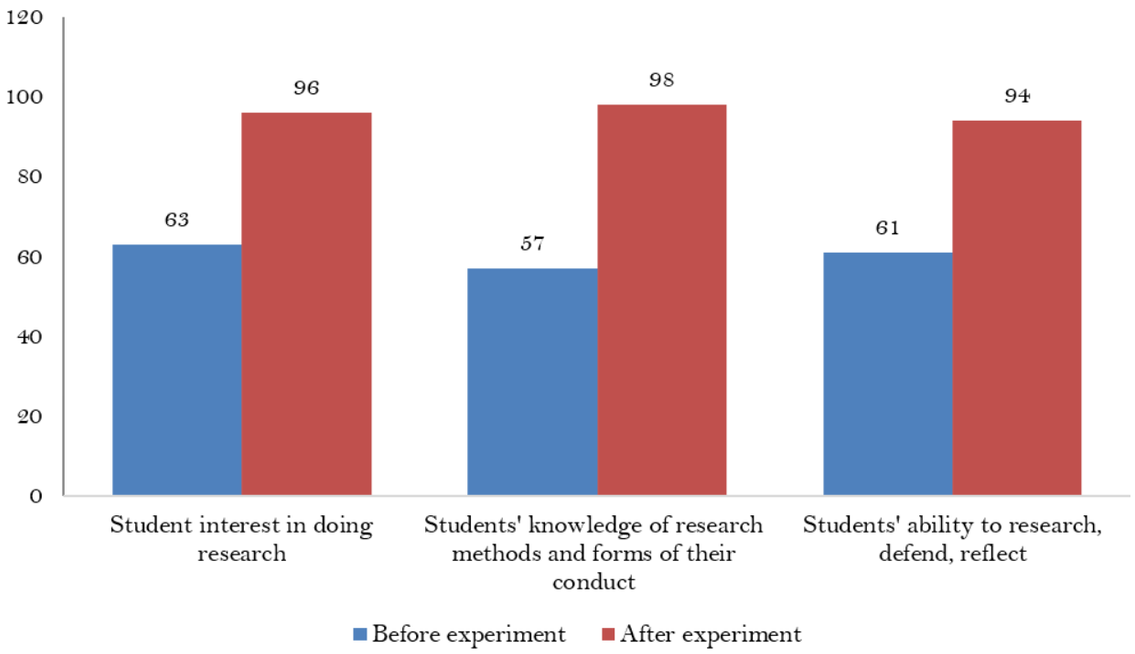

Figure 2. The ratio of research skill formation levels at the start and end of experimental work.

The significance of the findings was tested using the formula χ2 (chi-square) test.

The following hypotheses were formulated:

Null hypothesis H0: The levels of research skill formation among students from the CG and the EG are not significantly different.

Alternative hypothesis H1: The levels of research skill formation among students from the CG and the EG are significantly different.

χ^2 criterion calculated $\chi^2 = \sum_{i=1}^{k} \frac{(f_i^{\text{I}} - f_i^{\text{II}})^2}{(f_i^{\text{I}} + f_i^{\text{II}})}$ by the formula

Here f_i^1 and f_i^{II} are the frequencies of the compared samples.

$$\chi^2 = \frac{1089}{159} + \frac{1681}{155} + \frac{1089}{155} = 6{,}8 + 10{,}8 + 7{,}02 = 24{,}62$$

$$\chi^2_{0.05}(2) = 6$$

In the course of processing the results, it was obtained.

$$\chi^2 \rangle \chi^2_{0.05}(24,\ 62 > 6)$$

The null hypothesis is rejected at a high level of significance.

5. Conclusion

The issue between the objective need to develop students' research skills in the new paradigm of education and the subpar development of these skills among schoolchildren was confirmed by a study of the practice of developing these skills in Kazakhstan schoolchildren. Moreover, the search activity, the primary component of exploratory behavior, is largely lost on students due to traditional teaching methods. As a result, curiosity and the capacity for independent thought are lost, making it nearly impossible to engage in self-teaching, self-education, and, consequently, self-development. This confirmed the need to develop and test the author's teaching technology in the study of "Natural Science" as an academic discipline to confirm the hypothesis. Furthermore, the experimental results revealed the effectiveness of introducing the author's teaching technology in the study of the academic discipline "Natural Science," significantly increased the efficiency of the formation of research skills, and created conditions for the research learning of schoolchildren.

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