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The first-year chemistry course through a mobile device: A pilot study in seventh grade

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Abstract

Today, practically every secondary school student has a mobile device. At the same time, teenagers utilize mobile devices for everything, including the completion of various learning activities. Plenty of interactive resources allow the use of mobile devices in teaching chemistry. We believe in the significant potential of these gadgets in chemistry education by making students' learning more active. This pilot study explored the effect of our one-year interactive chemistry course on the students' learning outcomes and the psychological and pedagogical features of their learning environment in middle school. Thirty-four interactive lessons for seventh graders exploited some elements of the activity approach and were created with the maximum use of interactive technology such as smartphones and tablets. The course was implemented at a middle school in Karaganda, Kazakhstan. The pilot showed that using interactive materials boosts student motivation and productivity.

Keywords: Chemistry, Information and communication technologies, Interactive learning, mobile devices, Pedagogy, Teaching strategy.

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1. Introduction

The main innovation in education is the use of interactive learning technologies, which involve each student in the learning process, i.e., in the process of cognition [1]. One of the key problems in mobile learning is how to create interactive learning environments that promote successful teaching and learning, particularly in terms of keeping students motivated, engaged, and persistent (i.e., self-directed or self-regulated) [2]. According to Wessels, et al. [3]; Matsuuchi, et al. [4], and Nishiuchi, et al. [5], the main function of the interactive model is the dissemination of teaching materials. It is easier for teachers to manage and schedule lessons using modern mobile devices. Some research has been conducted on trends in science education [6, 7], including laboratory education[8, 9].

However, technology-enhanced chemistry education for middle school students has received little attention, particularly regarding the investigation of the potential effectiveness of teaching tools in terms of student learning outcomes. It is important to gain some chemistry literacy, as chemistry is essential for understanding natural sciences, technology, and engineering [10].

Designing effective, motivating, and enjoyable learning experiences in chemistry is a challenge [11]. Chemistry is generally viewed as a difficult and unpopular school subject due to the abstract nature of chemical principles Brown, et al. [12]. Johnstone [13] describes the specific nature of chemical knowledge as having three facets: macroscopic (i.e., visible - these are the reactions themselves), microscopic (i.e., invisible - these are atoms, ions, molecules, etc.), and their symbolic representations (symbols, chemical formulas, and chemical equations). The triple macro-micro-symbolic nature of every chemistry concept makes learning the subject especially complicated for novices.

Some researchers found that using mobile devices to teach chemistry brings positive benefits [14]. Technology can visualize chemical structures and processes, which is essential for lower-secondary students to understand chemistry experiments [15, 16]. According to Ambusaidi, et al. [17], the virtual lab had little influence on the academic achievement of students but fostered a positive attitude towards learning chemistry through the use of a virtual laboratory.

On the other hand, researchers discovered that mobile technologies may not always have the same positive effect on teaching chemistry. For example, Wood and Donnelly-Hermosillo [18] investigated the impact of an electronic chemistry game and lessons on learning nomenclature by students. The data showed that there was no significant difference in the students' performance. Students might become frustrated while dealing with complicated chemical procedures if they were not assisted by technology [19].

According to the research literature, it is possible to discuss the available prospects for the use of electronic media in teaching chemistry, realizing that much depends on the didactic approach to the choice of content. One notable approach is the Activity Theory-based model, which Núñez, et al. [20] applied to encourage innovative learning when conducting problem-solving experiments. Nuić and Glažar [21] studied how to motivate teachers to use e-learning in their chemistry lessons at middle school. Their findings suggest that if the e-learning technique is used more widely in schools, it has the potential for good results, especially with such basic concepts as states of matter, pure substances, and mixtures for 13- to 14-year-olds.

Nevertheless, such studies are still rare; the activity approach has not yet been practically mastered by the designers of computer programs. We consider it the most promising because it provides new opportunities to incorporate students' independent activities in lessons.

The goal of the pilot study was to explore the effect of our interactive chemistry course, which implements elements of the activity approach, on the students' outcomes, including psychological and pedagogical features of the learning process. The course was designed to introduce 7th graders to chemistry according to accepted standards. When designing the lessons, our priority was to support our students' actions related to mastering each new element of the course they were studying [22].

2. Background

2.1. Learning Outcomes and Feedback

Kubiatko, et al. [23] explore students' attitudes toward school chemistry from the following points of view: popularity, interest, difficulty, and importance. Stringfield and Kramer [24] designed a game-based review module for chemistry classes to determine whether it improved students' performance and interest in chemistry. The findings suggest that the game-based review module enhances students' final exam results and their interest in chemistry. Cahyana, et al. [25] research how the implementation of mobile game-based learning (M-GBL) impacts student outcomes. Their quasi-experiment indicates that M-GBL media improves student results. Sugiyarto, et al. [26] studied how Android-based games on chemistry nomenclature could enhance students' creativity and cognitive characteristics. Lay and Osman [27] found that the Malaysian Kimia (chemical) Digital Games (MyKimDG) module improved students' achievements and competencies. The experimental group showed considerable improvement in self-efficacy and productivity scores between the pre-test and post-test and outperformed the control group on the chemistry achievement test.

Srisawasdi and Panjaburee [28] investigated the effects of implementing game inquiry-based learning. The study focused on students' conceptual understanding of chemistry. Their findings proved that a computer game helped students better understand chemical concepts, particularly when combined with an inquiry-based learning approach. Rachmatullah, et al. [29] demonstrated that a game significantly improved students' conceptual understanding.

Seibert, et al. [30] developed multi-touch learning books (MLBs) to simulate students' participation in real experiments conducted in a laboratory. According to their findings, the students' outcomes improved significantly. Lou and Jaeggi [31] designed Technology-Assisted Guided Learning (TAGL) for chemistry lessons. They found that, in addition to the significant improvement in participants' performance, TAGL was able to eliminate the achievement gap between students with low prior knowledge and those with high prior knowledge. Arrabal, et al. [32]; Li, et al. [33], and Li, et al. [34] emphasize the positive results of computer support for high school student's learning activities, particularly in terms of their cooperation. Sadykov, et al. [35] developed and tested interactive lectures at the IT school in Karaganda, Kazakhstan. According to the findings, more than 70% of students preferred working in an interactive environment, which positively impacted their attitude towards the subject.

2.2. Learning Environment

According to Hung and Chou [36], to engage students in interactive learning, teachers should encourage student interactions and provide direct learning support to master science concepts. Before implementing ICT, it is critical to ensure that lessons are appropriate for students, as challenging language or unsuitable information on the Internet may cause problems.

Zanoj [37] identified a number of technologies and applications that enable students to enhance their mobile learning, with particular relevance to the subject of chemistry. Learning using smartphones, which connect and help students collaborate with the real world, makes the study of the subject more effective and prevents the isolation of the knowledge taught. Da Silva Júnior, et al. [38] developed a multilingual board game to help students learn about organic acids and bases. The suggested game encouraged students to participate in an engaging activity while learning and reviewing the subject. Cáceres-Jensen, et al. [39] developed a Socio-Scientific Environmental Chemistry module. Their technique fostered a learning environment that could be appropriate for solving real-world challenges in chemistry education. Li, et al. [40] presented a CHEMTrans chemistry education game with several chemical reactions. This game helped students learn chemical equations and improve their teamwork skills.

2.3. Motivation

Chemistry teachers and scholars need to understand students' motivation toward the subject. However, there are limited measures available to evaluate student motivation in this field. Several studies have explored students' motivation in chemistry.

Salta and Koulougliotis [41] adapted the Science Motivation Questionnaire to measure the motivation of school-age chemistry students. They found that girls had stronger self-determination and intrinsic motivation than boys. Middle school students demonstrated higher levels of motivation than high school students. Liu, et al. [42] validated the Academic Motivation Scale (AMS) for chemistry and found that males can be more motivated than females.

Safaruddin, et al. [43] examined the impact of the Project-Based Learning (PBL) strategy for the module "Heat Transfer" and found that the adoption of the PBL-based e-media strategy successfully enhanced students' learning motivation. Haw [44] found that among secondary school students in Malaysia, both males and females with an interactive teaching strategy were highly motivated to learn science. Moreover, students' motivation and science accomplishments showed a positive relationship. The implementation of interactive technologies in teaching and learning science shows promising effects according to the research literature and is worth expanding to the first-year chemistry course for seventh-graders in middle school.

This study addresses two research questions:

1. Can the implementation of our interactive course improve students' learning outcomes?
2. Can the implementation of our interactive course affect the psychological and pedagogical features of learning, including students' opinions, the learning environment, and motivation?

2.4. The Interactive Course for 7th Graders

The development of an interactive chemistry course for 7th graders began with a thorough analysis of the content and methods of the current chemistry curriculum at this level in European countries and Kazakhstan, as well as an exploration of which innovations in the subject's content were possible [45]. A total of 34 interactive lessons were created, covering all the main topics of the 7th-grade chemistry course [46].

Our interactive course takes into account middle school students' interests, abilities, and career opportunities in the field. The most important requirements for the learning platform are the availability of all information from the starting point to the final results and the accessibility of such materials for any student or teacher at any time.

The interactive chemistry course should provide the following competencies for students:

- Understanding the composition, structure, and properties of substances, as well as their applications.
- Correct use of chemical terminology, symbols of chemical elements, and chemical formulas.
- Understanding the role of chemistry in solving modern-day problems in various fields such as ecology, industry, energy, and medicine [47].

The interactive chemistry course includes eight chapters: (1) "Elements and Compounds," (2) "Mixtures," (3) "Physical and Chemical Changes," (4) "Atomic Structure," (5) "Combustion Reactions," (6) "Acids and Bases," (7) "Structure of the Periodic Table," and (8) "Food Composition: Nutrients."

Based on our earlier research [45], we developed two models of interactive lessons. The first model of an interactive lesson is used for a whole class, while the second model is used for group activities. The teacher delivers a lesson in the form of a heuristic conversation in the classroom. Students can use the school's Wi-Fi network to answer questions on their mobile phones, tablets, or computers. The teacher can observe the work screens of all students, although the results of their written work are displayed only on their screens. If a student has difficulty completing an activity, the teacher can provide advice or ask a question to the student. The displayed content in both forms can be saved on each student's computer or an external storage device. Every student can easily view the saved data at any time. All students can participate in the discussion.
As an example, we present the structure of our interactive lesson "Mixture" (our translation into English):

The first stage (Introduction problem). The lesson begins with task 1 https://learningapps.org/watch?v=pqbzp9bm320. Students are asked to match basic chemical concepts with their definitions Figure 1. Students can discuss their ideas and then complete the task. Those who have done so receive a successful completion signal on the screen ("Well done!" or others).

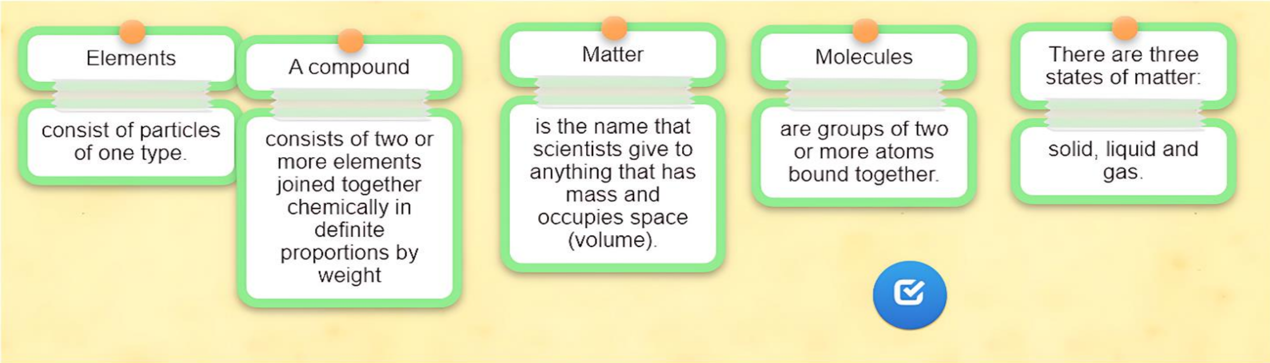

Figure 1.
Interactive task 1 (Completed).

The second stage (Explanation of the new material) involves the teacher using an interactive whiteboard and stopping periodically to ask students various questions. Students have time to reflect on a given topic (Figure 2) and answer the questions via mobile phones or tablets.

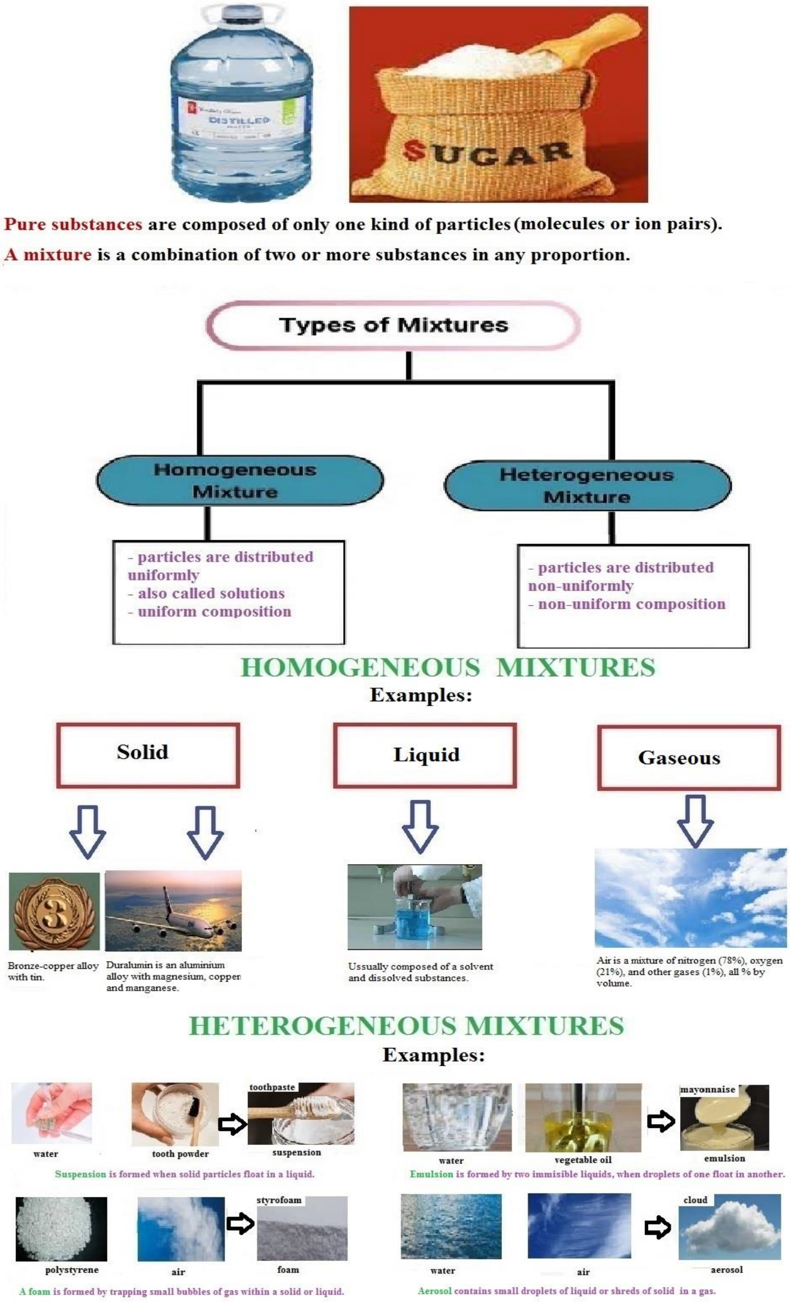

Figure 2.
The new material for the lesson “Mixtures”.

The third stage (Practice) involves students generating a new idea or modifying an existing abstract concept based on their experiences. They freely share their ideas with their classmates and the teacher. Task 2, "Which mixtures are homogeneous? Which are heterogeneous?" (https://learningapps.org/display?v=pyigpyfp520), asks students to categorize the mixtures they know well into two groups.

The fourth stage (assessment). Students are asked to solve task 3 "Determine and write the type of mixture" https://learningapps.org/watch?v=pqd4ybjet20. Students then refine their decisions based on comments from other students and feedback from the teacher (Figure 3). When students complete the assignment, the teacher can summarize the lesson.

Figure 3.
Interactive task 3.

Students in the control group went through the same phases, but the learning activities used a paper-and-pencil format.

3. Sample and Method

3.1. Participants

To test our research questions, we conducted a pilot study at a middle school in Karaganda, Kazakhstan. The researchers chose this school because it was equipped with the technical devices and resources needed for the experiment, and its administration was willing to participate.

The study was conducted in two 7th-grade classrooms, with a total of 28 students. These students had not previously taken chemistry and were aged 13 to 14 years old. The experimental group consisted of 15 students who studied our interactive course via mobile phones or tablets, while the control group consisted of 13 students who studied chemistry through the conventional method of teaching in a regular chemistry class.

3.2. Procedure

The pilot study had a pre-post-test design. The experimental group and the control group were kept separate from each other since each group attended chemistry lessons on different days. The students and the teacher were given an orientation and training on how to use the learning management system. Lesson plans for the teacher were prepared by the researchers. After the first week, the experimental and control groups received a pre-test to evaluate the learning environment features and students' motivation. In the second week, the active experiment started. It lasted for 34 weeks, with one academic hour (45 minutes) per week. Both groups were taught by the same chemistry teacher.

The experimental group participated in interactive lessons through an online platform and smartphone application. For instance, the interactive lessons were accessible to the experimental group students at any time, allowing them to access the website from home and school. The electronic learning materials for the course were created by the authors at LearningApps.org and are available at https://learningapps.org/user/sadastayer. We developed interactive materials for all topics of the 7th-grade chemistry course and utilized them throughout the academic year.

3.3. Data Collection Tools

An achievement test and three questionnaires (students' opinions, learning environment, and motivation) were used to collect quantitative data. For both groups, the learning environment and motivation before and after the study were measured, whereas students' opinions toward interactive lessons were measured only for the experimental group. The teacher's feedback and comments were collected and discussed to monitor the students' progress.

3.3.1. Learning Outcomes Assessment for 7thgrade Students

After the course, the students from both groups took the final test. The same final test was administered to both classes, considering the students' ages and their expected knowledge. The tests were distributed in a paper-and-pencil format. Students had 45 minutes to complete the final test, which consisted of 30 questions (short-answer, long-answer, and multiple-choice).

3.3.2. Psychological and Pedagogical Assessments

- *Assessment of students' opinions towards interactive lessons by* Sadykov and Ctrnactova [45]. Kubiatko, et al. [23] modified the questionnaire to determine the interest and attitude of middle school students towards interactive forms of teaching. The questionnaire consisted of ten close-ended questions (Appendix 1).
- *Assessment of the learning environment of the group* [48]. This technique can be used to assess the learning environment of student groups (classes) and identify indicators such as class mood, activity, efficiency, and conflict (Appendix 2).
- *Diagnostics of the structure of students' educational motivation* [49]. This technique allows for the determination of the major factors affecting student motivation [50]. All motives investigated using this technique are classified as educational (connected to the content and process of learning) and non-educational (Appendix 3).

4. Results and Discussion

4.1. Analysis of the Learning Outcomes

Our experimental group outperformed the control group on the achievement test (Chemistry 7th grade Standards) – see Figure 4. It shows the number of correct answers for the control (7A; 61.5%) and experimental (7B; 73.3%) groups. This result is well supported by research literature; mobile technologies and interactive learning enhanced students' learning outcomes [24, 25, 27, 30, 31].

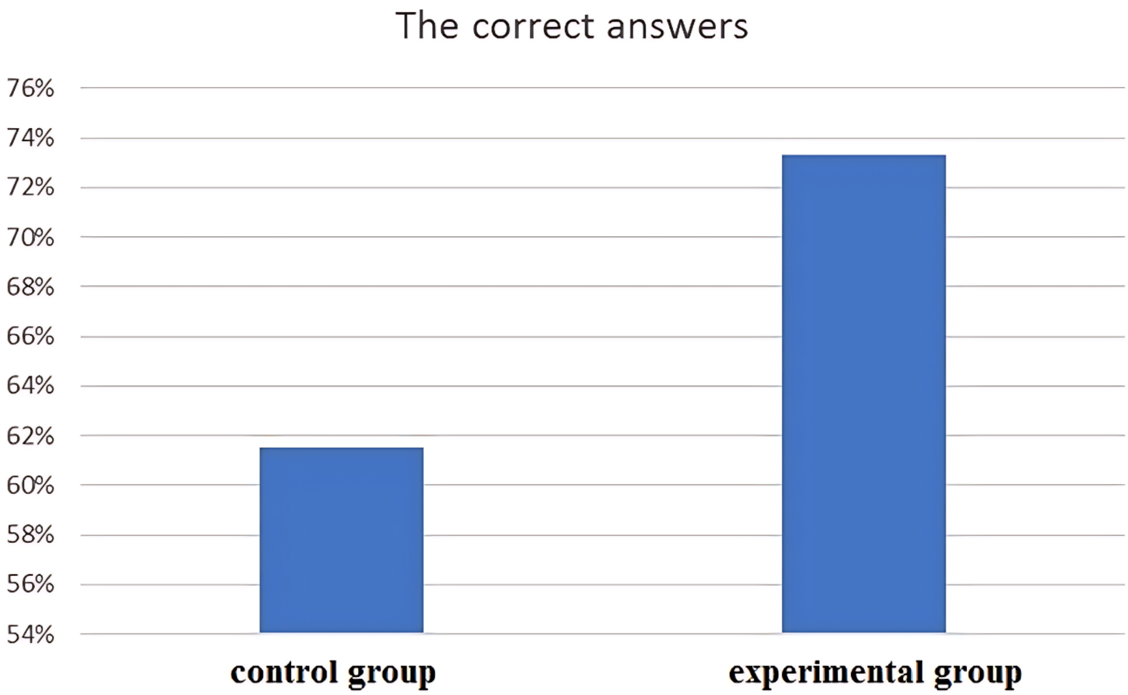

Figure 4.
The learning outcomes in control and experimental groups.

Students successfully completed "Elements and Compounds" (67.4% in the control group and 77% in the experimental group), "Atomic Structure" (70% in the control group and 75% in the experimental group), "Mixtures" (57.5% in the control group and 68.5% in the experimental group), and "Combustion Reaction" (55% in the control group and 67% in the experimental group), which were more complicated for students. Students' performance increased in general by 10% compared to the control group for all eight topics. The results suggest that our interactive lessons may primarily encourage students who can earn passing scores by themselves to achieve better grades, but this requires further investigation in the future.

4.2. Results of Psychological and Pedagogical Assessment

All of the surveys were carried out anonymously.

A) To determine the students' opinions regarding interactive chemistry lessons, we conducted a survey twice (Appendix 1). The first survey was administered after studying the fourth topic, "Atomic Structure." The second survey was conducted after the final topic, "Food Composition: Nutrients." Figure 5 illustrates the experimental group's average student attitudes toward the interactive chemistry lessons, showing responses to all ten questions.

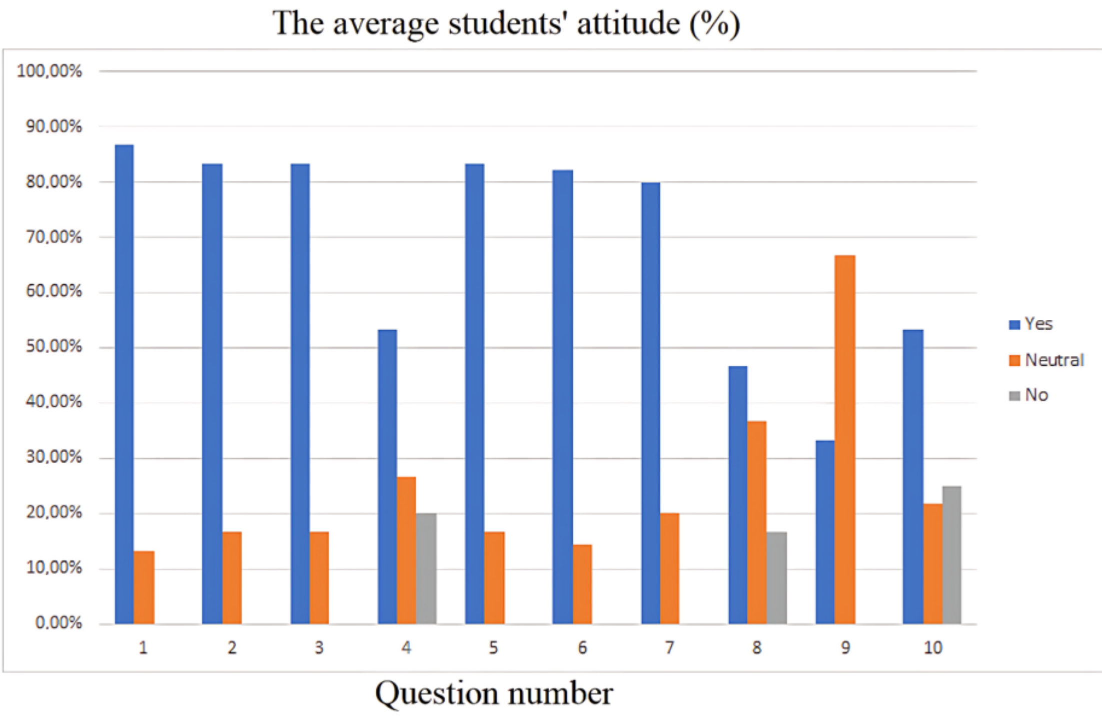

Figure 5.
The experimental group average students' attitude toward the interactive chemistry lessons.

Teaching the interactive lessons using a computer presentation seemed more interesting than the traditional form for 85% of students, while 15% of students found it difficult to answer (question 1). To question 3, "Was the explanation in the interactive lesson clear, and therefore, did I understand the topic well?", 83% of respondents answered positively. Only 17% of respondents chose the answer "neutral." More than half of the students believe that the interactive lessons contained too much information, diagrams, and images (question 4). Diagram 2 clearly shows that the majority of respondents (80%) were interested in solving problems using a mobile phone or tablet (question 7). To question 5, "Was knowledge gained in an interactive chemistry lesson applied in real life?", 83% of respondents answered "yes," and 17% of students answered "neutral." More than 46% of respondents indicated an interest in Kahoot, 37% responded "neutral," and 17% stated "no" (question 8).

According to the results, students in the experimental group found interactive chemistry lessons via computer or mobile devices to be fascinating and beneficial. These results are supported by Sadykov, et al. [35]; Arrabal, et al. [32]; Li, et al. [34]; Wong, et al. [51], and Kavaz and Kocak [52].

B) The following data were obtained using the *learning environment assessment.*

The control group's average score was 14 points, indicating a medium-low degree of learning environment in the group. The experimental group's average score was 11 points, indicating the same medium-low degree of learning environment in the group (Figure 6). In general, both groups were inactive; relationships within the group were unstable; students had limited confidence in the group's support and avoided public responsibilities. The students of both groups did not want to participate in Chemistry Week. The students in the experimental group often exhibited a certain level of conflict and lack of mutual understanding. Hung and Chou [36]; Irby, et al. [53]; Zanoj [37]; Da Silva Júnior, et al. [38]; and Li, et al. [40] showed that the main reason for a low score in such cases might be traditional teaching itself, as not all students like it or fit its requirements.

Post-test The control group's average score was 15 points, indicating the same medium-low degree of the learning environment in the group as it showed in the pre-test. The experimental group's average score improved to 22 points, indicating a medium degree of the learning environment in the group, which represented one step up compared to the original result. The majority of students responded that (1) the group had become less passive; (2) there was confidence in support during difficult times; (3) students became more involved in the group's social life; and (4) they attended lessons with great enthusiasm.

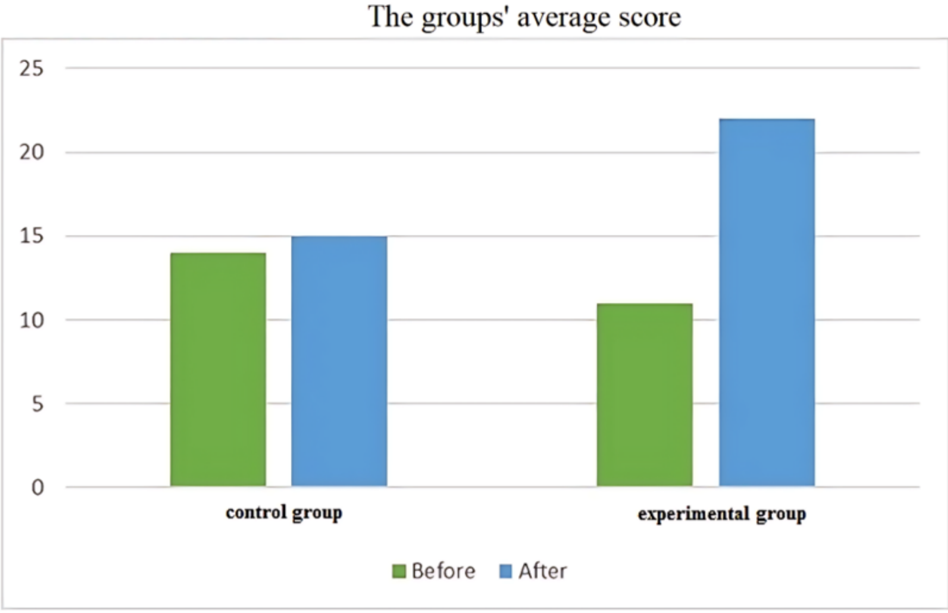

Figure 6.
The learning environment of the student groups before and after the experiment.

C) Diagnostics of the structure of the student's learning motivation.
Matyukhina [54] distinguishes the following types of motives:

A) Educational motives:

- Cognitive motives encourage students to learn and develop a desire to acquire new facts, master knowledge, and understand various methods of operation.
- Communicative motives are the reasons students communicate with one another.
- Self-development stimulates a student to make an effort to learn something new to become a better person in his or her own eyes.
- The student's position implies his or her understanding of how important learning is for the future.

B) Noneducational motives:

- Emotional motives encourage students to be active or passive in the learning process (i.e., problem-solving).
- External motives show the desire to earn approval and/or to get good grades.
- Achievement demonstrates the desire of students to attain excellent results and earn honorable positions among their classmates.

Dominant students' motives were identified before and after the pilot study. Table 1 and Figures 7-8 show that the first motive in the control group was communicative; however, in the experimental group, emotional motives were dominant. Other motives prevailed to varying degrees of importance.

Salta and Koulougliotis [41]; Cicuto and Torres [55]; Safaruddin, et al. [43] and Haw [44] mention that students cannot recognize their motivation very well without special training. However, we consider our students' responses, as well as the data obtained from this diagnostic along with the teacher's expert assessment, to be sufficiently indicative of the experiment's results.

Table 1.
Determining the dominant motives before the experiment.

	Dominant motives	
	Control group	Experimental group
1st place	Communicative	Emotional
2nd place	External	Achievements
3rd place	Achievements	Cognitive

Table 2 and Figures 7-8 showed the dominant motives after the experiment. Here, the most dominant motive in the control group was achievements, while in the experimental group, cognitive motives were dominant.

Table 2.
Determining the dominant motives after the experiment.

	Dominant motives	
	Control group	Experimental group
1st place	Achievements	Cognitive
2nd place	Communicative	Achievements
3rd place	External	Emotional

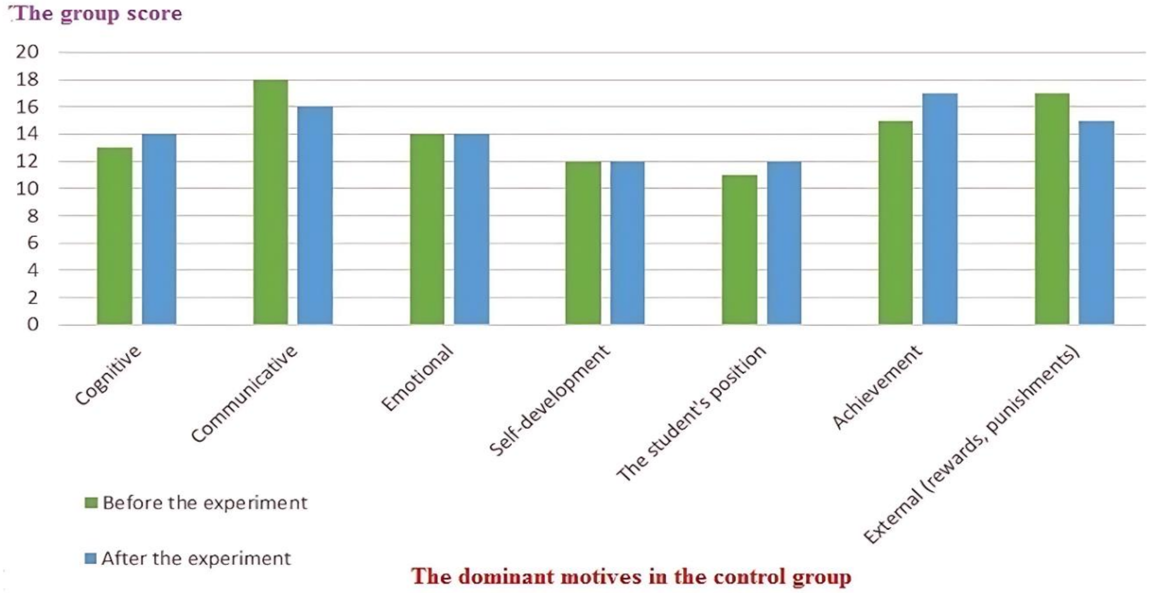

Figure 7.
The dominant motives before and after the experiment in the control group.

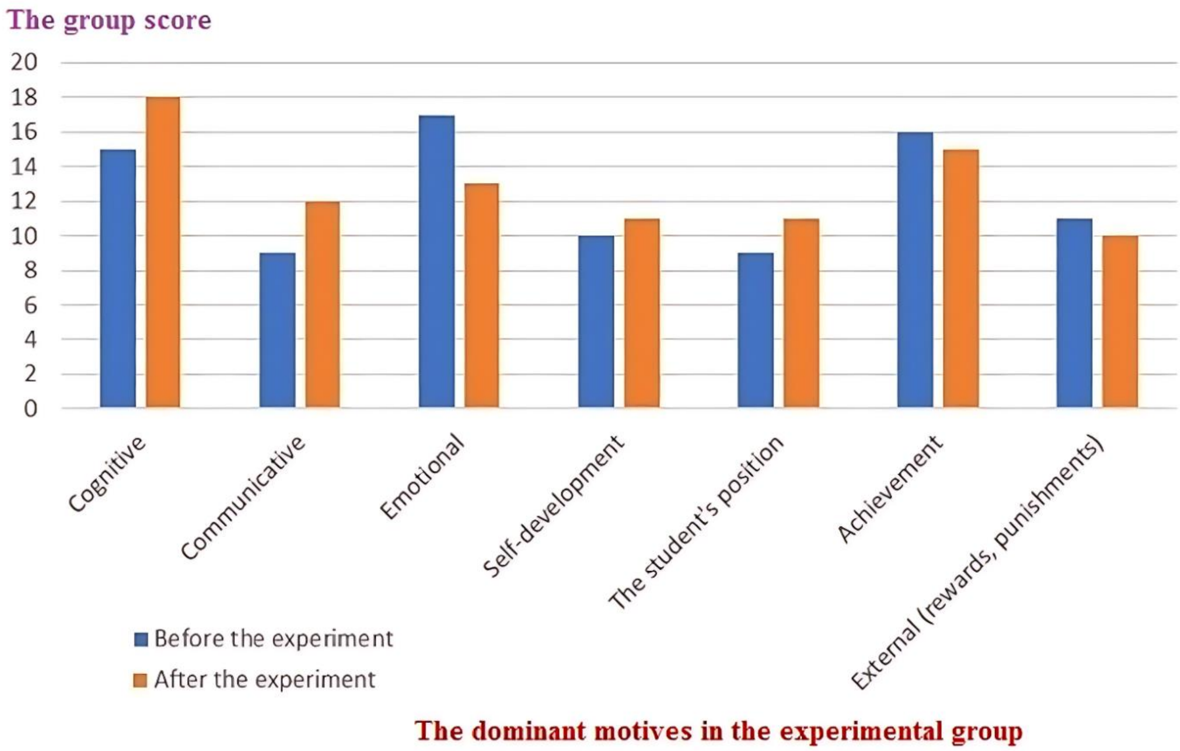

Figure 8.
The dominant motives before and after the experiment in the experimental group.

Before the experiment, the main motive in the control group was communicative. After the experiment, students in the control group tended to prioritize achievement motives, expressed as a desire to attain a specific position and gain approval from others. Data show that the learning process from the students' perspective was primarily driven by communicative and external motives in the control group.

In the experimental group (before the experiment), the emotional motive prevails among students, which is significant as these students learned mainly for grades. Achievements and cognitive motives dominate to almost the same extent. Students are interested in self-learning methods to organize their learning in a rational way. After the experiment, the cognitive motive occupies the leading position in the experimental group.

Figure 9 illustrates the changes in total scores for educational and non-educational motives in both the control and experimental groups before and after the experiment. Prior to the experiment, the educational motives in the experimental group were slightly lower than those in the control group.

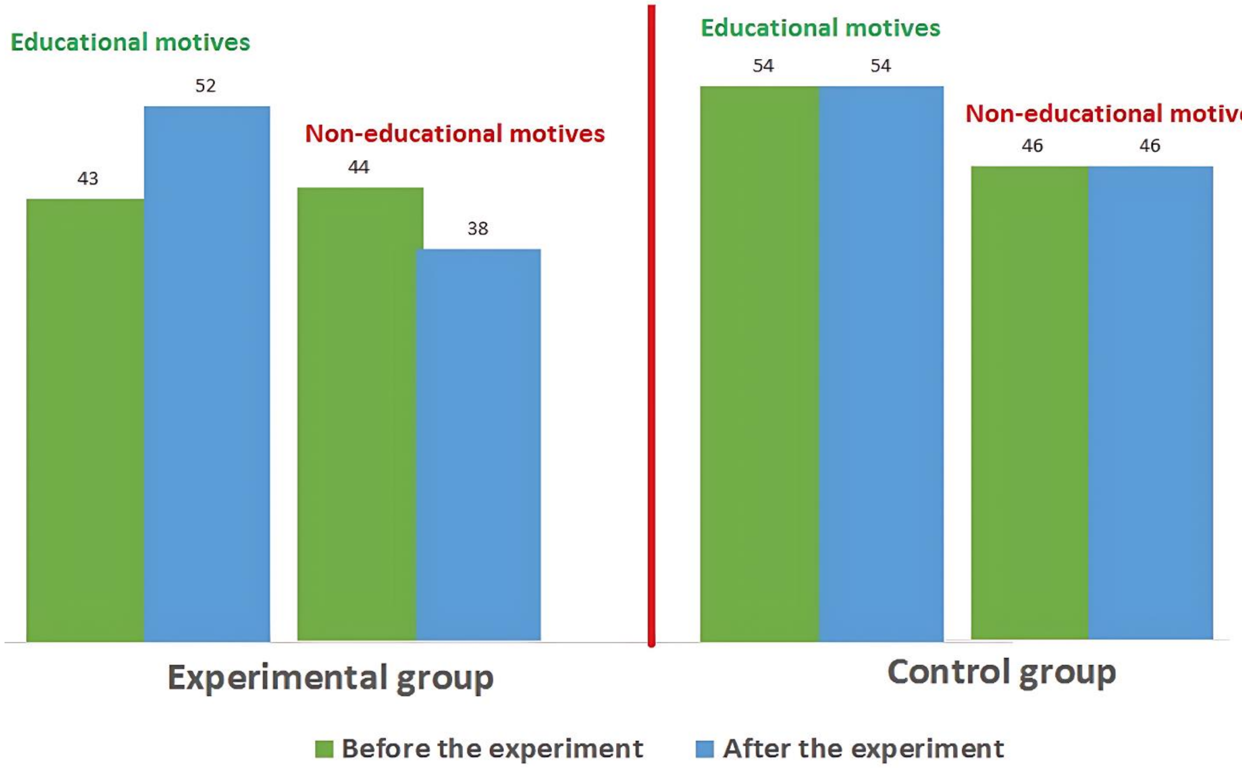

Figure 9.
The educational and non-educational motives in the experimental and control groups (raw scores).

Educational motives showed some growth in the experimental group, along with positive changes in the psychological climate in the classroom. We also noted a decrease in the importance of non-educational motives as a promising sign. In our opinion, these changes should be attributed to the instructional approach: the interactive teaching method stimulates students' activity and motivation. These changes were absent in the control group, where both educational and non-educational students' motives remained at the same level before and after the experiment. However, this result indicates that traditional teaching in the control group was sufficient to maintain students' initial educational motivation at a higher level compared to the experimental group. This can be considered an achievement of the teacher who worked with the group. The teacher's feedback aligned with the presented results.

5. Conclusions

Our pilot study showed promising results not only in terms of students' outcomes in mastering the mandatory chemistry concepts but also in terms of significant improvement in the psychological characteristics of the learning process. The current study of the effectiveness of interactive teaching is limited in its quantitative findings due to the small sample, and further research should be conducted with a significantly greater number of students involved. In addition, experimental and control groups should be made equal to each other across main baseline indicators, including students' motivation and psychological features of their learning environment. Moreover, thorough diagnostics should be used to monitor students' learning processes. For more in-depth studies, it is necessary to extend and deepen the assessment of students' motivation as an important personal change linked to the main features of the instruction.

The learning outcomes of the experimental group showed a significant increase in average scores. This improvement can be attributed to the active participation of the students through mobile phones or tablets during the lessons. The students' feedback confirmed the conclusion – students found the interactive lessons more interesting compared to traditional teaching methods. They expressed a desire to participate in interactive lessons and solve problems using modern technologies.

Though the motivation of seventh graders is rarely stable, it can and should be studied because it influences their learning and performance. In both groups, before the experiment, educational motives showed relatively low priority, and achievement motives were among the dominant ones. In the experimental group, according to all indicators, educational motivation increased against non-educational. Moreover, the cognitive motive, which is the most preferred by educators, occupies the leading position there. The majority of the students strived to acquire new knowledge and master necessary skills; they could identify interesting facts and displayed their interest in learning important properties of classical chemical phenomena and theoretical principles of chemistry. The traditional teaching model, in the best case, keeps students' motivation at the same level, but it is a challenge for any teacher to find ways and tools to improve it. Our pilot study showed that one of the ways to improve students' motivation toward chemistry might be the interactive teaching strategy implemented via mobile devices. Another benefit that could provide our interactive approach was the significant improvement of psychological features of the learning environment in the experimental group.

These data are important for understanding the patterns of the learning process in general and show some ways to improve it. Depending on the software development, we are going to elaborate on the activity-based components in the students' work with the teaching materials.

We believe that our pilot study is the first step toward solving the challenge of teaching chemistry to middle school students through an interactive approach. It offers simple tools to improve the learning process and produce better student outcomes.

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Appendix 1.
A questionnaire to determine the students' opinions toward interactive lessons [45].
The questionnaire concerned the attitudes of lower secondary school students toward interactive forms of learning. Questions 1, 2, 7, and 9 helped determine students' interest in interactive lessons compared to traditional lessons. Questions 3 and 4 evaluated whether the interactive lessons were understandable and did not present any significant difficulties for students. Questions 5, 6, 8, and 10 focused on how students evaluated the method and whether they would like to learn in this way more often.

	Yes	**Neutral**	**No**
1. Do you like interactive lessons that use computer presentations?			
2. Do you think that interactive lessons are more interesting than traditional lessons?			
3. Was the explanation in the interactive lesson clear, and therefore, did I understand the topic well?			
4. Do you think that the interactive lessons had too much information, diagrams, and images, making it difficult for me to understand?			
5. Was knowledge gained in an interactive chemistry lesson applied in real life?			
6. Would you like interactive lessons like these to be carried out more often?			
7. Were you interested in solving the tasks using a mobile phone or a tablet?			
8. Do you like the game Kahoot? It is quick and interesting, and it helps you check your knowledge.			
9. Do you think that solving the tasks in this way is more interesting than traditional methods of solving?			
10. Would you like chemistry tasks like this to be solved more often?			

Appendix 2.
Assessment of the learning environment of the student group [48].
Instruction manual Filling out the answer card is required. It provides indicators that characterize the student group's learning environment. It was created using the polar judgment technique. On the left, judgments reflect the positive psychological learning environment, while on the right, judgments reveal the negative. Between the polar judgments are the numbers "3 2 1 0 1 2 3." Your objective is to first select one of the polar judgments (left or right) that represents a typical picture of the relationship in your student group and the regular mood within it; second, select one of the numbers in a circle that corresponds to the intensity of each indicator: 3 for a high degree, 2 for a medium degree, and 1 for a low degree. If you can't decide which of the polar judgments best represents the usual learning environment of your student group, mark the number 0.

	The left pole of the statement (+)	**Score in points**	**The right pole of the statement (-)**
1.	The class is in a good and cheerful mood.	3 2 1 0 1 2 3	The atmosphere in the classroom is somber, not
2.	The class is active and functional.	3 2 1 0 1 2 3	The class is passive and inactive.
3.	The atmosphere in the classroom is respectful.	3 2 1 0 1 2 3	The atmosphere in the classroom is complex.
4	Students feel comfortable in the classroom.	3 2 1 0 1 2 3	Students feel uncomfortable in the classroom.
5.	Students understand and feel that the team will protect and support them if	3 2 1 0 1 2 3	Students lack confidence in the team's support during difficult moments.
6.	Students feel empathy for one another.	3 2 1 0 1 2 3	Classroom relationships are characterized by animosity.
7.	The class treats all its students fairly; everyone gets what they deserve.	3 2 1 0 1 2 3	The class is divided into preferred and neglected groups.
8.	The relationship between individual micro-groups within the class is characterized by mutual understanding and cooperation on common matters for them.	3 2 1 0 1 2 3	Micro-groups within the class conflict with one another, as their members conceal their interests.
9.	Disagreements in the classroom occur rarely and for significant reasons, and they are resolved properly and respectfully.	3 2 1 0 1 2 3	Disagreements often arise and are difficult to resolve.
10.	In stressful times, students come together.	3 2 1 0 1 2 3	In difficult moments, confusion and quarrels can arise in the classroom.

	The left pole of the statement (+)	Score in points	The right pole of the statement (-)
11.	When a new student enters the class, the team's approach is friendly and kind.	3 2 1 0 1 2 3	The class displays an indifferent or unfriendly attitude toward newcomers.
12.	Students enjoy being together at school.	3 2 1 0 1 2 3	Student dislike being together; everyone is preoccupied with their own interests.
13.	Students love their classes and celebrate their accomplishments.	3 2 1 0 1 2 3	Students are disinterested in their classes and their achievements.
14.	Students take learning seriously and want to master various professions.	3 2 1 0 1 2 3	Learning is not the main focus; the pursuit of academic success is not encouraged.
15.	The class is demanding and irritated by lazy individuals and truants.	3 2 1 0 1 2 3	Lazy individuals and truants are treated leniently.
16	Students actively participate in the social life of the class.	3 2 1 0 1 2 3	Students are passive in the social life of the class.
17	The class carefully considers the distribution of public assignments, taking into account everyone's preferences and	3 2 1 0 1 2 3	Assignments are distributed according to the principle of "if only it were not for me."
18	Students are eager to become involved in the classwork.	3 2 1 0 1 2 3	Students find it very difficult to engage in class activities.
19	Class activists enjoy authority and trust.	3 2 1 0 1 2 3	There are activists in the class who do not have the collective's support or respect.
20	The relationship between the class and the teacher is characterized by	3 2 1 0 1 2 3	The relationship between the class and the teacher is characterized by antipathy.

Processing and interpretation of the results. To calculate the learning environment (LE), add all the positive points (the left pole of the evaluation of statements "3, 2, 1, 0"), then subtract all the negative points (the right pole of the assessment of statements "0, 1, 2, 3") from the total points. The level of LE can be estimated based on the data in Table 1.

Table 1.
The level of psychological microclimate.

Number of scores	The degree of favourability of LE in the group
50 – 60	The high degree of LE
40 – 49	The medium-high degree of LE
21 – 39	The medium degree of LE
11 – 20	The medium-low degree of LE
0 –10	The minor favourability of LE
Negative scores	The unfavorability of LE

Based on the obtained average group data, it is possible to create a LE profile characteristic of this student group and show the severity of each of the studied components of LE.

Appendix 3.
Diagnostics of the structure of the student's educational motivation [49].
Instruction manual. The responses to the questionnaire are listed as follows: 3 points for true (+ +); 2 points for possibly true (+); 1 point for possibly false (-); and 0 points for false (- -).

1	To study a subject effectively, I must like the instructor.	0 1 2 3
2	I enjoy studying and expanding my knowledge about the world.	0 1 2 3
3	Communicating with other students at school is much more entertaining than sitting in class and studying.	0 1 2 3
4	I need to achieve a good grade.	0 1 2 3
5	My position demands that I excel in whatever I do.	0 1 2 3
6	Knowledge helps develop the mind and intelligence.	0 1 2 3
7	If you are a student, you must study diligently.	0 1 2 3
8	If there is an environment of malevolence and extreme strictness in the classroom, I lose my desire to learn.	0 1 2 3
9	I'm only interested in individual subjects.	0 1 2 3
10	I believe that academic success is an important basis for respect and recognition among classmates.	0 1 2 3
11	We must study to avoid moralizing and scolding from our parents and teachers.	0 1 2 3
12	I feel a sense of satisfaction when I solve a difficult task on my own.	0 1 2 3
13	I want to know as much as possible to become an interesting and cultured person.	0 1 2 3
14	At this point in my life, it is my civic obligation to study extensively and attend all classes.	0 1 2 3

15	I do not like to chat and get distracted in class because I need to understand the teacher's explanation and answer his questions correctly.	0 1 2 3
16	I appreciate it when they organize collaborative work with the students in the lesson (as a pair or a team).	0 1 2 3
17	I am very sensitive to the praise of my teachers and parents for my academic achievements.	0 1 2 3
18	I study well and aspire to be one of the best.	0 1 2 3
19	I read many books, except for textbooks (on science, sports, nature, etc.).	0 1 2 3
20	Studying at my age is the most important thing.	0 1 2 3
21	It's fun at school, more interesting than at home.	0 1 2 3

Processing and interpretation of the results. The number of points is calculated based on the survey results for seven motives and specific questions. The main motive is identified based on the results of the calculations (Table 2).

Table 2.
Processing and interpretation of the structure of the student's educational motivation

Motives	**Question numbers**
Cognitive	2 9 15
Communicative	3 10 16
Emotional	1 8 21
Self-development	6 13 19
The student's position	7 14 20
Achievement	5 12 18
External (Rewards, punishments)	4 11 17