



Distance learning: studying the efficiency of implementing flipped classroom technology in the educational system

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Abstract

Technology development and the general availability of information have affected modern society in such a way that the educational system requires immediate and decisive changes. The situation escalated during the pandemic when distance learning became an integral part of life of every teacher and student. Modern researchers call the educational system built on the flipped classroom model a pedagogical breakthrough, so it is important to study its impact from all sides; this explains the relevance of this paper. The purpose of this research was to study the effectiveness of flipped classroom as a distance learning component for students. The study was conducted at St. Petersburg State University and enrolled 56 students in the control and experimental groups ($n=28$ per group). The researchers used the questionnaire “Studying the motives of students’ educational activities” by A.A. Rean and V.A. Yakunin and a cross-section of grades to obtain information about academic performance and a survey for feedback from students. The findings show that flipped classroom had a positive effect on academic performance and student motivation. The number of “excellent” students increased by 17.9% and the numbers of “good” and “satisfactory” students decreased by 3.6% and 14.3%, respectively. The overall motivation of the group increased from 4.8 to 5.0. At the same time, the number of students with low motivation decreased by 7.2%, with medium motivation increased by 10.7%, and with high motivation decreased by 3.4%. A feedback survey showed that the vast majority of students were satisfied with the flipped classroom. At that, 89.2% of students answered that this model is suitable for knowledge assimilation, 92.8% believe that flipped classroom arouses their research interest, and 82.1% call the flipped classroom model the most suitable for interesting learning. The respondents noted the following advantages of the flipped classroom: saving time (82.7%), the opportunity to discuss more interesting topics in class (64.2%), the absence of dependence on time and place (38.1%), and the possibility of a deeper study (53.5%). The disadvantages included the inability to independently study

the material (10.7%), a large amount of material (17.8%), and technical problems (7.1%). These findings are of value for further study of the effectiveness of flipped classroom introduction into the educational system and may be used to compile statistics or as a basis for a similar experiment.

Keywords Distance learning · e-learning · Flipped classroom model · Online learning

1 Introduction

The rapid development of technology is changing all aspects of human life. Significant changes have also occurred in the educational system because now a person can access any information, regardless of his/her time and location, from his/her mobile phone (Taşpola et al., 2021). Taking into account this fact, the learning and teaching processes have changed for corresponding to modern realities. Now education is increasingly carried out online outside the classroom (Nayci, 2021). The COVID-19 pandemic has rapidly accelerated technology integration into the lives of students and teachers. Distance learning has become an integral part of modern education (Baggaley, 2015; Tang et al., 2020).

Distance learning requires teachers to use effective practices to support students and develop positive student-teacher relationships to encourage student motivation and engagement (Lai, 2017). Academic success is directly related to the correct preparation and use of suitable educational materials, the introduction of appropriate educational technologies as well as teaching methods and techniques (Karabatak & Polat, 2022). Studying the factors that influence student engagement is important because engagement has a positive effect on academic achievement (Mac Domhnaill et al., 2021). Traditional methods of formal education are no longer enough to meet complex social demands as people change career paths more often, seek alternative access to education, and struggle to balance competing needs in life, work, and education (Zhang et al., 2019). The above facts substantiate the relevance of this topic of work.

A flipped classroom is a combination of classroom activities (online or offline) with out-of-class ones. At that, direct learning takes place outside the classroom, often using information technology, and interactive learning occurs inside the classroom (Cui & Coleman, 2020). The most important aspects of this approach are as follows:

1. Spreading theoretical knowledge among students through video and audio materials.
2. Homework and projects are designed to consolidate the acquired knowledge and develop the students' creative thinking, that is, learning has a higher level.
3. For the classroom activities to be successful, the students should prepare by studying the preliminary material (Kaya, 2021).

The most important feature of the flipped classroom is taking into account the individual characteristics of students (Latorre-Coscolluela et al., 2021). It will suit both

those who prefer learning at a smoother pace and those who are used to learning quickly and get tired of the relatively slow rhythm of the whole group. In addition, it is an alternative for those who are unable to attend classes (Eroğlu & Yüksel, 2020).

The main advantages of flipped classroom include individualized learning (Sağır & Sakar, 2017). Each student can learn new material at an individual pace and watch the video several times. In addition, students can study in any convenient place at any convenient time. With the flipped classroom model, there is no need to spend class time explaining the basics. Students can study them on their own and spend time in the classroom on discussions, creative work, and questions for the teacher (Sağır & Sakar, 2017). In addition to the advantages, the flipped classroom has some disadvantages such as the inability to keep track of whether students have previously learned the proposed materials, a sharp technological need, the difficulty in independently mastering the material for those who are not used to learning, and the inability to ask questions while studying the material (Yildirim & Kiray, 2016). The main contribution of this research on the flipped classroom is to discover the effectiveness of this methodology in terms of academic performance and motivation, excluding other affective constructs, such as, for example, satisfaction.

Of course, the effective operation of the flipped classroom requires sufficient motivation and awareness of students (Obradovich et al., 2015). Some researchers have found that without the proper willingness on the part of the students, the model will not work properly as students may come to class unprepared or watch preliminary materials just before the lesson starts (Jonathan, 2021). At that, students will not have enough knowledge to participate in discussions.

1.1 Literature review

Numerous studies investigated the effectiveness of introducing the flipped classroom into the educational system. The authors from different countries update this database every day due to the topic's relevance. The methodology of a flipped classroom implies that more practical part of the lesson (for example, actions and problem solving), traditionally performed by students outside a classroom, is transferred to the classroom, while actions traditionally performed in a classroom (for example, presentation of information and information transfer training) are moved outside a classroom and before a class (Huang, 2019).

Flipped classroom began to enter the educational system a long time ago but only in recent years, during the pandemic, it began to be widely considered by educators around the world (Eroğlu & Yüksel, 2020). J. Wesley Baker was the first, who presented this model at the International Conference on Teaching and Learning in 2000 (Eroğlu & Yüksel, 2020). Flipped classroom successfully complements the distance learning system allowing students to study anywhere and at any time as well as use all the possibilities of modern technologies and unlimited access to information (Urfa, 2018).

A flipped classroom is changing the very essence of modern education. The student turns from a passive “assimilator” of information into an active researcher. Knowledge is no longer given in a finished, analyzed, and structured form (Schneider & Council, 2021). Now the student should study many sources, compare them,

form their opinion, and sometimes also enter into a discussion with peers, who have formed a different opinion based on the same information. At the same time, the teacher ceases to be a “wise man on stage” turning into a guide, adviser, and a person, who can suggest the right path and resolve the dispute (Tikhonova, 2018; Voronina, 2018).

Traditionally, flipped learning originates from blended learning, as it aims to benefit from what is presented and available online and traditional face-to-face learning when students and teachers meet. The latter is consistent with the values of traditional higher education. In addition, blended learning has virtually limitless design possibilities and applicability to various learning contexts and strategies (Graham et al., 2013). In previous studies, students have demonstrated a positive attitude towards blended learning (Nanclares & Rodríguez, 2016). Other researchers have indicated that blended learning is one of the most effective methods supporting traditional learning forms (Leszczyński et al., 2018). The difference between blended learning and a flipped classroom has been investigated. Thus, compared to blended learning and traditional learning, a flipped classroom significantly improved student outcomes (Capone et al., 2017; Thai et al., 2017).

Integrating the concept of flipped learning into online learning increases the value of online learning in times of disruption in traditional learning. Since the flipped classroom model also uses online learning resources, it is believed that combining online learning with a flipped classroom can open up a new model of blended learning for the relevant courses and increase the effectiveness of online learning (Huang, 2019). Such advantages of flipped classroom as individualized learning, the ability to catch up with those who are absent, increased personal responsibility for their education, increased motivation, development of creative abilities, the ability to save and archive material, and changing the teacher’s role to a friendlier one, increasing the time of contact between the teacher and the student, and the opportunity to learn anywhere at any time turn this model into a pedagogical breakthrough (Campillo-Ferrer & Miralles-Martínez, 2021; Taspolat et al., 2021). In addition, there are some disadvantages: lectures can be uninteresting, students ignore video materials, a passive approach, insufficient technological resources, the inability to teach practical things online, insufficient time to produce materials, etc. (Goksu & Duran, 2020).

It also follows from the previous literature that the vast majority of interventions in the framework of the “Flipped Classroom” program are performed as follows: (1) extracurricular students get access through a learning platform or system where all resources are uploaded. This platform aims to facilitate the learning process based on these resources; (2) there are three main strategies used in the classroom: discussing problems, practicing or doing exercises, and group projects (Tang et al., 2020). As for the studied issue, previous reviews have shown that a large number of previous papers on a flipped classroom aimed at discovering the effectiveness of this methodology in terms of academic performance. In this case, other affective constructs, such as motivation or satisfaction, are excluded (Gustilo et al., 2015; Tang et al., 2020).

There are 5 key factors to keep in mind when designing flipped classroom sessions:

1. Meaningful content, creative and meaningful material that will be used in real life.

2. Use of problem-based, game-based, and group interactive learning and practice projects.
3. Well-analyzed use of technologies.
4. Feedback from students.
5. Watching videos and listening to audio as homework (Yildirim & Kiray, 2016). Some researchers have concluded that the use of video in an active learning environment created by teachers contributed to the best achievements of students (Gustilo et al., 2015).

With the transition to distance learning, educational researchers have noticed a significant decrease in student attendance at online classes (Rotellar & Cain, 2016). Perhaps this is due to the loss of motivation by students due to a sharp and unexpected change in face-to-face meetings to online ones (Rotellar & Cain, 2016). To make online classes more interesting and educational, some universities in China have tried to introduce a flipped classroom model that allows for more productive use of online meeting time (Tang et al., 2020).

The vast majority of studies investigate the influence of flipped classroom on academic performance and student motivation (Morisse, 2015). However, some are also examining the willingness of teachers to adapt and accept the new system (Morisse, 2015). They need to draw up a suitable work plan, record or find educational video and audio materials, and think over the activity of students in the classroom in such a way that it is based on the material covered independently (Alsancak Sirakaya & Ozdemir, 2018). For example, in Austria, a system was even developed for training teachers to deal with the flipped classroom model (Brandhofer & Großböck, 2015). A flipped classroom has been tested in the teaching of science, technology, engineering and mathematics (STEM). It has shown promising results in terms of its potential to improve student retention (Talley & Scherer, 2013; Velegol et al., 2015), content comprehension (Love et al., 2014), student engagement (Gilboy et al., 2015) and interaction between students and teachers (McLean et al., 2016). In addition, students reacted positively to the independent nature of flipped learning courses (Johnson, 2013).

According to students, teachers, and methodologists, a significant disadvantage of the flipped classroom is insufficient technical support (Talley & Scherer, 2013). Insufficient knowledge and skills of some teachers in the field of technology may not allow them to competently develop and record materials for the course. Some experts believe that the creation of a full-fledged course for flipped classroom requires a specially formed group of specialists based on each university (Antonova & Merenkov, 2018).

1.2 Problem statement

The effectiveness of flipped classroom in the educational system is studied quite widely, especially in recent years, when education around the world had to be transferred to an online format. Technologization of the population, the development of modern software and platforms, the emergence of new educational strategies and directions, and forced distance learning have moved traditional forms of education

to the background giving way to new methods. Even though the flipped classroom model has been around for a long time, its effectiveness is still being studied. The novelty of this paper lies in a comprehensive study of the effectiveness of introducing the flipped classroom into the university educational system.

The research questions are the following: how can the flipped classroom model affect students' academic performance and motivation? Is there a difference between academic performance and motivation before and after applying the flipped class model? What are the advantages and disadvantages of this teaching method?

The main purpose of this article was to determine the effectiveness of using the flipped classroom model during distance learning.

Research tasks were the following:

- 1) Determine the academic performance in the control and experimental groups before the introduction of flipped classroom model.
- 2) Determine the motivation in two groups before the introduction of flipped classroom model.
- 3) Analyze the academic performance in the control and experimental groups after 4 months of using flipped classroom.
- 4) Conduct a re-survey to identify the difference in the students' motivation after the introduction of flipped classroom model.
- 5) Identify the main advantages and disadvantages of the flipped classroom model by surveying in the experimental group.

2 Method and materials

2.1 Sample

The study involved interested students of the educational institution: an advertisement was placed in the institution 2 weeks before the experiment. The advertisement informed of the study topic and details. Those who were motivated to participate were registered in the group of participants. To study the effectiveness of introducing a flipped classroom into the educational system, the authors selected 2 groups of Saint Petersburg State University students ($n=28$ in each).

A total sample consisted of 56 students in the 3rd year with the same specialty (philology). The average age of participants was 21 years. The same number in groups and the same specialty were chosen specifically to prevent possible errors in the results. Preference was given to 3rd year students because they are already well acquainted with the traditional form of education and can fully compare it with the flipped classroom model. The first group was the control and the second one was the experimental. The participants were males and females varying in ethnicity and academic achievements (Table 1).

Table 1 shows that the control group consisted of 11 males (39.2%) and 17 females (60.7%) and the experimental group enrolled 9 males (32.1%) and 19 females (67.8%). There were 16 (57.1%) and 17 (60.7%) city residents and 12 (42.8%) and 11 (39.2%) regional residents in the control and experimental groups, respectively.

Table 1 Student sample

	Control Group		Experimental Group	
	%	n	%	n
Males	39.2	11	32.1	9
Females	60.7	17	67.8	19
City residents	57.1	16	60.7	17
Regional residents	42.8	12	39.2	11

2.2 Research design

In order to study the effectiveness of a flipped classroom during distance learning, the researchers compared the average grades of students in the control and experimental groups. They obtained these values at baseline and after the experiment started. One of the study tasks was to determine the level and quality of students' motivation. In both groups, the authors conducted a survey according to "Studying the motives of students' educational activities" by A.A. Rean and V.A. Yakunin to determine the leading motives for learning in a higher educational institution. Comparison of the results before and after the implementation of the flipped classroom allows conclusion of its success. This method was chosen because it is considered one of the most effective for assessing the motivation of each student and the group as a whole.

The study participants received 16 statements ([Appendix 1](#)). The students of both groups should assess each statement between 1 and 7, that is, evaluate each motive of educational activity according to personal significance (1 for minimum and 7 for maximum significance). The higher the overall score for a certain motive, the more preferable this motive is for a group of students.

In addition, the authors surveyed the experimental group. It consisted of 5 questions ([Appendix 2](#)) for feedback to identify the positive and negative aspects of the flipped classroom. The reliability of surveys and questionnaires was assessed with the correlation coefficient. The technique was recognized as reliable, since the obtained indicator was not lower than 0.75. To check the validity of the methodology, the concordance coefficient was used. The coefficient accepts values not lower than 0.6, which indicates a good level of the methodology validity.

The survey and questioning were online using Google Docs. The experiment lasted one academic semester: from September 1 to December 24, during which Russian Language and Russian Literature were taught in the flipped classroom using Skype, Zoom, Google Docs, Google Classroom, and YouTube. The teachers of these two subjects adjusted the curriculum together with the methodologists of St. Petersburg University to match the flipped classroom model.

At the beginning of each academic week, students were given access to materials for 1 week. Google Classroom contained the videos recorded by teachers, video and audio materials found by teachers and relevant to the topics of classes, links to scientific articles, Google Docs with teachers' notes on the methodology for learning new material, and links to possible creative tasks (crossword puzzles, online games, quests, etc.) related to the studied material. In online classes, students, who were already familiar with the material provided, discussed it, asked questions of interest

to them, discussed the topics, and received advice from teachers regarding a more in-depth study of a particular issue.

The training scheme is shown in Fig. 1.

2.3 Statistical processing

Microsoft Silverlight was used for the calculations required in this study.

2.4 Ethical issue

All participants in the control and experimental groups were familiarized with the study tasks and objectives. Each student has given his/her consent to the participation and processing of personal (gender, origin) and professional (specialty, academic progress) data. To ensure anonymity, each participant was assigned an identification number.

2.5 Research limitation

The experiment did not take into account some factors mainly related to personal motivation such as ease or difficulty in studying certain subjects, changes in the level and quality of interest in the subject or learning in general, health status at the time of the study, personal problems of participants, etc. In addition, the spatial scope of the experiment is rather narrow since it involved only two groups from the same university.

3 Results

At baseline, the authors made a cross-section of academic performance in the control and experimental groups in two specialized subjects (Russian Language and Russian Literature) by finding a mean grade for each student as an arithmetic mean ([Appendix](#)

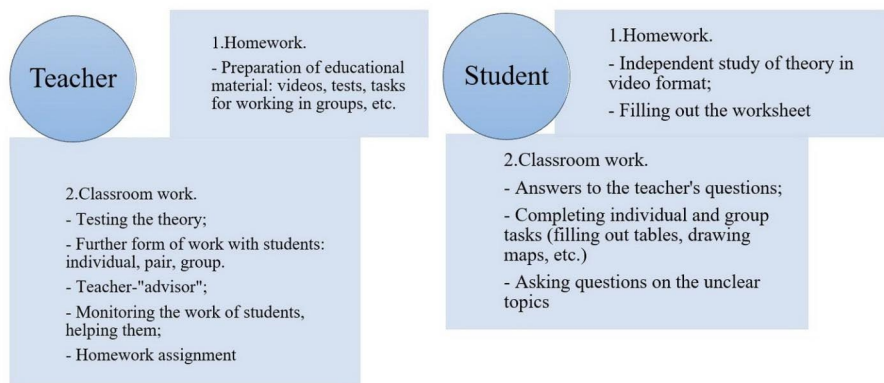


Fig. 1 The scheme of teaching students in a "flipped" classroom

3). It was found that 3 (10.7%) and 5 (17.8%) students had “excellent”, 19 (67.8%) and 17 (60.7%) had “good”, and 6 (21.4%) and 6 (21.4%) had “satisfactory” grades in the control and experimental groups, respectively (Fig. 2).

A survey according to the method by A.A. Rean and V.A. Yakunin showed the motivation of each student in two groups (Appendix 4). In the control group, based on the highest (6.2) and lowest (3.0) values, three subgroups were formed: low (3.0–4.0), medium (4.0–5.2), and high motivation (5.2–6.2); mean motivation was 4.9. Based on these findings, the students of the control and experimental groups were divided into subgroups regarding motivation. In the control group, 5 (17.8%) students had low, 8 (28.5%) had medium, and 15 (53.5%) had high motivation.

In the same way, in the experimental group, based on the highest (6.1) and lowest (2.7) values, three subgroups were formed: low (2.7–3.7), medium (3.7–5.1), and high motivation (5.1–6.1); mean motivation was 4.8. In the experimental group, 6 (21.4%) students had low, 5 (17.8%) had medium, and 17 (60.7%) had high motivation.

Four months after the introduction of the flipped classroom, the mean grades were analyzed again. Appendix 5 shows that they changed in both groups. At that, in the control group, 4 (14.2%) students had “excellent”, 18 (64.2%) had “good”, and 6 (21.4%) had “satisfactory” grades. These findings differ from baseline but extremely insignificantly: the number of “excellent” students increased by 3.5%, the number of “good” students decreased by 3.6%, and the number of “satisfactory” students did not change. The academic performance in the experimental group changed more significantly: 10 (35.7%) students had “excellent”, 16 (57.1%) had “good”, and 2 (7.1%) had “satisfactory” grades; the number of “excellent” students increased by 17.9%, the number of “good” students decreased by 3.6%, and the number of “satisfactory” students decreased by 14.3% (Fig. 3). These data answer the first question of the study: how can the flipped classroom model affect students’ academic performance

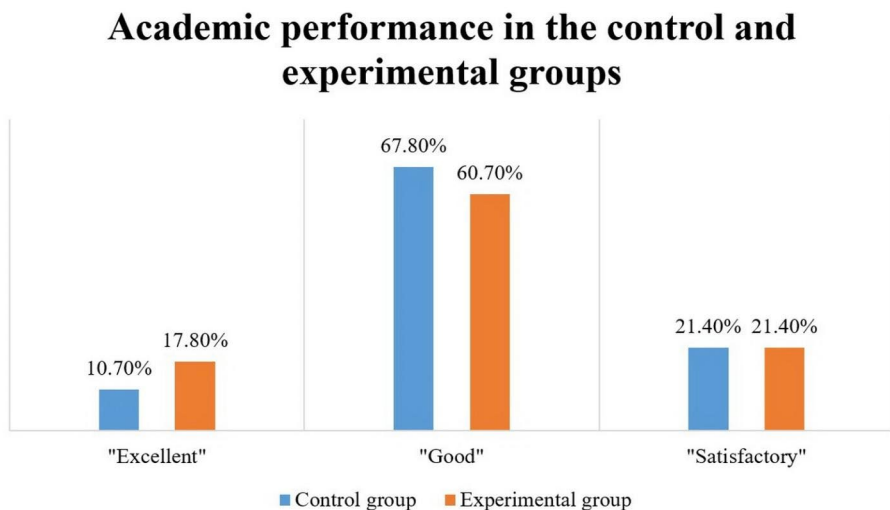


Fig. 2 Academic performance in the control and experimental groups at baseline

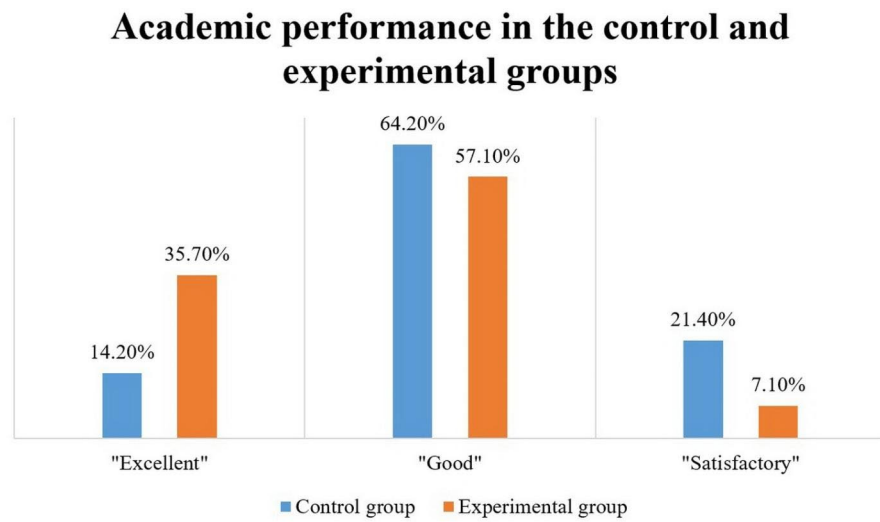


Fig. 3 Academic performance in the control and experimental groups at the study end

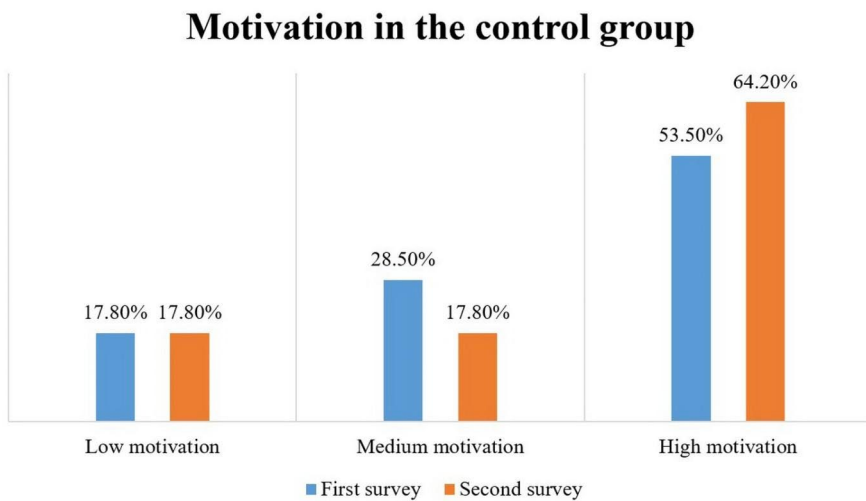


Fig. 4 Motivation changes in the control group

and motivation? Thus, all indicators had a small but positive shift (Figs. 3, 4 and 5). This indicates that the flipped class model has some influence on these indicators.

Figure 3 shows that the performance in the experimental group with flipped classroom increased: there were significantly more “excellent” students and three times fewer “satisfactory” students. The number of “good” students remained virtually unchanged. At the same time, in the control group with the traditional education, there were no significant changes. A repeated survey according to the method by

A.A. Rean and V.A. Yakunin ([Appendix 6 A](#)) showed that the overall motivation in the control group decreased slightly: 5 (17.8%) students with low, 5 (17.8%) with medium, and 18 (64.2%) with high motivation ([Fig. 4](#)).

[Figure 4](#) shows that the number of students with low motivation did not change, with medium motivation decreased by 10.7%, and with high motivation increased by 10.7%. Mean motivation in the experimental group increased from 4.8 to 5.0, that is, by 0.2. There were 4 (14.2%) students with low, 8 (28.5%) with medium, and 16 (57.3%) with high motivation ([Fig. 5](#) and [Appendix 6B](#)). All these results indicated a difference between academic performance and motivation before and after applying the flipped class model in teaching students. Thus, the second question of the study was confirmed.

[Figure 5](#) shows that the number of students with low motivation decreased by 7.2%, with medium motivation increased by 10.7%, and with high motivation decreased by 3.4%. It should be noted that the mean motivation in both groups changed after the second survey (decreased in the control group and increased in the experimental group) so the respective values were changed following the new data. In general, there is a positive trend in the experimental group and no significant changes in the control group. [Figures 6](#) and [7](#) show the results of a survey in the experimental group for feedback to identify the advantages and disadvantages of the flipped classroom.

[Figure 6](#) clearly shows that the vast majority of students prefer the flipped classroom model. So, 25 students (89.2%) noted that flipped classroom is better for knowledge assimilation, 23 students (82.1%) called it the most suitable for interesting learning, and 26 students (92.8%) agree that this model arouses their research interest. A minority of students supported the traditional educational model: 3 (10.8%), 5 (17.9%), and 2 (7.2%) students, respectively.

[Figure 7](#) shows that most of the students emphasized the advantages of the flipped classroom. Thus, 24 students (82.7%) noted that the innovation saves time, 18 stu-

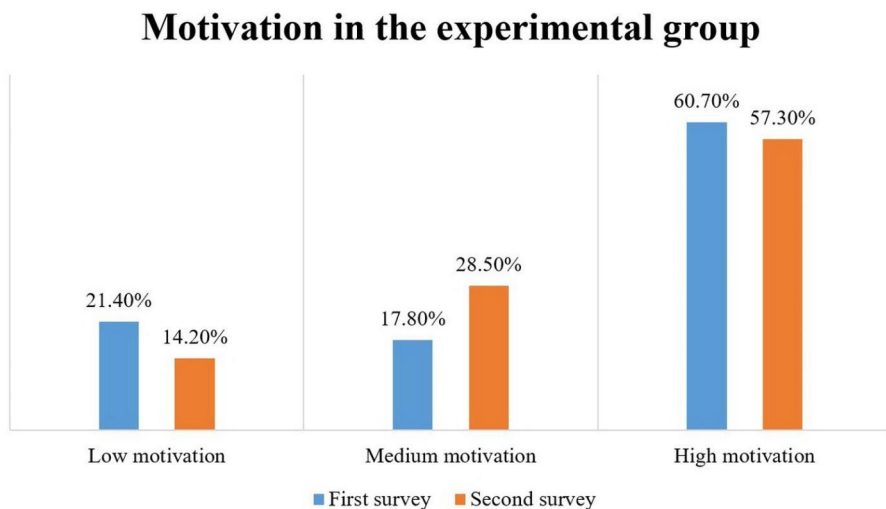


Fig. 5 Motivation changes in the experimental group

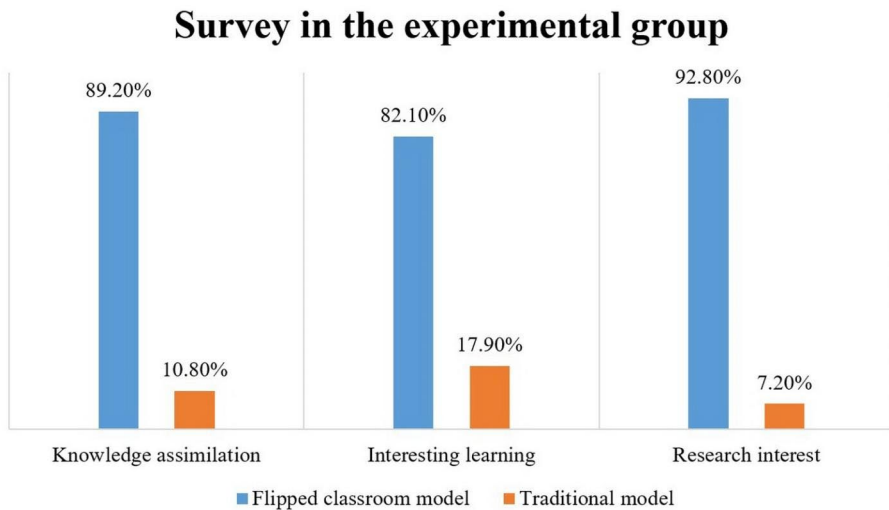


Fig. 6 Survey results in the experimental group

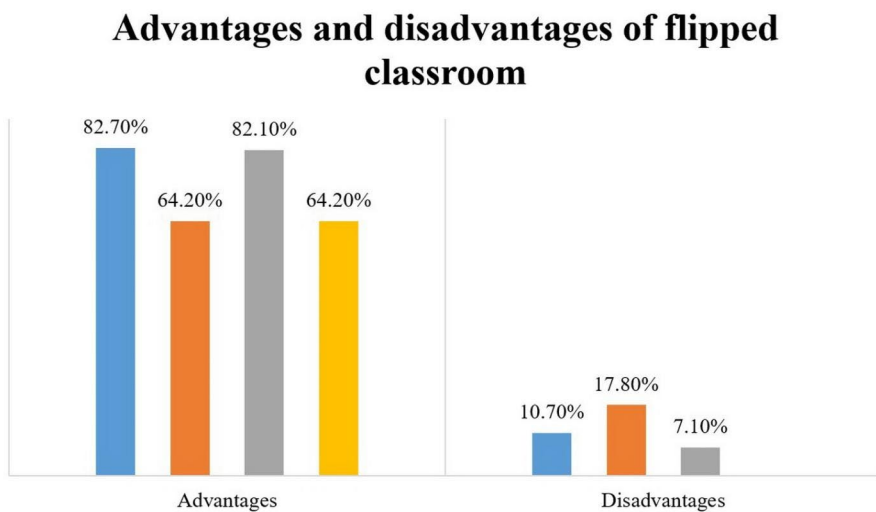


Fig. 7 Advantages and disadvantages of the flipped classroom model

dents (64.2%) emphasized that interesting topics are discussed in the lesson, while basic information is left for independent study, 23 students (82.1%), among other advantages, indicated that they can study and receive information in a convenient place at a convenient time, and 15 students (53.5%) highlighted the opportunity to study the material and related issues in depth.

Accordingly, Figs. 6 and 7 demonstrate the answer to the third research question: what are the advantages of this method of teaching. Disadvantages were the follow-

Table 2 The comparative data of the two student groups before and after using the flipped class model

Indicator	Control group (28 people)		Experimental group (28 people)		Standard error
	Before	After	Before	After	
Academic performance					
Excellent	3	4	5	10	0.446
Good	19	18	17	16	0.333
Satisfactory	6	6	6	2	0.300
Motivation					
Low	5	5	4	4	0.056
Average	2	5	8	5	0.078
High	21	18	16	19	0.045

Table 3 The comparative data of the two student groups after ANOVA analysis

Group	Sum of squares	Mean square value	F
Between the groups	0.022	0.0061	0.097
In the groups	0.842	0.0651	
Total	0.845		

ing: inability to independently study the topic's basic foundations (10.7%, $n=3$), too much material for independent study (17.8%, $n=5$), and technical problems (7.1%, $n=2$).

Table 2 shows the comparative data of the two student groups before and after training.

The results of Table 2 reveal that the academic performance and motivation indicators of the experimental group are higher than those of the control group. Hence, the applied flipped class model had positive dynamics in the indicators of the tested group.

The ANCOVA test showed that there were no significant differences in the motivation of students depending on the teaching method (Table 3). However, this result should be carefully interpreted, since the sample sizes were small and there were large gaps between the sizes of effects showing heterogeneous results.

4 Discussion

The study showed that the students, who switched to flipped classroom, improved their academic performance and motivation. A similar study in Turkey showed the same trend (Debbag & Yıldız, 2021). About 80 teachers, who participated in the experiment, used a combination of qualitative and quantitative methods (achievement test and motivation scale) to identify the difference in academic performance and student motivation before and after the study. As in the current paper, Turkish students were divided into two groups: control and experimental. An analysis of the experimental data showed a slight difference in the two criteria in the control group and significant differences in the experimental group (Debbag & Yıldız, 2021).

Swedish researchers, who investigated the effectiveness of the flipped classroom implementation in the curriculum (Stöhr et al., 2020), asked questions about the

model's impact on student performance, asynchronous and synchronous activities, which would be the most effective, and the best approach to the administration of the new educational format. The study based on transactional distance theory collected data from 52 students based on their homework over two periods: campus classes and online classes according to the flipped classroom model. These data showed that the academic performance, although slightly, still became better. These findings correspond to those in the current research. In addition, student attendance and activity during online classes have increased significantly.

A Turkish study, the purpose of which was to investigate the factors influencing academic performance and academic engagement of students (Talan & Batdi, 2020; Talan & Gulsecen, 2019), divided 190 students into three groups: flipped classroom, blended learning, and traditional educational system. The students studied computer technologies. Parametric methods were used for data analysis. The results showed that student performance increased by 17.55, 16.49, and 15 points in the flipped classroom group, blended learning group, and control group, respectively. Although the methods of this study differ from those in the present paper, the trend is the same. The flipped classroom model has a positive effect on student achievement and academic engagement.

The second Turkish study examined the impact of the flipped classroom on students' writing skills (Altas & Enisa, 2020) and enrolled two groups, a control ($n=30$) and an experimental ($n=30$) one. The experiment showed that the flipped classroom group significantly outperformed the group with the traditional learning style. These findings coincide with the trends observed in the current paper.

The third Turkish study (Alsancak Sirakaya & Ozdemir, 2018) enrolled 66 students and used the Motivation Strategy Scale, the Self-Study Readiness Scale, and the Academic Performance Test as data collection tools. The experiment's purpose was to identify differences between the control and experimental groups in terms of academic performance, independence, and motivation. At the study end, the tests showed that students, who used flipped classroom, had higher grades than those who studied traditionally. In addition, the authors emphasized higher motivation in the experimental group compared to the control group. These conclusions are consistent with the findings of the current research.

The fourth Turkish study (Karabatak & Polat, 2022) investigated the effectiveness of introducing the flipped classroom into the educational system and divided the students into control and experimental groups. For data collection, the academic performance 26-item test by Bingöl and Halisdemir and the Likert-type academic satisfaction scale by Schmitt et al. were used. The findings indicate that students in the experimental group had better academic success and were more satisfied with the learning process compared to the control group. These conclusions correspond to those in the current paper.

Researchers from Cyprus (Taşpola et al., 2021) studied the effectiveness of flipped classroom for 30 students of the experimental group taking a programming course at the university. They used qualitative and quantitative methods including a group interview and a student academic achievement test. By the study end, students in the experimental group had higher grades than those who learned subjects traditionally. These findings are consistent with those in the current study.

A Chinese study (Tang et al., 2020) had a control group ($n=695$) and an experimental group with a flipped classroom model ($n=658$). The findings showed that only 25.5% of students considered online classes based on the flipped classroom model useful and effective. These results are not consistent with those in the current paper.

German research on the implementation of the flipped classroom in medical education (Huber et al., 2021) has shown mixed results. The author argues that the semester with the flipped classroom model is subjectively perceived better than the face-to-face semester of traditional education. It should be noted that the findings of the current paper indicate an objective positive effect of the flipped classroom model, which does not fully coincide with the German study.

A study in India (Vivek & Ramkumar, 2021) explored the difference in traditional, blended, and flipped approaches. Engineering students were enrolled in the experimental group. These findings suggest that the blended approach did not meet the expectations of the researchers and turned out to be ineffective. At the same time, flipped classroom teaching has shown great potential by gathering positive feedback from students and having a positive impact on academic achievements (Vivek & Ramkumar, 2021). These findings are similar to those in the current paper.

In an experiment conducted in Saudi Arabia (Jdaitawi, 2020), researchers examined the learning emotions in students within traditional and flipped education. The findings show a significant superiority in academic performance in the experimental group compared to the control group. Although the current research does not examine emotions, based on a survey of students, it can be confidently stated that they like the flipped classroom model more than the traditional educational system.

5 Conclusion

The objectives of the current research were to study the impact of the flipped classroom introduction into the educational system on students' academic performance and motivation using the questionnaire "Studying the motives of students' educational activities" by A.A. Rean and V.A. Yakunin, a cross-section of students' grades, and a survey. The sample consisted of the control ($n=28$) and experimental ($n=28$) groups. The control group had traditional classes and the experimental group learned according to the flipped classroom method. The findings showed that academic performance in the experimental group has changed significantly. The number of "excellent" students increased by 17.9% and the number of "good" and "satisfactory" students decreased by 3.6% and 14.3%, respectively. Mean motivation in the experimental group increased from 4.8 to 5.0, that is, by 0.2. There were 4 (14.2%) students with low, 8 (28.5%) with medium, and 16 (57.3%) with high motivation. The number of students with low motivation decreased by 7.2%, with medium motivation increased by 10.7%, and with high motivation decreased by 3.4%.

The vast majority of students prefer the flipped classroom model. So, 25 students (89.2%) noted that flipped classroom is better for knowledge assimilation, 23 students (82.1%) called it the most suitable for interesting learning, and 26 students (92.8%) agree that this model arouses their research interest. A minority of students

supported the traditional educational model: 3 (10.8%), 5 (17.9%), and 2 (7.2%) students, respectively.

Most of the students emphasized the advantages of the flipped classroom. Thus, 24 students (82.7%) noted that the innovation saves time, 18 students (64.2%) emphasized that interesting topics are discussed in the lesson, while basic information is left for independent study, 23 students (82.1%), among other advantages, indicated that they can study and receive information in a convenient place at a convenient time, and 15 students (53.5%) highlighted the opportunity to study the material and related issues in depth. The disadvantages included the inability to independently study the basic foundations of the lesson topic (10.7%, $n=3$), too much material for independent study (17.8%, $n=5$), and technical problems (7.1%, $n=2$).

The findings show a positive trend in flipped classroom use. Academic progress and motivation of students are growing, of course, affecting the quantity and quality of knowledge acquired.

Even though a lot of studies have been devoted to the efficiency of the flipped classroom model, there is also a large space for further research. The findings of this paper can be used as a basis or supplement for future practical and theoretical studies.

6 Appendix 1

List of motives from “Studying the motives of students’ educational activities” by A.A. Rean and V.A. Yakunin:

1. Become a highly qualified specialist.
2. Get a diploma.
3. Successfully continue the studies in subsequent courses.
4. Successfully study and pass exams with “good” and “excellent” grades.
5. Permanently receive a scholarship.
6. Acquire deep and solid knowledge.
7. Always be ready for the next lesson.
8. Do not neglect to study the subjects of the educational cycle.
9. Keep up with fellow students.
10. Ensure the success of future professional activities.
11. Fulfill pedagogical requirements.
12. Achieve the respect of teachers.
13. Be an example for fellow students.
14. Gain the approval of parents and the people around.
15. Avoid judgment and punishment for poor academic performance.
16. Get intellectual satisfaction.

7 Appendix 2

Questionnaire to determine the advantages and disadvantages of the flipped classroom introduction into the educational system:

1. Which lesson structure suits you best for mastering knowledge: the classical or the flipped classroom model?
2. Which lesson structure makes learning new material more interesting: the traditional or the flipped classroom model?
3. Which system of lesson design arouses your research interest: the traditional or the flipped classroom model?
4. List the advantages of the flipped classroom model.
5. List the disadvantages of the flipped classroom model.

8 Appendix 3

Results of a grade cross-section to identify the academic performance in the control and experimental groups before the flipped classroom implementation.

Control Group			Experimental Group				
1	“Good”	15	“Good”	1	“Satisfactory”	15	“Satisfactory”
2	“Good”	16	“Good”	2	“Good”	16	“Good”
3	“Good”	17	“Good”	3	“Good”	17	“Good”
4	“Excellent”	18	“Good”	4	“Good”	18	“Good”
5	“Good”	19	“Excellent”	5	“Good”	19	“Good”
6	“Satisfactory”	20	“Good”	6	“Satisfactory”	20	“Excellent”
7	“Good”	21	“Good”	7	“Satisfactory”	21	“Excellent”
8	“Good”	22	“Good”	8	“Good”	22	“Good”
9	“Good”	23	“Satisfactory”	9	“Good”	23	“Satisfactory”
10	“Satisfactory”	24	“Good”	10	“Excellent”	24	“Good”
11	“Good”	25	“Excellent”	11	“Good”	25	“Good”
12	“Good”	26	“Satisfactory”	12	“Excellent”	26	“Satisfactory”
13	“Satisfactory”	27	“Good”	13	“Good”	27	“Excellent”
14	“Satisfactory”	28	“Good”	14	“Good”	28	“Good”

9 Appendix 4

A. The survey results of the control group according to the method by A.A. Rean and V.A. Yakunin at baseline.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	5	6	6	6	5	5	7	6	7	7	5	6	6	7	6	5
2	4	4	4	5	4	5	5	7	5	5	4	5	6	6	4	5
3	6	6	5	6	5	5	5	4	5	3	5	4	3	3	6	5
4	7	7	6	6	6	6	7	5	7	7	6	6	6	5	6	7
5	5	6	4	4	7	6	5	5	5	4	7	7	6	4	6	6
6	3	4	4	3	3	3	4	3	5	2	3	3	2	2	4	4
7	5	5	7	6	7	7	5	6	6	4	5	4	4	4	6	5
8	7	7	5	6	5	6	5	6	7	7	6	6	6	5	7	5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
9	4	6	5	6	7	7	4	5	5	5	6	6	4	6	5	6
10	2	3	3	2	4	4	4	4	3	3	5	6	6	3	2	3
11	5	6	5	5	5	6	6	6	6	7	4	5	4	4	6	5
12	7	7	5	6	7	7	4	6	5	5	5	6	6	7	5	4
13	3	3	3	4	4	2	2	3	3	3	3	5	4	3	3	3
14	2	2	2	3	2	2	4	4	3	3	3	3	5	3	3	5
15	6	6	7	7	7	7	5	6	6	5	7	5	5	6	6	7
16	5	5	6	5	5	5	5	7	5	5	4	7	4	4	6	5
17	6	7	7	6	6	6	7	4	5	4	4	7	6	6	6	7
18	5	5	5	7	4	4	4	5	5	4	6	6	6	7	6	4
19	5	5	6	6	6	6	6	7	7	6	7	6	6	5	7	7
20	6	5	7	7	5	6	6	5	7	4	6	5	5	5	7	6
21	3	5	4	4	4	3	3	5	5	4	3	4	4	6	4	4
22	5	4	4	4	6	5	5	3	5	5	7	4	6	6	5	4
23	4	3	3	3	4	4	5	2	3	3	2	5	4	4	3	4
24	6	6	6	4	5	5	5	5	7	6	5	4	4	5	7	5
25	5	5	5	7	6	7	7	6	6	6	6	7	5	6	6	5
26	6	6	2	5	6	3	4	5	5	5	3	6	3	3	4	2
27	6	5	5	5	7	4	5	6	6	5	5	7	5	5	5	4
28	5	5	7	4	4	4	4	6	6	5	7	4	6	5	7	4

The horizontal numbers correspond to the ordinal number of the question in the questionnaire, and the vertical numbers correspond to the identification number of the control group member.

B. The survey results of the experimental group according to the method by A.A. Rean and V.A. Yakunin at baseline.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	2	4	4	3	1	2	3	3	6	3	2	3	2	2	4	1
2	5	5	4	5	5	6	6	7	4	4	5	4	6	6	5	6
3	5	6	6	5	7	4	5	6	4	5	4	5	4	4	6	5
4	4	5	5	4	5	6	6	7	5	6	6	4	5	4	6	5
5	7	5	4	5	5	6	4	5	7	5	4	5	6	4	4	4
6	3	3	3	4	1	2	2	4	3	5	3	4	4	3	3	4
7	2	5	5	3	3	4	4	4	3	4	2	4	4	3	6	3
8	5	5	5	6	5	7	4	5	5	4	5	7	5	5	6	6
9	6	6	6	6	5	6	6	7	6	5	6	5	5	7	5	6
10	7	6	5	5	6	6	7	7	7	7	5	7	5	6	6	5
11	5	6	5	5	5	6	5	6	5	6	3	5	3	3	5	4
12	7	6	6	5	7	5	7	7	6	6	6	7	5	5	7	7
13	3	5	4	7	4	3	3	3	6	5	5	6	4	6	5	5
14	6	6	5	6	5	4	6	4	4	5	7	5	6	6	4	7
15	3	5	5	4	3	3	3	5	3	3	4	1	3	4	2	2
16	5	6	6	6	6	7	4	5	5	7	6	5	5	5	4	6
17	4	6	6	6	6	5	5	4	5	4	4	6	6	5	6	5
18	5	5	5	6	5	6	5	4	6	6	5	7	5	6	5	5
19	6	5	6	6	5	7	5	4	6	6	6	4	5	5	7	4

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
20	5	5	7	7	7	6	6	6	7	6	6	5	7	7	6	5
21	6	6	7	7	5	5	7	5	5	6	5	7	6	6	5	6
22	5	6	4	5	5	6	4	5	5	7	5	4	6	5	6	5
23	1	2	2	4	2	3	3	3	6	4	3	2	2	3	2	2
24	5	6	5	6	6	4	5	6	4	5	5	4	6	5	6	5
25	7	4	5	5	5	6	5	5	7	4	5	4	5	6	5	6
26	2	2	4	2	4	3	3	1	6	4	3	3	2	2	4	4
27	6	6	6	6	5	7	7	7	7	5	6	5	6	5	7	5
28	5	4	7	4	6	5	4	6	5	4	4	4	6	5	5	6

The horizontal numbers correspond to the ordinal number of the question in the questionnaire, and the vertical numbers correspond to the identification number of the experimental group member. Based on the highest (6.1) and lowest (2.7) values, three subgroups were formed: low (2.7–3.7), medium (3.7–5.1), and high motivation (5.1–6.1); mean motivation was 4.8.

10 Appendix 5

Results of a grade cross-section to identify the academic performance in the control and experimental groups after the flipped classroom implementation.

Control Group			Experimental Group				
1	“Good”	15	“Good”	1	“Satisfactory”	15	“Good”
2	“Excellent”	16	“Good”	2	“Good”	16	“Excellent”
3	“Good”	17	“Satisfactory”	3	“Good”	17	“Good”
4	“Excellent”	18	“Good”	4	“Excellent”	18	“Good”
5	“Good”	19	“Satisfactory”	5	“Good”	19	“Good”
6	“Satisfactory”	20	“Good”	6	“Satisfactory”	20	“Excellent”
7	“Good”	21	“Good”	7	“Good”	21	“Excellent”
8	“Good”	22	“Good”	8	“Good”	22	“Good”
9	“Good”	23	“Satisfactory”	9	“Good”	23	“Good”
10	“Good”	24	“Good”	10	“Excellent”	24	“Good”
11	“Good”	25	“Excellent”	11	“Good”	25	“Excellent”
12	“Good”	26	“Satisfactory”	12	“Excellent”	26	“Good”
13	“Satisfactory”	27	“Good”	13	“Good”	27	“Excellent”
14	“Satisfactory”	28	“Good”	14	“Excellent”	28	“Good”

11 Appendix 6

A. The survey results of the control group according to the method by A.A. Rean and V.A. Yakunin at the study end.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	5	6	6	4	5	5	7	4	7	7	5	6	6	5	6	5
2	4	4	4	5	4	5	7	7	5	5	4	5	4	6	4	6
3	6	4	5	5	5	5	5	4	5	6	5	4	5	3	6	5
4	6	6	6	6	6	6	5	5	7	7	6	3	6	5	6	7
5	5	6	4	4	7	6	7	5	5	4	6	7	6	5	6	6
6	3	4	3	3	4	3	4	3	5	3	3	3	2	2	4	4
7	5	5	7	6	7	5	5	6	6	5	5	4	4	4	5	5
8	7	7	5	7	5	6	5	6	5	7	6	6	6	5	6	5
9	4	6	6	6	7	7	4	4	5	5	4	6	4	6	5	6
10	2	3	3	2	3	4	4	4	3	4	5	6	6	3	2	4
11	6	6	5	5	5	5	6	6	6	7	5	5	4	4	6	5
12	7	7	6	6	7	7	4	3	5	5	4	6	6	7	5	4
13	3	3	3	4	4	3	2	3	4	3	3	5	4	3	3	2
14	2	2	2	3	3	2	4	4	2	3	3	3	5	5	3	5
15	6	6	7	5	7	7	6	6	6	4	7	5	5	6	6	7
16	5	5	6	5	5	5	5	7	5	5	4	7	5	4	6	5
17	6	7	4	6	6	6	7	5	5	4	4	7	6	6	6	7
18	5	5	5	7	5	4	4	5	5	4	5	6	6	7	6	4
19	5	5	6	6	6	6	6	7	7	6	7	6	6	5	7	7
20	6	5	7	7	5	6	4	5	7	4	4	5	5	5	7	6
21	3	5	6	4	4	3	3	5	5	4	4	4	4	6	4	4
22	5	4	4	4	6	6	5	3	5	5	7	3	6	6	5	4
23	4	3	3	4	4	4	5	2	3	3	3	5	4	4	3	4
24	6	6	6	4	5	5	5	5	7	6	5	4	4	5	7	5
25	5	5	5	7	6	7	7	6	5	6	6	7	5	6	6	5
26	6	6	2	6	6	3	4	5	5	5	3	6	3	3	4	2
27	6	5	5	5	7	5	5	6	6	5	5	5	5	5	5	4
28	6	5	7	4	4	4	4	4	6	5	7	4	6	6	7	6

The horizontal numbers correspond to the ordinal number of the question in the questionnaire, and the vertical numbers correspond to the identification number of the control group member. Based on the highest (6.1) and lowest (3.1) values, three subgroups were formed: low (3.1–4.1), medium (4.1–5.1), and high motivation (5.1–6.1); mean motivation was 4.7.

B. The survey results of the experimental group according to the method by A.A. Rean and V.A. Yakunin at the study end.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	2	5	4	3	3	2	3	3	6	3	4	4	4	2	4	1
2	5	5	6	5	5	6	6	7	4	4	7	4	6	6	5	6
3	7	6	6	5	7	5	5	6	4	5	4	5	6	4	6	5
4	4	5	5	5	5	6	6	7	5	6	6	6	5	4	6	6
5	7	5	4	5	5	6	4	5	7	5	4	5	6	5	4	4
6	3	3	3	4	5	2	2	4	3	5	3	4	4	1	3	4
7	5	5	6	3	3	5	4	4	3	4	4	4	4	6	6	3
8	5	5	5	6	5	7	4	5	5	4	5	7	5	5	6	6
9	6	7	6	6	5	7	6	7	6	5	6	5	6	7	5	6
10	7	6	5	5	6	6	7	7	7	7	5	7	5	6	6	5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
11	5	6	5	5	5	6	7	6	5	6	6	5	3	3	5	4
12	7	6	6	5	7	5	7	7	6	6	6	7	5	6	7	7
13	3	5	4	7	4	4	5	3	6	5	5	6	4	6	5	7
14	6	6	5	6	5	5	6	4	4	5	7	6	6	6	4	7
15	3	5	5	4	3	6	3	5	5	3	4	4	3	4	2	5
16	5	6	6	6	7	7	4	5	5	7	6	5	5	5	4	6
17	4	6	6	6	6	5	5	6	5	4	4	6	6	5	6	5
18	5	5	5	6	5	6	5	7	6	6	5	7	5	6	5	5
19	6	5	6	5	5	7	5	4	6	6	6	4	5	5	7	6
20	5	5	7	7	7	6	6	6	7	6	6	6	7	7	6	5
21	6	6	7	7	5	5	7	7	5	6	5	7	6	6	5	6
22	7	6	4	5	5	6	4	5	5	7	5	4	6	5	6	5
23	3	2	2	4	2	3	3	3	6	4	3	2	3	5	2	2
24	5	6	5	6	6	4	5	6	4	5	5	4	6	5	6	5
25	7	4	5	5	5	6	5	5	7	4	5	4	5	6	5	6
26	2	5	4	6	4	4	3	5	6	4	3	3	2	4	4	4
27	6	6	6	6	5	7	7	7	7	5	6	5	6	5	7	5
28	5	4	7	4	6	5	7	6	5	4	4	4	6	5	5	6

The horizontal numbers correspond to the ordinal number of the question in the questionnaire, and the vertical numbers correspond to the identification number of the experimental group member. Based on the highest (6.2) and lowest (3.0) values, three subgroups were formed: low (3.0–4.0), medium (4.0–5.2), and high motivation (5.2–6.2); mean motivation was 5.0.

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Data Availability Data will be available on request.

Declarations

Conflict of interest Authors declare that they have no conflict of interests.

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