Assessment of effectiveness of practice teaching biology methods in collective learning: the pilot study

Symbat Myrzagaliyeva [1*], *Rimma* Izbassarova[2], *Ayagoz* Kuanyshbekova[1], *Saltanat* Ibadullayeva[3]

[1] Al-Farabi Kazakh National University, Almaty, 050040, Kazakhstan
[2] Abai Kazakh National Pedagogical University, Institute of Natural Sciences and Geography, 13 Dostyk Ave., Almaty, 050010, Kazakhstan

[3] Korkyt Ata Kyzylorda university, Institute of Natural Sciences, Kyzylorda, Kazakhstan

Abstract. This study constitutes a pilot investigation conducted in the absence of a control group. Its objective was to evaluate the efficacy of practical learning within a collaborative setting among first-year students specializing in biotechnology. The research session focused on the topic "Methods for the development and production of biological products: The role of biological products in human life." Sixteen students were divided into four groups of four students each. The lesson was facilitated using the Jigsaw group teaching method, integrating both theoretical and practical components. Pre- and post-class tests were administered to evaluate students' performance, revealing significant improvements after the session.The assessment of students who underwent the post-class test significantly exceeded their performance in the pre-class test. For theoretical questions, this yielded: $T=14.478$, $P<0.001$, and for practical questions: $T=19.104$, $P<0.001$. Additionally, the study revealed that the implementation of the Jigsaw method leads to a substantial increase in the percentage of students achieving high grades and a significant decrease in the proportion of students receiving low grades. The percentages of students receiving high grades increased by 43.75% (excellent) and 6.25% (good), while the percentage of low grades decreased by 50% (fair) and 12.5% (bad). This study provides empirical evidence supporting the utilization of collaborative, experiential learning approaches in enhancing biology education, particularly in fostering both theoretical understanding and practical skills among students in the field of biotechnology.

1 Introduction

* Corresponding author: s.myrzagaliyevaa@gmail.com

A.V. Petrovsky noted that: "Learning is the communication of a person with humanity" [1]. Learning is not only the transfer of knowledge and skills from one generation to another, but also the exchange of experiences, ideas and values between people. A person learns not only from books and lectures, but also from communicating with other people - his teachers, colleagues, friends and even casual acquaintances. This communication is the power of learning, which not only develops intelligence and professional skills, but also contributes to personal growth and the formation of a worldview.

Nowadays, in the field of education, the effectiveness of teaching methods, especially in the field of biology, remains a topic of paramount importance. The goal of biological education at the present stage is to prepare a biologically and environmentally competent person who must understand the significance of life as the highest value. A modern person, no matter what type of activity he prefers in the future, should be able to build his relations with nature on the basis of respect for man and the environment [2].

Practical training plays a key role in biological education. The founder of the "learning by doing" concept, John Dewey, revolutionized educational practice by emphasizing experiential learning. In his work "Experience and Education" (1938), he wrote: "Give students something to do, not something to learn; and doing is of a nature that requires thinking; learning leads to natural results [3]. This statement by John Dewey emphasizes the importance of active student participation in the educational process. He advocates not only providing students with memorization material, but also giving them assignments or activities that require active thinking and reflection. Learning by doing means learning from experiences resulting directly from one's own actions, as contrasted with learning from watching others perform, reading others' instructions or descriptions, or listening to others' instructions or lectures [4].

As Jean Piaget, the Swiss psychologist and educator, observed: "We cannot understand anything until we have done it. Experience is the best teacher [5]. This underscores the importance of practical experience in the process of acquiring knowledge and developing understanding.

Educational institutions often use a seminar format that is aimed at small groups of students in order to enhance their individual participation and discuss selected topics or problems. Several studies have reflected that individual learning, which has been a core component around which the education system has been institutionalized, does not fully enable learners to learn the process of learning. It has been observed that people learn faster and in much greater depth in groups, making them familiar with the process of learning. Collective learning is a term that is often used to refer to this concept of learning in groups (dyads, teams, organizations, communities, and societies) [6].

As teachers constantly strive to optimize learning outcomes, studying the effectiveness of biology teaching through collective approaches is becoming increasingly important. This learning format, which takes place not only in the classroom, but also in everyday life, helps to stimulate students' active thinking and their involvement in the learning process [7]. While acting jointly, members of a collective (agents) consciously or unconsciously gain experience of both individual and collective activity. That is, a process of their learning takes place. Here and below, we understand learning as "a process and result of gaining individual experience" [8,9]. This interpretation of the term is a particular case of the more general notion of learning as a process of gaining knowledge, skill, and habits [10].

A collaborative approach to biology teaching emphasizes collaborative learning strategies in which students actively interact with peers to gain knowledge, solve problems, and deepen their understanding of biological concepts. By using group dynamics and creating a collaborative learning environment, educators strive to enhance student engagement, critical thinking skills, and shared learning experiences.

The purpose of the study is to identify the most effective methods that contribute to deeper learning of the material and the development of key skills of students in the field of biology when working in groups.

The novelty of this study lies in evaluating the effectiveness of various practical methods of teaching biology in the context of collective learning. While there is a significant amount of research on the effectiveness of teaching methods in the field of biology, few of them focus specifically on collective learning. The research aims to fill this gap by analyzing how various practical methods can be most successfully applied in a collective educational environment, making it an important contribution to the field of pedagogical practice and scientific understanding of optimal methods of teaching biology. The study is a pilot study to evaluate the effectiveness of the "Jigsaw" method in application to teaching a biotechnology discipline [11].

2 Materials and Methods

2.1 Participants

16 first-year students of al-Farabi Kazakh National University specializing in biotechnology who volunteered to participate in the study and signed written informed consent were involved as subjects. The research session was held 1 time.

2.2 Research Model teaching

For utilising the practical team approach in our experimental lesson, we have chosen the topic devoted to the Methods of development and production of biopreparations as well as their role in human life. This topic has been selected because it is the one of the key issue that students must master in the Department of Biotechnology. The study used a team-based approach to teaching called the Jigsaw method [11]. The participants were divided into teams using the "Mosaic" method [12].

2.3 Data collection tools

Questionnaire surveys are widely utilized for gathering data in academic or marketing research across diverse fields. This article employs online questionnaire surveys conducted via Google Forms, distributed to participants via email and WhatsApp, with subsequent analysis of the responses.

2.4. Data evaluation and statistical analysis

Pre- and post-class participants were asked to take a Google form test consisting of 12 questions divided into 2 parts: theoretical (6 questions) and practical questions (6 questions), with one correct answer about the methods of developing medicines of biological origin. The test was evaluated on a 6-point scale (6 = excellent, 5-4 = good, 3-2 = fair and 1 = bad). The test questions before and after the lesson were of the same content.

The cumulative scores before and after the lesson were combined and compared for effectiveness using a standard deviation and a paired sample T-test. All statistical calculations were performed manually and using the Excel program.

3 Results and Discussion

The study used a team-based approach to learning called the Jigsaw method [13]. In order to form 4 groups, the "Mosaic" division method was used [12]. The essence of which is that the teacher needs to prepare an image or text in parts in advance (in our case, the image of DNA, microscope, virus and butterfly was divided into 4 parts) and distribute it to all students. The goal of the students is to find the right part of the image among the rest of the students. In the structure of this method students are members of two different groups, the 'home groups' and the 'expert groups' with 4-5 members, to work on an instructional material that has been broken down into sections. Each student from every 'home group' is assigned a portion of the material. Then the home groups' break apart, like pieces of the jigsaw puzzle, and each home team sends representatives to join with other representative's form all the other teams and form 'expert groups'. While in the expert groups the students study intensively their particular material to ensure that they understand it well and prepare it for peer tutoring. Later, each student returns to his/her respective home group where (s)he teaches his assigned material to the rest of his/her group and learns the other sub-topics from his /her peers in the group [12]. The algorithm of actions is shown in Fig.1

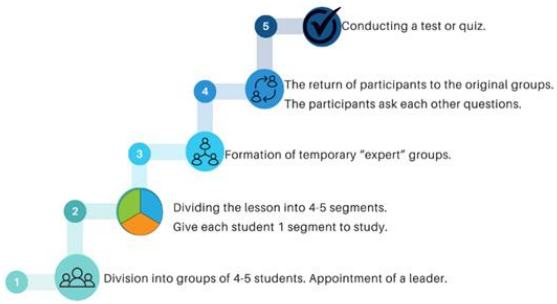

Fig.1 The algorithm of the lesson using the "Jigsaw" method.

Students were asked to take a Google test after and before class. By taking the test before class, students can assess their level of understanding of the material before studying it. This helps you understand which topics require additional attention or study. After the lesson, passing the test allows students to assess how well they have mastered the material. If they cannot answer the questions correctly, this indicates knowledge gaps and allows them to adjust their learning strategies.

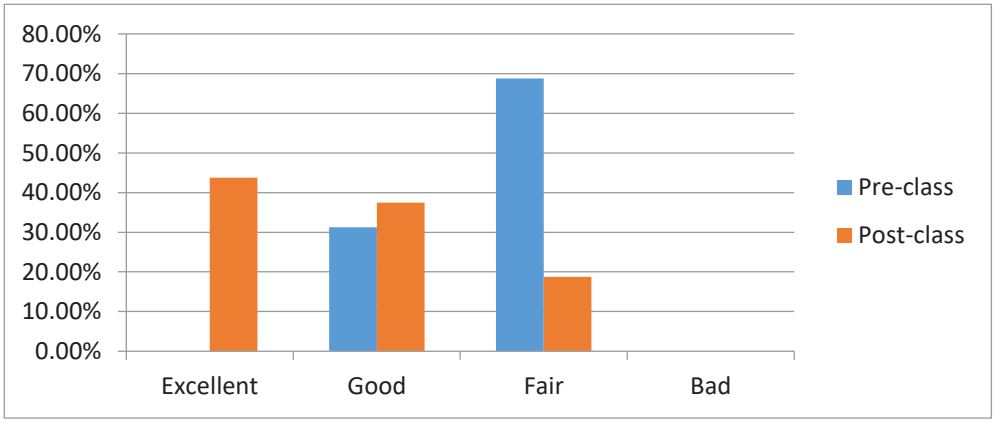

Fig.2 Percent of students with different level of scoring in theoretical issues

Figure 2 shows the percent of students with different levels of scoring in theoretical issues pre-class and post-class (6 = excellent, 5-4 = good, 3-2 = fair and 1 = bad). The percentage of students who took the test pre-class is marked in blue and the percentage of students who took the test post-class is orange.

In the "excellent" category, the percentage of students who took the test pre-class was 0% and post-class it increased to 43.75%. Before the lesson, the percentage of students who scored "good" was 31.25%, and after the lesson with the «Jigsaw» method, their percentage was 37.5%. Moreover, upon further analysis, it becomes obvious that the number of students achieving "fair" at the beginning of classes 68.75% decreased to 18.75% after the lesson. None of the students received a "bad" grade.

The average arithmetic score of students who passed the test on theoretical issues before the lesson was 3.19 points, which increased to 5.06 points after the lesson. This observed increase indicates the positive impact of the lesson on students' understanding and assimilation of theoretical material. A significant increase in the average score indicates an effective and successful assimilation of theoretical material, which confirms the success of practical training using the «Jigsaw» method in preparing students for theoretical issues.

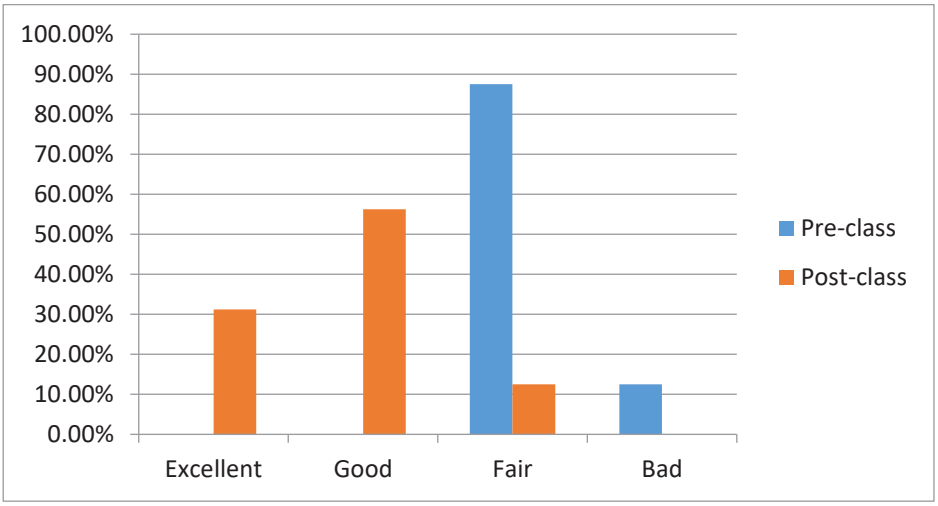

Fig.3 Percent of students with different level of scoring in practical issues.

Figure 3 presents the percent of students with different levels of scoring in theoretical issues pre-class and post-class (6 = excellent, 5-4 = good, 3-2 = fair and 1 = bad). The percentage of students who took the test pre-class is marked in blue and the percentage of students who took the test post-class is orange.

The percentage of students who took the practical questions test before class and scored "excellent" increased from 0% to 31.25%, "good" from 0% to 56.25%. If we consider in detail, the percentage of students who scored "fair" at the beginning of the lesson decreased from 87.5% to 12.5% after the lesson. It should also be noted that the percentage of students who scored "bad" before class decreased from 12.5% to 0%.

Based on the data, the «Jigsaw» practical training method proved to be effective. There has been a significant increase in the percentage of students who received high grades ("excellent" and "good"), as well as a significant decrease in the proportion of students who received low grades ("fair" and "bad"). The percentages of students receiving high grades increased by 43.75% (excellent) and 6.25% (good), while the percentage of low grades decreased by 50% (fair) and 12.5% (bad).

In addition, after using the «Jigsaw» method in the classroom, there was a significant increase in the average arithmetic score of students from 2.19 to 4.88 points, which indicates its effectiveness in deepening the assimilation of practical material.

To assess the effectiveness of the test passed by the students, a total score was collected, after which a standard deviation was applied. The standard deviations for both data sets before and after the lesson are ± 1.41 for theoretical issues and ± 1.296 for practical issues. The analysis shows that after the lesson, the average scores of students increased significantly, and the standard deviation decreased, which indicates an increase in the uniformity of results. Practical issues howed higher scores both before and after the lesson, which may indicate their simpler nature or better assimilation of the material.

Additionally, a comparative analysis of the results before and after the session was conducted using a paired sample T-test. For theoretical issues: T-statistical value: 14.478, P-value: < 0.001,and for practical issues: T-statistical value: 19.104, P-value: < 0.001

In both cases, the p values are significantly lower than the selected significance level, which indicates a statistically significant difference between the results pre-class and post-class, both according to both theoretical and practical issues. This means that, on both theoretical and practical issues, the lesson had a positive impact on students' academic performance, leading to a statistically significant increase in their average scores.

In this study, we examined the efficiency of practical training utilizing the Jigsaw method. Contrary to traditional methods, employing the Jigsaw method in practical training for students of biological disciplines has demonstrated effectiveness. Upon comparing overall test scores, we observed improvements among students following instruction with the Jigsaw method, underscoring its efficacy as a teaching approach.

Drawing upon empirical research and theoretical foundations, this article seeks to investigate the impact of collaborative learning methods on student learning outcomes within the realm of biology. Through data analysis and synthesis of pertinent research findings, our aim is to elucidate the strengths, limitations, and potential applications of collaborative approaches in biology education.

The utilization of group methods, specifically the Jigsaw method chosen for our study, yields positive outcomes in addressing problems with non-uniform solutions. Beyond completing educational tasks, employing such group methods in teaching provides students with opportunities to cultivate their psychological skills through collaborative work and interpersonal interaction.

4 Conclusion

In conclusion, this study underscores the effectiveness of practice teaching methods within a collective learning environment, particularly in the context of biotechnology education. The utilization of experiential learning, facilitated by the Jigsaw group teaching method, proved highly beneficial in enhancing students' theoretical understanding, practical skills, and group interaction. Notably, significant improvements were observed in both theoretical knowledge and practical competencies among first-year students specializing in biotechnology. The findings highlight the importance of active student engagement and a supportive classroom atmosphere in facilitating effective learning experiences. The research

is aimed at identifying how the chosen method has the most positive impact on the process of acquiring knowledge and skills among students in this field. With empirical evidence supporting the efficacy of collaborative, experiential learning approaches, educators can consider integrating such methods into biology education curricula, thereby fostering comprehensive skill development and preparing students for success in the field of biotechnology.

In addition, we have identified the potential for further improvement of this method and its application in various scientific and practical tasks. Thus, the study of the effectiveness of practical biology methods in the Jigsaw method has demonstrated its value and prospects in the modern scientific world.

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