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Research Insights
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INTEGRATING COOPERATIVE LEARNING IN DISTANCE EDUCATION FOR METHODOLOGY OF TEACHING MATHEMATICS COURSE

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Abstract. Lesson planning and the development of pedagogical documentation constitute integral components of educators' responsibilities in the Republic of Serbia. Within the framework of the "Methodology of Teaching Mathematics" course, future mathematics teachers address these aspects, particularly by formulating daily lesson plans for mathematics classes in primary and high school education. Considering the proven benefits of cooperative learning in enhancing student achievements and fostering their social skills, and mindful of the disruptions caused by the COVID-19 pandemic to the delivery of the "Methodology of Teaching Mathematics" course due to the shift to distance education (which posed challenges due to the absence of direct collaboration during classes), a novel instructional approach that involves the integration of cooperative learning strategies was adopted. Through a qualitative analysis of written lesson plans produced by students who completed assignments related to lesson planning during and after engaging in cooperative learning within the context of distance education, it was evident that these students significantly outperformed their peers who worked independently.

Keywords: cooperative learning; distance learning; lesson plans; methodology of teaching mathematics

Introduction

In the Serbian educational system, teachers are required to create lesson plans for each class they teach. In addition to the overarching curriculum, which encompasses the planning of teaching and learning throughout the entire school year, and operational plans, which involve planning lessons for a specific topic or subtopic during the school year, teachers in the Republic of Serbia must document their lesson planning for every individual class they conduct. While there is no standardized template for writing daily lesson plans, as it is a document for personal use by the teacher, these plans generally follow a specific format. This format includes relevant instructional content, planned articulation of the class, anticipated

teacher and student activities, as well as information on the class's objective, planned teaching and learning outcomes, teaching methods and instructional formats used, observed intradisciplinary and interdisciplinary connections in the instructional content, the development of students' interdisciplinary competencies during the class, and the use of instructional materials and literature. Additionally, teachers often articulate in their lesson plans how students, by acquiring knowledge and skills in each class, will be able to partially fulfill certain wider educational achievement standards at the end of a given period of education (at the end of primary or high school).

Within the course "The Methodology of Teaching Mathematics" in the third year of the mathematics teacher module of undergraduate mathematics studies, students are theoretically and practically introduced to all aspects of lesson planning. This, of course, presupposes a prior understanding of all general components of written lesson plans (class objectives, outcomes, educational standards, methods and forms of work, connections between instructional content, etc.).

Given that the implementation of this course was particularly challenging during the COVID-19 pandemic and having in mind that cooperative learning generally results in enhanced academic performance when compared to individual learning settings, particularly within the university context (Johnson & Johnson, 2002), a new working methodology within the subject "The Methodology of Teaching Mathematics" was devised, focusing specifically on integrating cooperative learning in distance education.

Theoretical background

Cooperative learning refers to a learning approach in which students are organized into small groups to elevate cognitive learning through social interactions, requiring each group member to achieve common goals through equivalent cooperative efforts (Yang et al. 1997, 2009). When organizing cooperative functioning, students should be guided by the idea: Be respectful and open to others, be willing to encourage, share, and assist each other, but also to question the views of others and resolve conflicts when they arise (Slavin 1996). "Maximizing students' cognitive learning through social interactions" distinguishes cooperative learning from other theories in terms of expected learning outcomes. Instead of emphasizing the importance of acquiring specific and relevant skills (e.g., mathematical, computer science, engineering), with cooperative learning focus is on improving general cognitive competence and students' social interactions (Oxford, 1997; Johnson et al. 2014; Falentina et al. 2022). Students should achieve a higher level of cognitive learning through frequent mutual communication within a cooperative learning framework. The definition of cooperative learning reveals three fundamental requirements. The first of them state that students must be organized into small groups. Oxford (1997) suggested that the size of a cooperative learning group should be less than seven.

Additionally, Luo et al. (2023) argue that an ideal small group should consist of two to five members and Johnson, Johnson, and Holubec (2020) recommend groups of two or three students. The second requirement is that students in a group should share common goals. These common goals should be tangible units, objects, and final products (Johnson et al. 2014). The third requirement indicate that efforts invested in cooperation by group members should be equal and that group members should be assigned similar tasks to achieve common goals (Damon & Phelps 1989).

All cooperative learning (formal, informal) is characterized by five basic elements: Positive Interdependence; Individual Accountability; Promotive (Face-To-Face) Interaction; Interpersonal and Small Group Skills; Group Processing (Johnson & Johnson, 1998). When it comes to *positive interdependence*, group members should perceive that they need each other to complete the group's tasks. One way to achieve this is by creating positive interdependence through setting mutual goals (maximizing one's and others' productivity), providing joint rewards, and assigning roles by the instructor. Through those activities, group accountability is created. Positive interdependence refers to a situation in which all members of a group rely on resources provided by other group members to achieve expected learning outcomes (Johnson et al. 2009). *Individual accountability* involves assessing the quality and quantity of each member's contributions and providing results to the group and individuals. Individual accountability means that everyone's performance should be visible to all the group members so that every team member can realize their responsibilities in the group. When an individual realizes that their performance is visible to the entire group, they become self-regulated in fulfilling their responsibilities in group work (Silalahi & Hutauruk 2020). Individual accountability can be affirmed when the performance of a team member is assessed or documented, and the results of this assessment are made available to both the individual and the entire group. *Promotive (face-to-face) interaction* implies that group members enhance each other's productivity by helping, sharing, and encouraging efforts to produce. Promotive interaction occurs when students are inspired to engage in meaningful conversations and expand upon their discussions (Hooper 1992). Within groups, members elucidate, discuss, and impart their knowledge to one another. Instructors organize groups in a way that encourages members to deliberate on every aspect of the task they are collaborating on.

Cooperative skills include leadership, decision-making, building trust, communication, and conflict management skills. Groups can't function effectively if members do not have and use necessary social skills. Possessing these social skills enables students to enhance meaningful interactions in group work (Johnson et al. 2009). During cooperative learning process, teachers emphasize to students that they should work on these skills to contribute to the development of *interpersonal and small group* dynamics. Moreover, the appropriate use of social skills participates in building social relationships and strengthens positive interdependence among group members (Putnam et al. 1989). Numerous social

skills have been identified and evaluated, including tasks like issuing reminders to group members (leadership), asking follow-up questions (communication), sharing personal experiences (trust-building), engaging in negotiations until consensus is reached among all group members (decision-making), and addressing conflicts as mutual issues (conflict management) (Johnson et al. 2009). *Group processing* refers to the need for groups to have specific time to discuss how well they are achieving their goals and maintaining effective working relationships among members. Within group processing each group is reflecting on their teamwork process to determine what member actions are kept, adjusted, or avoided. It can also prompt group members who infrequently participate in group work to recognize the significance of their involvement in cooperation, leading them to become more proactive in subsequent cooperation rounds (Bachtold et al. 2023). Consequently, when group processing is inclusive of all members, there is enhanced unity, optimizing their social relationships. This cooperative state may persist even after the instructional period concludes (Putnam et al. 1989).

Incorporating peer interaction into distance education poses a challenge for teachers. According to Cox and Cox (2008), integrating the elements of cooperative learning in distance learning is effective, for instance, through structured synchronous and asynchronous group discussions to achieve positive interdependence, individual accountability, and group processing, while online meetings and chats represent the ways to promote students' interaction and social skills.

Recommendations of heterogeneous grouping offer a number of advantages: higher achievers learn by teaching their lower achieving peers, as long as their teaching focuses on explaining, rather than just supplying simple answers; by learning in heterogenous groups, students can learn about people different from themselves, and learn to cooperate with them; preparing students to cope with an increasingly heterogenous world, those who have more (when it comes to knowledge, skills, or financial) resources should be willing to share (Webb et al. 2009).

When we focus on the influence of cooperative learning on students' achievements, there are results indicating that students who achieved their knowledge in online cooperative learning environment outperformed students with general cooperative learning on learning achievement (Kurilovas and Kubilinskiene 2020). Also, when it comes to the influence of online cooperative learning on learning satisfaction the results of the research conducted by Wang & Wu (2022) showed significantly positive correlations between online cooperative learning and learning satisfaction.

Methodology

The Methodology of Teaching Mathematics in 2020 was conducted online due to the impossibility of holding in-person classes caused by the COVID-19 pandemic. In this setup, students received materials to study every week, followed

by consultations with the teacher via Google Meet meetings to clarify any uncertainties. Each student, future mathematics teacher had an assignment regarding independently writing a lesson plan for an assigned teaching unit in elementary school and one lesson plan for a teaching unit in high school. The deadline for each lesson plan was one month from the day of assigning the teaching unit, and students could use all available literature.

In 2021, the course Methodology of Teaching Mathematics was again conducted online, with lectures and exercises held through MS Teams meetings. Students were assigned to write lesson plans for designated teaching units, but for elementary school lesson plans, they cooperated in groups, creating one lesson plan for the class of introducing new mathematical contents and one for practical classes. High school lesson plans were done individually, creating only one lesson plan for the class of introducing new mathematical contents, as in the previous year. Students working on elementary school lesson plans were divided into 7 groups of three and one group of two students. Students were divided according to Kagan's instructions regarding group heterogeneity, ranking them based on their activities and performance during theoretical and practical classes within the Methodology of teaching mathematics up to that point before grouping (Kagan 1994). In each group, one student from the top, one from the middle third, and one from the bottom third of the rank list participated. Additionally, a survey was conducted in which students listed two colleagues they would like and two they would not like to be in a group with. Students who were listed in the survey were not placed in the same group as the student who listed them, aligning with Kagan's (1994) suggestions to consider students' interpersonal relationships during group formation to avoid later cooperation difficulties. Within each group, students had different responsibilities agreed upon at the beginning of their work. To create these two lesson plans, students had 15 days. The work on creation of the lesson plans proceeded as follows. After dividing responsibilities, students worked independently on their tasks.

For easier understanding, students within one group will be referred to as Student 1, Student 2, and Student 3.

– Student 1 analyzed the curriculum and for the corresponding grade, examining the teaching unit, content, teaching and learning methods, monitoring, and evaluation in accordance with official and current state-level proposals and regulations.

– Student 2 analyzed textbooks, problem collections from different educational publishers, examined definitions, statements, proofs of statements, rules, and procedures that students should be familiar with or master.

– Student 3 also analyzed textbooks and collections of tasks from different educational publishers and considered examples and tasks to be covered or solved with students during two lessons (one lesson plan for the class of introducing new mathematical contents and one for practical class).

After 7 days of work, students met (online) without the presence of the teacher, discussed, and informed each other about their results and proposals for statements, definitions, rules, procedures, examples, and tasks that, in their opinion, should be connected into a coherent whole, in accordance with the instructions and requirements presented in the curriculum. On that occasion, students had to, through teamwork or agreement, define the structure of both lessons and define the activities of teachers and students for the two specified lessons. Then students worked independently again, each on their task.

– Student 1, based on the way the lessons would be conducted, analyzed the characteristics of different teaching methods, forms of work, recognized appropriate teaching methods and forms of work, defined the objective of the lesson, and intradisciplinary and interdisciplinary connections of teaching content.

– Student 2, based on the way the lessons would be conducted, analyzed, and determined learning outcomes, educational standards of student achievements, interdisciplinary competencies that students develop in the given lessons, indicated key concepts, and used teaching aids.

– Student 3 created the expected layout of the blackboard at the end of the lesson, indicated ways to evaluate the students' learning outcomes, and later presented the work of their group.

After 7 days, students met again (online), discussed, and acquainted themselves with the aspects of the lesson plans they analyzed and developed in the second part of the group work. Students then completed the lesson plans, which were subsequently submitted for evaluation. The pair that worked together did an appropriate redistribution of responsibilities by agreement.

This kind of methodology of cooperative learning was implemented to create and emphasize positive interdependence between students, their individual accountability, to promote students' interaction and to put them in position to develop their social skills (Johnson & Johnson, 1998).

Participants

In our research, sample consisted of 44 third year students from the Faculty of Science, University of Kragujevac, Serbia. They were divided into two groups.

Students who participated in the 2020 "The Methodology of Teaching Mathematics" course and who didn't learn within cooperative learning environment are the control group of students. In the control group there were 21 students, future mathematics teachers (16 females and 5 males). A total of 39 lesson plans were collected from the students from the control group – 20 lesson plans for teaching units for elementary school mathematics and 19 lesson plans for teaching units for high school mathematics. One student did not submit any lesson plan, while another submitted only the lesson plan for the teaching unit for elementary school.

Students who participated in the 2021 "The Methodology of Teaching Mathematics" course are the experimental group of students, and those students were organized to learn with cooperative learning approach. In the experimental group there were 23 students (19 females and 4 males). A total of 16 lesson plans for teaching units for elementary school mathematics (8 lesson plans for the class of introducing new mathematical contents and 8 for practical classes). As for high school lesson plans, students wrote them individually after group work. This way, 21 lesson plans for high school mathematics were collected.

Results

Analysis of students' lesson plans

The collected lesson plans underwent qualitative analysis to examine how students structured their lesson plans, to what extent they adhered to pedagogical guidelines, and how they integrated various elements of the curriculum. Naturally, all key segments of the lesson plans were analyzed, starting from the precise formulation ofobjective and outcomes for the given lessons, to the recognition of educational standards, interdisciplinary competencies developed in those lessons, the selection of appropriate forms of work, teaching methods and teaching aids, as well as reflections on interdisciplinary and intradisciplinary connections in the curriculum. Additionally, the identification of key details in the selection of teaching content and proposed activities for both teachers and students during the lesson was scrutinized.

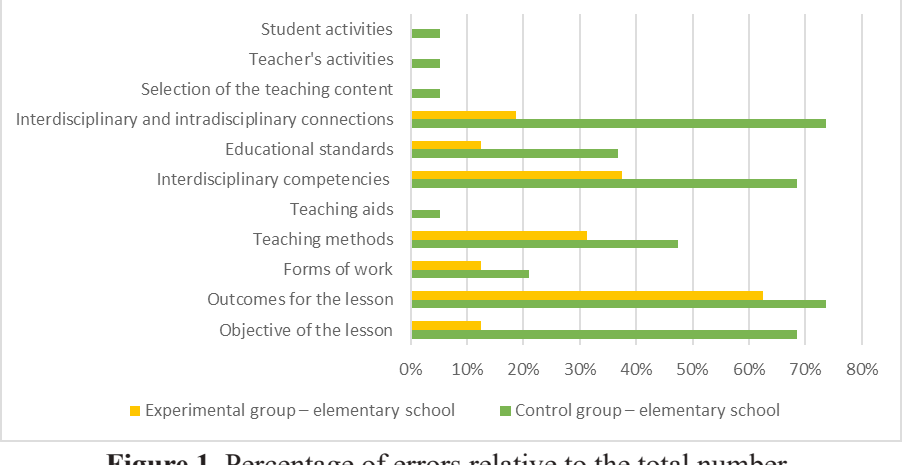

Figure 1. Percentage of errors relative to the total number of collected lesson plans for elementary school mathematics

In Figure 1, the ratio (in percentages) between the number of lesson plans with identified errors written by students who wrote those lesson plans and the total

number of submitted lesson plans is presented separately for students in the control and experimental group. When looking at the highest number of errors in both groups, the majority of errors relate to the precise definition and operationalization of learning outcomes. Considering that education in the Republic of Serbia is oriented towards outcomes rather than content, which is heavily emphasized at various levels, we were particularly rigorous in analyzing the lesson plans. Specifically, the use of verbs or stating unmeasurable student abilities was not allowed; it was necessary to break down outcomes into smaller components and grade them according to the levels of standards, from basic to advanced levels. Students in the experimental group showed better skills compared to students in the control group in defining outcomes by over 10%. On the other hand, concerning the definition of lesson objectives, which is also crucial to do accurately, students who cooperatively created lesson plans during distance learning showed significantly better results (errors were observed on average in every eighth submitted lesson plan in the experimental group, while students who created them independently had inaccuracies and deficiencies in over two-thirds of the submitted lesson plans). The next most significant difference in errors identified was planning lessons to encourage intradisciplinary and interdisciplinary connections and their recognizing (less than 20% of lesson plans in the experimental group compared to 73% in the control group). Figure 1 also shows significant differences in the analysis of lesson plans regarding educational standards for the end of elementary education prescribed by appropriate regulations, as well as in recognizing and planning lessons to develop students' interdisciplinary competencies, also prescribed by appropriate regulations. A small number of deficiencies were observed in the lesson plans of the control group concerning the selection of teaching content, planning teacher and student activities, as well as in the selection of teaching aids while there were no such shortcomings in the experimental group lesson plans.

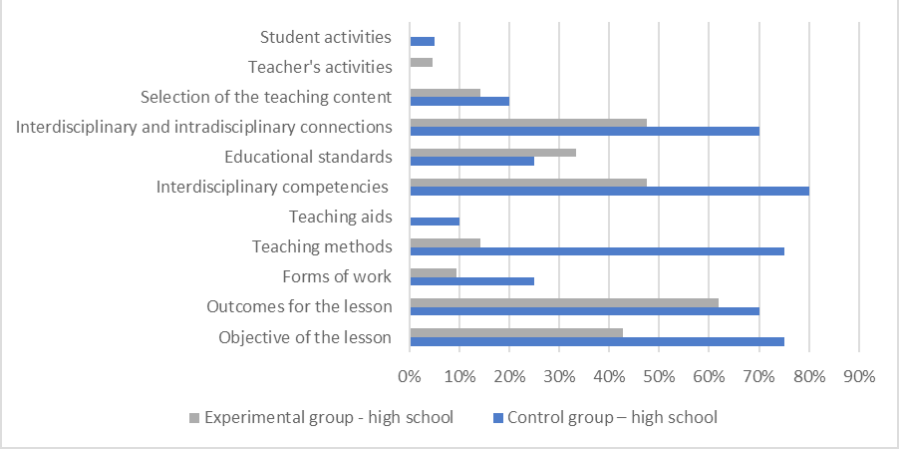

Figure 2. Percentage of errors relative to the total number of collected lesson plans for high school mathematics

As mentioned earlier, lesson plans for high school mathematics classes in both groups were created independently (after the creating lesson plans for elementary schools), specifically for mathematics classes introducing students to new concepts, assertions, and rules. Despite their independent creation, we analyzed them to determine whether cooperative work among students influenced their understanding and conception of various segments of lesson plans. What is evident from Figure 2 is that the ratio of errors in the two groups in defining the outcomes of teaching and learning in lesson plans corresponds to the ratio of these errors observed in lesson plans for elementary school. Regarding the precise definition of lesson objectives, errors were observed in almost twice as many lesson plans in the control group compared to the experimental group. Like the lesson plans for elementary school, students in the experimental group significantly better selected examples and tasks promoting intradisciplinary and interdisciplinary connections in their lesson plans, as well as the development of students' interdisciplinary competencies. Interestingly, students in the experimental group also significantly better planned and recognized the use of teaching methods (14% contrary to 75% of shortcomings) and forms of work (9% contrary to 25% of shortcomings) in lesson plans for high school compared to elementary school. In contrast to the control group, where errors were noted in the choice of teaching aids and planning student activities in several lesson plans, no such errors were observed in any lesson plans for high school by students in the experimental group. It is noteworthy that errors in planning teacher activities were not observed in the works of students in the control group, while in one lesson plan of the experimental group, this was described in an unacceptable manner. Also, students from the control group outperformed their peers from experimental

group in recognizing and citing educational standards for high school mathematics education. Generally, based on the number of mistakes and shortcomings made by students, even though they created lesson plans independently, the experimental group students showed a greater mastery in creating lesson plans for high school mathematics classes compared to control group students.

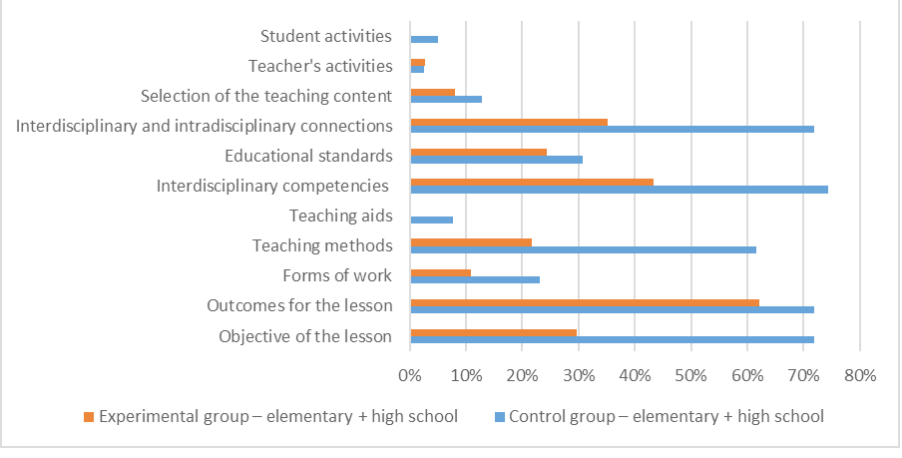

Figure 3. Percentage of errors relative to the total number of collected lesson plans for both groups of students

Overall, by comparing the ratio of the number of lesson plans with identified deficiencies and errors to the total number of lesson plans created by students in the experimental and control groups, at both the elementary and high school levels, it is clear from Figure 3 that students in the experimental group wrote higher-quality lesson plans. Specifically, out of the 11 observed categories, students in the experimental group outperformed their peers in the control group in as many as 10 categories. The only category where there were no differences in errors between students in the control and the experimental groups was the planned activities of the teacher. A minor difference in the ratio of the number of errors to the number of lesson plans was present in the selection of mathematical content, recognition of educational achievement standards, and the definition of teaching and learning outcomes, in favor of students in the experimental group. Interestingly, in the planning of student activities and the selection of teaching aids, where a small number of students in the control group made mistakes, no such mistakes were observed in the lesson plans of students in the experimental group. The most significant differences in the ratio of errors to the number of lesson plans (expressed in percentages), were noticed in the analysis of intradisciplinary and interdisciplinary connections of teaching content, in the recognition and planning of the development of students'

interdisciplinary competencies, the selection and recognition of teaching methods and forms of work, while the greatest difference (up to 43%) was recorded in the precise formulation of the objective of the mathematics lesson, all of them in favor of students in the experimental group.

Students' impressions regarding distance cooperative work

After submitting their lesson plans, students were instructed to give essay answers about their impressions of the way they worked; whether they were satisfied with working with their peers; and to identify the strengths and weaknesses during cooperative work.

In general, students expressed a high level of satisfaction with this organized way of working. Their views on the organization of work are represented by the following statements.

I am very pleased with my group, their engagement, work, and the effort of my colleagues. Despite my initial concerns, I can now confidently say that all three of us gave our best (Student E3).

The cooperation was excellent, and I am satisfied with our work. This was a positive experience (Student E7).

I admit that I am generally not a fan of group work, so I was a bit sceptic about the entire project at the beginning. However, I must emphasize that, in the end, everything turned out better than I expected it to be. I particularly liked that each had the opportunity to express their opinion and stance, yet we managed to find common ground and complete the lesson plans in a way that left everyone satisfied with the result. Our communication took the form of discussions, agreements, and compromises (Student E11).

If there were any differences between the three of us, they were when composing the text for the lesson plan. Cooperative work was productive. (Student E13).

Students also wrote, in their brief reflections on group work, about the significance of cooperative work in the context of further learning and future professional work in school, both in terms of achievements and the development of their social skills.

Our future profession will require us to be collegial and capable of adapting to team working conditions, making such tasks useful for our development in that regard. Cooperation allows each of us to contribute our maximum (Student E4).

I believe that this type of work is very beneficial for us, not only for learning how to prepare for lessons but also for getting accustomed to working in a group (Student E12).

This working method encourages us to exchange various experiences and information, which I find very beneficial as there is a lot to learn through this process (Student E14).

The positive aspects are certainly listening to and accepting different opinions than our own, socializing, and improving our knowledge (Student E18).

When it comes to the way groups were formed, some students believed that it was good to step out of their comfort zones and work with students they don't usually spend much time with, people who have different perspectives regarding the learning topic and with who they don't often cooperate with.

As an advantage of such work, I would highlight the opportunity to connect with individuals with whom we are not typically close and the chance to cooperate with people who have a different way of thinking and perspective on things (Student E21).

On the other hand, two students were not favorable towards the methodology of dividing students into groups.

I think students would be happier if they could choose group members themselves (Student E16).

The drawbacks of such an approach to work were that, up to that point, students were mostly not accustomed to working in an online environment.

The negative aspects are that the current situation requires this type of work to be online. I believe it would have been more interesting and there would have been a more productive atmosphere if it were done in person (Student E2).

Additionally, in three responses, the characteristics of students were recognized that they are more individualists than team players.

What I didn't like about group work is that we had to coordinate responsibilities with other members, whereas in individual work, this is not the case (Student E22).

Conclusions and summary

Based on the qualitative analysis of written lesson plans by third-year mathematics students, future mathematics teachers, several aspects related to the outcomes of cooperative learning implementation in line with the concept proposed by Johnson & Johnson (characterized by positive interdependence, individual accountability, promotive interaction, interpersonal and small group skills, and group processing) (Johnson & Johnson, 1998) can be observed. Firstly, it is noticeable that students in the experimental group, who created lesson plans through cooperative work in an online environment within the framework of mathematics teaching planning, significantly outperformed their peers who created works independently. Based on Figure 1, when creating these lesson plans for primary school, they made significantly fewer mistakes in various segments evaluated during the analysis of these written lesson plans. On the other hand, the cooperative work of students positively influenced the acquisition and development of their competencies to plan high school mathematics teaching and independently create lesson plans for this purpose. Indeed, by analyzing Figure 2, we concluded that students in the experimental group largely outperformed their peers in various aspects of writing lesson plans for high school mathematics, following different aspects that teachers consider during lesson planning. Overall, based on all three graphs (Figure 1, 2, 3)

showing the frequencies of students' errors and mistakes, the students in the experimental group demonstrated a significantly higher level of theoretical and practical knowledge in the "Methodology of Teaching Mathematics" course compared to their peers in the control group. Additionally, their experiences with cooperative learning are genuinely positive. Based on their responses after completing lesson plans for primary and high school, it can be concluded that such experience was beneficial for them, both in terms of gaining knowledge and skills in lesson planning and all its aspects, as well as in acquiring social skills. Therefore, having in mind on all the obtained results, it can be concluded that cooperative learning in an online environment should be given more attention during the implementation of courses related to the acquisition of methodological knowledge and competences for students, future mathematics teachers.

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