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Effects of introducing the cooperative learning approach in Kosovo's secondary school physics

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Abstract

Kosovo ranks among the lowest in PISA science assessments. This may be due to the dominance of frontal work (FW) in secondary school science subjects, which leads to low student interest in these subjects. The cooperative learning (CL) approach, however, is a widely recognized pedagogical method that fosters engagement and enhances learning. This study aimed to examine the effects of CL on secondary school students' achievements in physics lessons, particularly in thermodynamics. Key factors such as interest, social skills, and logical thinking were considered in understanding students' achievements. A quasi-experimental pre-post design was employed, with data collected through paper-and-pencil tests assessing knowledge and logical thinking, as well as questionnaires on student interest and social skills. The study included 135 15-year-old students, divided into two groups: experimental (CL) and control (FW). The results revealed that the CL group significantly outperformed the FW group on the knowledge test, with notable improvements in students' interest in physics and social skills. The study suggests that physics teachers adopt CL strategies to achieve multiple educational objectives.

Keywords: cooperative learning, physics education, secondary school, social skills, student achievements, student interest

INTRODUCTION

In physics lessons, students deepen their understanding of the subject while developing key skills. It is the teacher's responsibility to create a learning environment that maximizes this process. Teachers must carefully select teaching strategies that influence student performance, interest in physics, and the development of other skills. Frontal work (FW) is often chosen for various reasons, particularly time constraints (Fischer & Kauertz, 2022). In FW, the teacher addresses the entire class, and content delivery through presentations and explanations is typically more time-efficient than individual or group work (Hassidov, 2019). However, studies have shown that students' low performance in FW may contribute to poor results in physics (Eshetu et al., 2017). Consequently, teachers should strive to identify and implement effective teaching methods that enhance student learning and help achieve learning objectives. Understanding motivational strategies is crucial for engaging students and fostering interest in physics lessons (Astalini, 2021; Jugović, 2017; Meulenbroeks et al., 2024).

Student performance is shaped by various educational experiences, which influence achievement through both quality and quantity (Ugwuanyi et al., 2020). To overcome learning barriers, selecting appropriate teaching strategies is crucial. Cooperative learning (CL) is widely recognized as an effective approach (Li et al., 2024). Despite its long history, CL remains underutilized in Kosovo's education system (Beka, 2014).

CL involves small groups where students collaborate to enhance both their own and their peers' learning (Bilgin, 2006; Estébanez, 2017; Johnson & Johnson, 1993). It encourages students to discuss concepts, write about them, connect learning to personal experiences, and apply knowledge in real-life contexts (Eshetu et al., 2017). Additionally, CL fosters teamwork by requiring students to work toward shared goals or complete group tasks beyond individual capabilities (Gillies, 2016; Lestari et al., 2019). Students are also responsible for

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Contribution to the literature

- This research contributes to the literature by providing context-specific evidence on the effectiveness of CL strategies in Kosovo's secondary school physics education.
- The study examines CL's effects on academic achievement, social skills, and student interest following 20 hours of thermodynamics instruction, building on previous studies to show how CL fosters not only knowledge gain but also increased interest and improved social skills.
- The findings suggest changes in teaching practices in contexts where traditional methods dominate, indirectly encouraging teachers to empower themselves with CL knowledge through examples of good practice.

ensuring their peers' success within the group (Zarei & Layeq, 2016).

CL has been integrated into science education, with Coca (2013) noting that 14- and 15-year-old students must learn compulsory physics and chemistry, covering concepts like density, pressure, and temperature. Studies show that CL, combined with technology, improves understanding of thermodynamics more than traditional methods. CL students perform better on final knowledge tests, regardless of assessment type. A study on 8th-grade science education found that CL, when paired with hands-on activities, significantly improved science process skills compared to teacher demonstrations (Blajvaz et al., 2022). This highlights CL's role in enhancing engagement and skill development, reinforcing its value as a pedagogical strategy.

Forming small groups in CL promotes socialization and enhances learning across subjects from preschool to secondary school (Shaby et al., 2024). Research shows that CL benefits all curricular areas, grade levels, and student types, including those with special educational needs, gifted students, and those from diverse backgrounds (Kagan, 1999; Kibirige & Lehong, 2016; Kilpeläinen-Pettersson et al., 2025; Sharan, 2002). Key components for successful CL include face-to-face interaction, positive interdependence, individual accountability, group assessments, and social skills (Altun, 2015; Yavuz & Arslan, 2018). Aryanti and Widodo (2020) demonstrated that CL enhances students' social skills in science classes, while Raviv et al. (2019) encouraged science teachers to implement CL in laboratories. A meta-analysis by Johnson et al. (1981) of 122 studies found that CL leads to higher achievement compared to competitive or individualistic learning. CL encourages students to value others' perspectives, engage in discussions, develop stronger social skills, and foster higher expectations of collaboration.

Common CL strategies include think-pair-share, jigsaw, and team-based learning (Macpherson, 2015). Here are brief descriptions of the CL strategies used. Team-based learning is a strategy that promotes CL through structured small-group activities, fostering active engagement and accountability among students (Burgess & Matar, 2020). The jigsaw technique involves students becoming experts on specific topics and teaching them to their peers, enhancing individual mastery and group collaboration (Blajvaz et al., 2022; Karacop, 2017). Think-pair-share is a simple yet effective strategy where students reflect on a concept, discuss it with a partner, and then share their ideas with the class, promoting knowledge sharing and teamwork (Astalini, 2021). Recent research by Blajvaz et al. (2022) demonstrated that using the jigsaw technique in physics lessons significantly improved students' physics skills, metacognitive awareness, and interest, recommending its regular use in classroom practice.

Altun (2015) discusses the pros and cons of CL, highlighting the importance of collaboration. Students noted that while working with the same peers, they hadn't interacted before. Motivating weaker peers and addressing individual weaknesses were seen as essential for team success. The need for diverse abilities and a shared goal was emphasized, where individual achievements affected overall success. Effective communication and subject proficiency were key, and even one struggling student could negatively impact the team, creating undue pressure.

Cámara-Zapata and Morales (2020) found that student persistence in physics was influenced by CL, prior learning, and community size. In this approach, teachers guide students to resources while students take ownership of their learning, promoting constructivism and ensuring all students reach the appropriate learning level. CL also helps students develop collaboration skills, enhancing engagement, critical thinking, and teamwork, making it an effective strategy for improving learning outcomes (Yuliani, 2021).

Academic achievement is influenced by a student's formal reasoning abilities, which involve unique information-processing skills that enhance their capacity to engage with material. Research suggests that cognitive skills, along with individual, social, and family factors, play a role in predicting academic performance and warrant further exploration (Devetak & Glažar, 2010; Johnson & Smith, 2020; Kibirige & Lehong, 2016; Valanides, 1997). Taber (2014) notes that even students with well-developed formal reasoning skills may struggle with science concepts if their situational interest is low. However, CL and activities that emphasize social skills can transform passive students into active participants. An interactive classroom environment encourages students to engage more actively with the material (Rizkia et al., 2021). Lavonen et al. (2021) has found that secondary students' situational interest in physics was positively affected by science activities that included presenting research questions, constructing inquiries, and interpreting data. CL situations sparked curiosity, and students' personal interest in science emerged as a key predictor of their situational interest in the subject.

In 2015, Kosovo ranked third from the last among 72 countries that participated in the PISA science assessments, and the situation remained similar in 2018. By 2022, Kosovo continued to face significant challenges, ranking 77th out of 80 countries in science (OECD, 2023). This can largely be attributed to the traditional education system, which predominantly relies on teacher-centered learning and rote memorization. Traditional classrooms often viewed as ceremonial spaces, had students sitting in rows like spectators while the teacher led instruction from the front (Karanezi, 2014). Additionally, the school system struggles with limited professional and financial resources, which may also contribute to low motivation in science and hinder career aspirations (Zhai & Liu, 2024).

A major challenge in secondary school physics education is a lack of enthusiasm and poor social skills, creating difficulties for teachers (Nugroho, 2020). Research suggests that CL and technology use have facilitated learning, particularly in basic thermodynamics concepts, more effectively than traditional methods (Coca, 2013). In addition to academic achievement, CL also fosters interest and social skills, which are crucial for students' future success (Manolas & Leal Filho, 2011; Zhou et al., 2024).

CL is a widely employed strategy in primary and lower secondary education, but its use in upper secondary schools is limited due to large class sizes and time constraints (Beka, 2014; Blajvaz et al., 2022; Coca, 2013). The authors recommend implementing CL through structured group work that promotes student collaboration, shared responsibility, and active engagement. They suggest organizing students into small groups to discuss, solve, and present tasks, emphasizing the importance of peer interaction in enhancing understanding and learning outcomes.

The literature also lacks studies on the impact of CL on interest in physics lessons. This research aims to address this gap in both literature and practice, especially in countries like Kosovo, where CL is largely absent from the education system. There is also a lack of scientific research on CL in primary, secondary, and higher education institutions in Kosovo (Beka, 2014).

In Kosovo, non-compulsory secondary education begins at age 15 and is divided into general and vocational education tracks, with upper secondary education lasting three years. During this period, students at gymnasiums and vocational schools prepare for the state baccalaureate exam (Pupovci, 2019). The Kosovo curriculum framework adopts a competence-based approach to cater to diverse learner needs. This framework aims to shift from content-based to outcome-focused teaching methods that prioritize student competencies, including knowledge, skills, values, attitudes, and emotional development (Berisha, 2020; Ministry of Education Science and Technology [MEST], 2016; Pupovci, 2019).

All of this highlights the need to design and conduct research on CL not only to enhance student achievement but also to foster interest in physics and develop social skills, even in less supportive environments.

The main research questions for this study were as follows:

RQ1. Is there a significant difference in knowledge gain between students taught using CL (experimental group) and those taught using FW (control group)?

RQ2. Does interest in physics differ significantly between the experimental and control groups?

RQ3. Is there a notable change in the experimental group's self-assessment of social skills before and after physics lessons?

MATERIALS AND METHODS

The study sought to evaluate the impact of CL on secondary school students' academic achievement, interest in physics, and social skills. This research was conducted using a quasi-experimental method (Furtak et al., 2012; Olabiyi & Awofala, 2019). The research design approach was quantitative.

Sample

The research was conducted using a non-randomized purposive sample. The students were 15 years old and attended mixed-gender classrooms. The study involved 135 10^{th} grade students at a vocational secondary school in Kosovo. In vocational secondary schools, 10^{th} grade students have two physics lessons per week. Following the guidelines for a two-group quasi-experimental design, the minimum required sample size was calculated to ensure sufficient statistical power. For instance, Cohen (1992, p. 158) provides sample size recommendations based on effect sizes and statistical tests; for a medium effect size (d = .5), approximately 64 participants per group are needed to achieve 80% power at the .05 significance level (two-tailed test). Accordingly, a total sample size of 135 participants is considered adequate for conducting a meaningful statistical analysis.

Of the participants, 66 (48.9%) were in the control group, and 69 (51.1%) were in the experimental group. The sample included 59 (44%) female and 76 (56%) male students. The experimental group (CL) consists of 41 males (53.9%) and 25 females (42.4%), while the control group (FW) includes 35 males (46.1%) and 34 females (57.6%). Although there are slightly more males in the experimental group and more females in the control group, the overall gender distribution is fairly balanced. This similarity is sufficient to minimize any gender-related bias in the group comparisons.

In line with the quasi-experimental design, a non-random, purposive selection method was employed, and participants were assigned to the experimental and control groups based on existing class divisions. Both groups were equivalent in terms of grade level, subject matter, and weekly instructional hours.

To preserve anonymity, each student was given a code consisting of the letter "S" and a number (e.g., S1). All data were collected in Albanian. Students participated voluntarily and had the right to withdraw at any time. Participants were thoroughly familiarized with the study's content; anonymity, confidentiality, and data protection were guaranteed. Students were informed that the collected data would be used exclusively for research purposes. The basic principles of the code of ethics for research in the social sciences were observed at all stages of the study.

Instrument and Procedures

To assess students' individual characteristics, tests and questionnaires were used, including a knowledge test on learning content, a questionnaire on interest in physics and social skills, and the test of logical thinking (TOLT) (Lee & Sulejman, 2018; MEST, 2019; Tobin & Capie, 1984; Uslu & Salih, 2021). The physics interest and social skills questionnaires relied on self-evaluation using a five-point Likert scale, while the knowledge test and TOLT provided objective scores based on classical paper-and-pencil formats.

Knowledge data were collected using 20 tasks, with a maximum score of 40 points. The tasks aligned with the curriculum's learning objectives (MEST, 2016). The number of thermodynamics-related tasks varied based on curricular goals and content difficulty.

The TOLT is a 10-item group test with a maximum score of 10 points. It assesses five forms of reasoning: controlling variables, proportional, probabilistic, correlational, and combinatorial reasoning. The test was translated into Albanian (Tobin & Capie, 1984) and administered in a paper-and-pencil format.

To assess students' interest in physics, an adapted version of a paper-and-pencil self-assessment questionnaire was used (Lee & Sulejman, 2018). Participants rated ten items on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Table 1. Cronbach's alpha coefficients for the research instruments

Instruments	Pre-intervention	Post-intervention	N
Physics knowledge test	.632	.882	20
Interest on physics	.751	.840	10
Social skills	.755	.925	20
TOLT	.624	-	10

Note. N: Number of items

Additionally, a 20-item questionnaire was customized to evaluate social skills (Uslu & Salih, 2021), using the same five-point Likert scale.

Cronbach's alpha coefficients in **Table 1** provide an indication of the reliability of the data-gathering instruments (Saidi, 2019). According to Nunnally and Bernstein (1994), a Cronbach's alpha of .70 or higher is generally considered acceptable for research purposes, indicating good internal consistency. In the case of the TOLT, the original study by Tobin and Capie (1981, p. 417) reported a Cronbach's alpha of .85, suggesting good reliability. However, the Cronbach's alpha obtained for the Kosovar version is lower.

Two physics education experts reviewed all instruments to ensure their validity, reliability, objectivity, and sensitivity. The validity and reliability of the questionnaires were assessed through factor analysis and internal consistency analysis using Cronbach's alpha coefficient. Objectivity was ensured through clear, consistent instructions and a standardized completion method.

Data Collection

The study was conducted in 2023. The research instruments were used in the selected school and classes following both FW and CL approaches. At the beginning of the study, the principal and students were informed about the study and provided their consent. The students then completed paper-and-pencil tests (knowledge test and TOLT) and questionnaires (interest in physics and social skills). The instruments were used under comparable conditions in the experimental and control groups. The instruments were administered on two different days: on the first day, students completed the TOLT and the physics knowledge test, while on the second day, they completed the questionnaires.

This was followed by thermodynamics lessons taught according to lesson plans by a researcher and co-author of this paper, who regularly taught all the physics classes involved in the study, thereby avoiding the introduction of a new individual. Because he actively co-designed the study, he was thoroughly familiar with all aspects of its design.

In the experimental group, students were divided into groups of four, with a mix of male and female students. Each student was assigned a complementary role based on the planned CL activity (e.g., leader, recorder, resource manager, experimenter, and evaluator). Three CL techniques were implemented: team-based learning, jigsaw, and think-pair-share, to enhance collaboration and learning (Omeodu & Utuh, 2018). The students' tasks and roles were introduced in detail on-site, and roles rotated during the lessons. In the team-based methodology, students initially completed assignments individually and then discussed their responses in small groups to reach a consensus. To foster interdependence, the jigsaw strategy was applied, assigning each student a specific subtopic to learn and teach to their peers, as suggested to some extent by Karacop (2017). To enhance conceptual understanding, the think-pair-share approach encouraged individual reflection, peer discussion, and sharing within the whole class.

In the control group, the teacher delivered content to the whole class, while students listened and took notes, as is typical in FW. Learning activities were completed individually. The content covered in both groups was identical; only the teaching approach differed. The implementation of the thematic unit lasted ten weeks (20 lessons) in both groups. After 20 carefully prepared lessons, the instruments were administered again, except for the TOLT.

Although both groups covered the exact same content over the same ten-week period–20 lessons–the teaching approaches differed significantly. In the experimental group (CL), students engaged in small-group CL using methods such as the jigsaw technique, where roles like leader, experimenter, and reporter were assigned. This fostered interactive learning through hands-on experiments and peer teaching. In contrast, the control group (FW) received direct instruction, where students listened to the teacher, took notes, and completed exercises independently, without group projects or teamwork. This difference in teaching methods accounts for the variations in student engagement despite identical content and time allocation.

To facilitate better understanding of the above, we include an example of one lesson. An example of one 45-minute lesson entitled thermometers and measuring temperature is described below. It was delivered as FW, representing traditional teaching methods, and CL, employing the jigsaw technique. Both approaches had the same learning objectives: for students to define temperature, explain how it is measured using different types of thermometers, and identify at least five types of thermometers and describe their differences. In the FW group, students were seated in pairs and learned primarily through teacher-led instruction. In contrast, the CL group worked in groups of up to five students, with each member assigned a specific role (e.g., leader, recorder, timekeeper, or resource manager). The lesson began in both groups with the same introductory questions designed to activate prior knowledge, such as what instrument is used when we have a fever and whether they knew any types of thermometers. In the FW setting, students answered individually in a teacher-directed Q&A format. In the CL group, these questions sparked small-group discussions. The FW group was introduced to thermometer types through a PowerPoint presentation. Students watched, listened, and took notes while the teacher explained. In the CL group, students engaged more actively: each group was given a physical thermometer along with guiding questions and a textbook. In the main part of the FW lesson, the teacher explained all five thermometer types–electrical resistance thermometer, metal thermometer, thermocouple, pyrometer, and medical thermometer–in a sequential lecture. Students were mostly passive recipients of information. Conversely, the CL group used the jigsaw method. Students first worked in expert groups to become familiar with one thermometer type, then returned to home groups to teach their peers. Worksheets and mini-presentations supported this collaborative structure. The FW discussion involved a whole-class review using multiple-choice questions, with students responding individually. In the CL setting, each group presented their thermometer type to the class, followed by open discussion and comparison. To wrap up the FW lesson, the teacher summarized the key points, and students completed a teacher-prepared quiz displayed on the screen. In the CL group, each group shared one key insight they had discovered and collaboratively answered concluding questions, which they then presented to the class.

Data Analysis

Depending on the type of empirical data collected (numerical or non-numerical variables), the data is processed at the descriptive level (including frequency distributions, mean values, and measures of variation) and at the inferential statistics level (using non-parametric tests) (Pallant, 2020). All data was recorded in Excel and statistically analyzed using statistical package for the social sciences (SPSS).

Visual examination and the Shapiro-Wilk test confirmed that the data were not normally distributed, indicating the need for non-parametric testing. In the normality test, all variable groups had significance values less than .01, demonstrating a statistically significant deviation from normality. Therefore, Spearman's correlation and the Mann–Whitney U test were used for analysis.

The Mann-Whitney U test and normalized gain (g) were used to investigate differences between the CL and FW groups. To assess the difference from pre-intervention to post-intervention for one group, the Wilcoxon signed-rank test was used. To analyze the connection between two variables, Spearman correlations were applied.

Table 2. Mann-Whitney U test values for pre- and post-intervention measures: *M* is the average score out of 40 on the physics knowledge test and out of 10 on the TOLT & a 5-point Likert scale assessed interest and social skills, with 1 = strongly disagree and 5 = strongly agree

Instruments	CL		FW		Mann-Whitney U test		
	M	*SD*	*M*	*SD*	*M-W U*	Wilcoxon N	*p*-value
Pre-intervention							
Knowledge test on physics	2.59	1.13	2.52	1.24	2,237.00	4,562.00	.854
Interest on physics	3.70	.384	3.59	.569	2,084.50	4,499.50	.395
Social skills	3.38	.486	3.40	.496	2,135.00	4,346.00	.531
TOLT	1.68	.141	2.05	.159	1,997.00	4,208.00	.208
Post-intervention							
Knowledge test on physics	26.36	8.96	20.42	10.58	1,522.00	3,937.00	.001
Interest on physics	4.49	.198	3.44	.565	185.50	2,600.50	.001
Social skills	3.80	.381	3.25	.370	488.00	3,903.00	.001

Table 3. Spearman correlation results between TOLT and knowledge test after the intervention

Group	Variables	Spearman's rho	Spearman significance (2-tailed)	*N*
CL	TOLT and knowledge test	.343**	.001	66
FW	TOLT and knowledge test	.426**	.000	69

Note. **Correlation at .01 (2-tailed) & **Correlation is significant at .01 level (2-tailed)

Hake's (1998) normalized gain (*g*) quantifies the improvement in students' scores from pre-test to post-test, categorizing the effectiveness of, for example, a teaching method. Hake (1998) established guidelines for defining low gain ($g < .3$), medium gain ($.3 \leq g < .7$), and high gain ($g \geq .7$). This represents growth normalized to the class average. The partial growth for an individual student was determined similarly, considering all replies from all subject areas. In this situation, *g* can be negative if a student answers more questions correctly before the intervention than after (Hake, 1998).

RESULTS

Student Performance on the Administered Instruments in Both the Experimental and Control Groups, Pre- and Post-Intervention

Table 2 shows the comparative results for students' knowledge, interest, social skills, and logical thinking, at both the beginning and the end of the intervention for both groups. The comparison is made first at the start (CL vs. FW) and then at the end. Regarding interest, the CL group had an average of 3.70, while the FW group had 3.59 ($U = 2084.50$, $p = .395$). After the intervention, the CL group scored significantly higher in interest (mean [*M*] = 4.49) than the FW group ($M = 3.44$) ($U = 185.50$, $p = .001$).

Furthermore, no significant differences in social skills were observed between the CL ($M = 3.38$) and FW groups ($M = 3.40$) before the intervention ($U = 2135.00$, $p = .531$). After the intervention, the CL group showed higher social skills ($M = 3.80$) compared to the FW group ($M = 3.25$) ($U = 488.00$, $p = .001$). These findings suggest that the intervention positively impacted the CL group's interest in physics, knowledge, and social skills.

Finally, the TOLT results also revealed no significant differences between the CL group ($M = 1.68$) and the FW group ($M = 2.05$) ($U = 1997.00$, $N = 4208.00$, $p = .208$). These results show that no recognizable differences were observed between the CL and FW groups with respect to the variables measured before the intervention. The Mann-Whitney U-test analysis after the intervention, comparing the two groups (CL and FW) on variables such as physics knowledge, interest in physics, and social skills, revealed significant differences between the groups.

Student Knowledge vs. TOLT Correlation in Both the Experimental and Control Groups, Pre- and Post-Intervention

Table 3 presents Spearman correlations between TOLT and physics knowledge test achievements. In the CL group, Spearman's is .343 ($p = .001$), indicating significant positive relationships. In the FW group, Spearman's correlation is .426 ($p = .000$), also showing strong positive correlations. These results confirm a statistically significant relationship between TOLT and physics knowledge test achievements in both groups.

Knowledge Gain of Students Taught Using CL vs. FW

Table 2 and **Table 4** show that in the experimental group where CL was applied, achievements increased from 2.59 in the pre-test to 26.36 in the post-test. The normalized gain factor for the experimental group is 0.63, representing a medium gain. This indicates a significant impact of the CL method on physics knowledge gain in this group.

Table 4. Physics knowledge test: *M* and *SD* for the number of achieved points out of 40, and average normalized gain (*g*)

Groups	Pre-test		Post-test		*g*
	M	*SD*	*M*	*SD*	
CL experimental	2.59	1.136	26.36	8.961	.63
FW control	2.52	1.244	20.42	10.58	.41

In the control group, where the FW method was used, the results show a lower gain, from 2.52 in the pre-test to 20.42 in the post-test. The normalized gain factor for this group is 0.41. The calculated *g*-value for this method suggests that FW has a weaker effect on improving physics knowledge compared to CL.

The analysis indicates that CL has a significantly more positive impact on improving physics knowledge than FW, as reflected by a higher *g*, which underscores the effectiveness of a cooperative approach in the teaching process. **Table 2** presents the results from both the experimental and control groups before and after the intervention. There were no significant differences in scores on the physics knowledge test during the pre-test, with the CL group scoring $M = 2.59$ and the FW group scoring $M = 2.52$ ($U = 2237.00$, $N = 4652.00$, $p = .854$). However, the CL group performed significantly better on the post-intervention physics knowledge test (CL: $M = 26.36$; FW: $M = 20.42$) ($U = 1522.00$, $N = 3937.00$, $p = .001$).

Physics Interest Levels of the Experimental Group and the Control Group in the Physics Classroom

Based on the data in **Table 2**, the analysis of the Mann-Whitney U-test comparing the two groups, CL and FW, does not indicate any significant differences between the groups pre-intervention in their level of interest in physics, as measured by a Likert scale. The CL group ($M = 3.70$) and the FW group ($M = 3.59$) showed no significant difference ($U = 2084.50$, $N = 4499.50$, $p = .395$).

Post-intervention analysis, however, reveals significant differences: the CL group exhibited a higher interest in physics ($M = 4.49$) compared to the FW group ($M = 3.44$) ($U = 185.50$, $N = 2600.50$, $p = .001$).

Self-Assessment of Social Skills in the Experimental Group Before and After the Intervention

RQ3 specifically addresses changes in social skills within the experimental group, as the CL method was expected to influence social skills, unlike the traditional approach (FW). For this reason, the Wilcoxon signed-rank test was conducted to analyze differences in social skills scores before and after the intervention in the experimental group. The *M* for social skills significantly increased from 3.38 (standard deviation [*SD*] = 0.49) pre-intervention to 3.80 ($SD = 0.38$) post-intervention (**Table 2**). The test statistic ($Z = -4.98$), based on negative ranks, confirms a significant improvement in social skills scores after the intervention. The *p*-value ($p < 0.001$) is below the .05 significance level, indicating that the observed difference is statistically significant. These results demonstrate that the CL intervention had a substantial positive impact on the social skills of participants in the experimental group. It is important to note that **Table 2** reveals statistically significant differences in self-assessed social skills between the CL and FW groups at the end of the intervention.

DISCUSSION

The research aimed to compare CL with FW in Kosovar physics classes, with a particular focus on social skills in CL. The results are discussed in relation to the research questions.

Regarding research question **RQ1**, which examines the significant difference in knowledge gain between students taught with CL in the experimental group and those taught with FW in the control group, the findings indicate that the experimental group using CL strategies scored significantly higher on the physics knowledge test than the control group using traditional FW methods.

This result aligns with previous studies showing that CL can lead to higher academic achievement (Coca, 2013). Specifically, students who participated in CL demonstrated greater understanding and retention of thermodynamic concepts. This improvement can be attributed to the interactive nature of CL, which encourages students to discuss and clarify concepts with their peers, enhancing comprehension and critical thinking.

Moreover, the findings support existing literature highlighting the benefits of CL in science education, including improved academic performance and social interaction (Altun, 2015; Blajvaz et al., 2022; Johnson & Johnson, 1993; Li et al., 2024; Shaby et al., 2024).

The current study reports a positive correlation between physics knowledge and the development of logical and formal thinking skills in the CL group. This supports Tobin and Capie's (1984) assertion that these skills are essential for success in science education. The emphasis of CL on problem-solving and critical discussion plays a key role in developing these cognitive skills.

Thus, the study confirms that CL not only improves knowledge and interest but also enhances crucial cognitive and social skills. These results suggest that secondary physics teachers should promote CL to improve students' achievements in thermodynamics, increase their interest in physics, and strengthen their social skills.

The use of CL strategies, such as team-based learning, jigsaw, and think-pair-share, can create a more engaging and effective learning environment. This is particularly important in Kosovo, where traditional teaching methods still prevail and interest in science remains low (Beka, 2014; Pupovci, 2019).

In relation to research question **RQ2**, which explores the difference in physics interest between the experimental and control groups in physics lessons, the results show that the increased interest in physics observed in the experimental group after the intervention supports the idea that CL can enhance students' enthusiasm and engagement in the subject. This finding is consistent with previous research suggesting that active participation and collaboration in CL environments make learning more engaging and enjoyable (Gillies, 2016; Lavonen et al., 2021; Meulenbroeks et al., 2024). A positive change in students' attitudes toward physics is crucial, as motivation is a key factor in academic success and future interest in science careers (Zhai & Liu, 2024).

RQ3 addresses the difference in the self-assessment of social skills in the experimental group before and after the thermodynamics lessons in physics. The improvement in social skills in the experimental group illustrates the social skills benefits of CL. Students working in groups learn to communicate effectively, resolve conflicts, and cooperate to achieve common goals. This result is consistent with studies showing that CL promotes the development of interpersonal skills (Aryanti & Widodo, 2020; Yuliani, 2021; Zhou et al., 2024). The identified improvement in social skills is particularly important for holistic educational approaches, where the development of social and emotional skills is as important as academic knowledge. The results also reveal a difference in social skills between the experimental and control groups following the thermodynamics lessons, despite these skills not being intentionally fostered in the control group. This finding aligns with Mendo-Lázaro et al. (2018), who reported that although students in the control group began with social skills comparable to those in the experimental group, significant differences emerged over time, with the control group showing lower levels of basic social skills.

CONCLUSIONS

The purpose of this article was to investigate the impact of incorporating a CL strategy into secondary school physics lectures. A quasi-experimental study on CL in the context of the Kosovar education system is presented. It highlights the statistically significant positive effects of CL after a 20-hour intervention on thermodynamics in physics classes on secondary school students' achievements in the knowledge test and interest in physics, compared to traditional FW, as well as the increase in social skills in the CL group. These results are of central importance, as they show that CL can meet the dual challenge of making learning more enjoyable and developing important interpersonal skills that are essential for pursuing a variety of careers.

The limitations of the study lie in the sample size, which may affect the generalizability of the results. The study was conducted in a specific educational context, which somewhat limits its transferability to other settings. The duration of the intervention may not accurately reflect CL's long-term effects on student development.

The research findings serve as a starting point for future studies, which should further investigate and validate the benefits of CL in different subjects and educational settings. The present study provides evidence for further qualitative and quantitative research on thermodynamics. Future studies should examine the long-term effects of CL on students' academic and social development. Investigating the effectiveness of different CL strategies across various subjects and educational levels can provide a more comprehensive understanding of the advantages of CL. Research can also explore the reasons for deviations from previously published results to identify variables that influence the effectiveness of CL.

The implications of this study, as well as the findings from the literature, may extend beyond physics education and suggest that CL can be a transformative educational practice. By fostering a CL environment, educators can improve both academic achievement and social skills development. Teachers should incorporate CL strategies into their classroom practice to enhance student engagement, academic achievement, and social development. Techniques such as jigsaw, think-pair-share, and team-based learning can greatly enrich the learning experience. It would be beneficial for schools to provide professional development and opportunities for teachers to effectively apply CL approaches. Workshops and training can equip teachers with the necessary skills to promote CL in their classrooms. Education professionals should consider revising the curriculum to some extent to highlight CL as a successful teaching strategy. This would provide a more consistent approach across schools and grade levels and encourage diversity in teaching methods.

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