Effectiveness of Jigsaw Learning Method in Teaching Science and Mathematics

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Abstract

This study investigates the effectiveness of the Jigsaw learning method, a collaborative teaching approach, in improving learning outcomes in Science and Mathematics among secondary school students in Nepal. The research employed a mixed-methods sequential explanatory design, involving 40 grade ten students divided into experimental and control groups. Quantitative analysis revealed no significant difference in pre-test scores between the experimental and control groups. However, post-test results showed a significant difference, with the experimental group outperforming the control group. Qualitative data collected from classroom observations and interviews with the students and teacher indicated improved understanding, higher engagement, and positive attitudes toward the Jigsaw method. The study concludes that the Jigsaw method significantly enhances Science and Mathematics learning outcomes and fosters a more interactive educational environment. Recommendations include integrating and prioritizing the Jigsaw method into the national curriculum and providing teacher training on collaborative learning strategies to implement well in Science and Mathematics classroom.

Keywords: Jigsaw method, Science education, Mathematics education, learning outcomes, collaboration, secondary education

Introduction

Science and Mathematics education plays a vital role in addressing complex challenges in human life, offering structured insights into the natural world. Science and Mathematics is interrelated as well as a fundamental subject, is essential for understanding natural phenomena and technological advancements. However, in Nepal, Mathematics and Science is often perceived as a difficult subject at the secondary level, leading to poor academic performance and low student engagement (Paudel & Rajbhandary, 2022). Traditional teaching methods, such as lecture-based instruction, have been criticized for their lack of student engagement and failure to promote critical thinking (Acharya, 2019).

The Jigsaw learning method, a collaborative teaching strategy developed by Elliot Aronson in the 1970s, has shown significant promise in enhancing student engagement and learning outcomes. This method involves dividing students into "home groups" and "expert groups," where each student becomes an expert on a specific topic and then teaches it to their peers.

Collaborative learning is an educational approach that involves students working together in small groups to achieve a common goal. It emphasizes active participation, peer interaction, and shared responsibility for learning (Barkley et al., 2004). The Jigsaw method, a specific form of collaborative learning, was developed by Elliot Aronson in the 1970s to reduce racial tensions in desegregated classrooms in the United States (Aronson et al., 1978). Since then, it has been widely adopted in various educational settings, from primary schools to higher education.

The Jigsaw method involves dividing students into "home groups" and "expert groups." Each student in the home group is assigned a specific segment of the lesson to study. They then join their expert groups, where they collaborate with peers studying the same segment. After gaining expertise, students return to their home groups to teach their peers, ensuring that every student is both a learner and a teacher (Aronson, 2000). This cooperative structure promotes accountability, engagement, and a deeper understanding of the subject matter.

The Jigsaw method offers several advantages over traditional teaching methods. First, it promotes active learning, where students are not passive recipients of information but actively participate in the learning process (Drouet et al., 2023). By requiring students to teach their peers, the method reinforces their understanding and retention of the material. Second, the Jigsaw method fosters critical thinking and problem-solving skills, as students must not only grasp their segment but also connect it with the larger topic and respond to questions from their group members (Azizah & Putri, 2020). Third, the method enhances social and communication skills, as students must clearly articulate their knowledge and collaborate effectively with others (Slavin, 2014).

The effectiveness of the Jigsaw method may also be influenced by cultural and contextual factors. In Nepal, where traditional teaching methods dominate, the introduction of collaborative learning strategies such as the Jigsaw method could face resistance from both teachers and students. However, studies such as those by Sharma (2023) and Gautam and Acharya (2023) suggest that with proper training and support, the Jigsaw method can be successfully implemented in Nepalese classrooms.

Despite its advantages, the Jigsaw method is not without challenges. Some students may struggle with the responsibility of teaching their peers, especially if they lack confidence in their understanding of the material. Additionally, the method requires careful planning and management by the teacher to ensure that all students are actively engaged and that the learning objectives are met (Dollard & Mahoney, 2010). Furthermore, the effectiveness of the Jigsaw method may vary depending on the subject matter, the students' prior knowledge, and the classroom environment.

The theoretical foundation of the Jigsaw method is rooted in social constructivism, a learning theory developed by Lev Vygotsky. Social constructivism emphasizes the importance of social interactions in the construction of knowledge. According to Vygotsky (1978), learning is a social activity that occurs through interaction with others, particularly more knowledgeable peers or adults. The Jigsaw method aligns with this theory by creating a collaborative learning environment where students co-construct knowledge through peer teaching and group discussions.

Vygotsky's concept of the Zone of Proximal Development (ZPD) is particularly relevant to the Jigsaw method. The ZPD refers to the gap between what a learner can achieve independently and what they can achieve with guidance from a more knowledgeable other (MKO). In the Jigsaw method, students work within their ZPD as they learn from their peers and receive support from their group members. This collaborative approach enables students to achieve higher levels of understanding than they would through individual study (Mcleod, 2024).

John Dewey's theory of experiential learning, often referred to as "learning by doing," also supports the use of the Jigsaw method. Dewey (1938) argued that education should be a process of active inquiry and problem-solving, rather than passive absorption of information. The Jigsaw method embodies this principle by engaging students in hands-on activities, peer teaching, and collaborative problem-solving. This approach not only enhances students' understanding of the subject matter but also develops their critical thinking and problem-solving skills.

A constructivist classroom environment, as described by Phillips (1995), is one where students are actively involved in the learning process, and knowledge is constructed through social interactions and experiences. The Jigsaw method creates such an environment by encouraging students to take ownership of their learning, collaborate with their peers, and engage in meaningful discussions. This approach fosters a deeper understanding of the material and promotes lifelong learning skills.

Numerous studies have demonstrated the effectiveness of the Jigsaw method in improving academic achievement and student engagement. For example, Karacop (2017) conducted a study with pre-service science teachers and found that the Jigsaw method significantly improved their understanding of Science and Mathematics concepts compared to traditional lecture-based instruction. Similarly, Jafariyan et al. (2017) reported higher student satisfaction and better learning outcomes when the Jigsaw method was used in a medical Science course.

The literature review highlights the theoretical and empirical support for the Jigsaw method as an effective teaching strategy. The method aligns with social constructivism and experiential learning theories, emphasizing the importance of collaboration, peer teaching, and active student participation. While the Jigsaw method has been shown to improve academic achievement and student engagement, its effectiveness may vary depending on the subject matter, students' prior knowledge, and the classroom environment. This study contributes to the existing body of knowledge by examining the effectiveness of the Jigsaw method in secondary Science and Mathematics education in Nepal, a context that has been underexplored in previous research.

Statement of the Problem

The practice of recent and innovative pedagogical and methodological techniques, including activity-based inquiry, argumentation, discussion, collaborative learning, and demonstration, are less prevalent in Nepalese classrooms (Acharya, 2019; Bajracharya&Brouwer, 1997; Curseu et al., 2018). Writing note and rote learning are predominant in Science classes. Recitation and note-taking techniques are not advantageous to student involvement or group cooperation for learning (Acharya, 2016; Cimermanová, 2018). In a traditional learning environment, which is common in our nation, school-level students frequently experience learning difficulties and feels inadequacy to recognize the value of their daily courses and assignments (Schmidt et al., 2019). Lack of active participation in classes leads to poor academic results. According to National Assessment of Student Achievement (NASA) in (Education Review Office [ERO], 2020), 61% of students have remained below essential and basic levels, indicating minimal learning. Furthermore, in the same report, only 18% of students could answer the items asked based on the national curriculum of grade ten when proficient one is considered as a minimum expected (Dhakal, 2020). Furthermore, according to the report of Ghimire (2024) in The Kathmandu Post, the status of non-graded (NG) students in science is nearly thirty percent in the

Secondary Education Examination (SEE) in 2024 which is second highest among overall subjects. Hence, finding efficient teaching strategies is crucial in today's secondary schools to improve scientific students' interest, understanding, and retention of the most significant tasks.

The major problem is vividly seen in the students to solve the higher ability problems in Science and Mathematics. This situation is dominant mostly because the conventional lecture-based method frequently fails to develop students' critical thinking abilities and a thorough grasp of scientific ideas (Hanze& Berger, 2007). In addition to this, there remains a significant gap in our understanding of how this particular Jigsaw method contributes to improved academic outcomes. There is no strong research in Nepal to identify and address the existing gaps in the relationship between the Jigsaw method and academic achievement to enhance the overall educational experience for students. Furthermore, the literature on the application and effects of collaborative learning as a pedagogical strategy in secondary science education is noticeably lacking despite the rising corpus of research supporting this approach.

Research Objectives

The primary objective of this study is to evaluate the effectiveness of the Jigsaw learning method in teaching Science and Mathematics at the secondary level. Specific objectives include:

- To examine the impact of the Jigsaw method on students' academic achievement in Science and Mathematics.
- To identify the role of the Jigsaw method in fostering student interest, participation, and collaboration.

Research Hypothesis

Null Hypothesis (H_0): There is no significant difference in the mean achievement scores of students taught using the Jigsaw method and those taught using traditional methods.
Alternative Hypothesis (H_1): The mean achievement scores of students taught using the Jigsaw method are significantly higher than those taught using traditional methods.

Methodology

This study employed a mixed-methods sequential explanatory design, which combines quantitative and qualitative approaches to provide a comprehensive understanding of the research problem. The sequential explanatory design involves two phases: (1) quantitative data collection and analysis, followed by (2) qualitative data collection and analysis to explain and elaborate on the quantitative findings. This design was chosen because it allows for a deeper exploration of the effectiveness of the Jigsaw method in teaching Science and Mathematics, addressing both the "what" (quantitative) and the "why" (qualitative) aspects of the research.

The study was conducted in a quasi-experimental framework, where two groups of students experimental and control were compared. The experimental group was taught using the Jigsaw method, while the control group received traditional lecture-based instruction. The quasi-experimental design was selected because it allows for practical implementation in real classroom settings, where random assignment of students to groups is often not feasible.

The population for this study consisted of grade ten students from secondary schools in Kathmandu, Nepal. A purposive sampling technique was used to select one institutional school for the study, based on accessibility and willingness to participate. The sample included 40 students, divided equally into an experimental group (n = 20) and a control group (n = 20). The students were selected based on their enrollment in the Science and Mathematics Mathematics course, ensuring that both groups had similar academic backgrounds and prior knowledge of the subject. The following tools were used for data collection:

Pre-Test and Post-Test Achievement Tests

A standardized achievement test was developed based on the grade ten Science and Mathematics curriculum, focusing on topics such as gravitation, pressure, and Archimedes' principle, set, compound interest, currency and exchange rate. The test consisted of 25/25 multiple-choice questions, designed to assess students' understanding of key concepts. The pre-test was administered before the intervention to establish baseline performance, while the post-test was conducted after the intervention to measure learning outcomes.

Classroom Observation Form

A structured observation form was used to record students' engagement, collaboration, and participation during the Jigsaw sessions. The form included indicators such as Level of student engagement, quality of collaboration, interest in classroom activities

Interview Guidelines

Semi-structured interviews were conducted with three students from the experimental group and the Science and Mathematics teacher who facilitated the Jigsaw sessions. The interviews aimed to gather insights into students' experiences, challenges, and perceptions of the Jigsaw method.

Data Collection Procedure

The data collection for this study spanned a period of six weeks and involved two groups of grade ten students: an experimental group and a control group. At the beginning of the process, a pre-test based on science and Mathematics was administered to both groups to assess their baseline understanding of selected Science and Mathematics topics. This pre-test helped establish a point of comparison for evaluating the effectiveness of the instructional methods used during the intervention phase.

During the intervention phase, the experimental group received instruction through the Jigsaw learning method across six sessions. The Jigsaw process involved the formation of home groups and expert groups, where students in expert groups studied sub-topics collaboratively and then returned to their home groups to teach their peers. The sessions concluded with group presentations and class-wide discussions, encouraging active engagement and deeper understanding. Meanwhile, the control group studied the same content through traditional lecture-based instruction without the collaborative elements of the Jigsaw strategy.

After the intervention period, both groups completed a post-test to evaluate any changes in their academic performance. In addition to the test scores, the researcher conducted classroom observations during the Jigsaw sessions to gather qualitative data. These observations focused on aspects such as student engagement, collaboration, participation, and interest. The collected data provided valuable insights into how the Jigsaw method influenced the classroom dynamic s and student learning outcomes compared to traditional teaching methods. Semi-structured interviews were conducted with selected students and the teacher to gather qualitative insights into the effectiveness of the Jigsaw method.

Procedure of Using Jigsaw Method

Resor (2008) and Jeppu et al. (2023) have explained the best way to use the Jigsaw I in classroom. According to them, the Jigsaw can be used in the class with four basic steps. The first step of using this method is to prepare home group. Different reading selections on the subject is broken into the reading into different portions. The pupils are allocated into different groups, which are termed the home groups. In addition, a guidance document is created to help students respond to inquiries and compile data for every choice or segment.

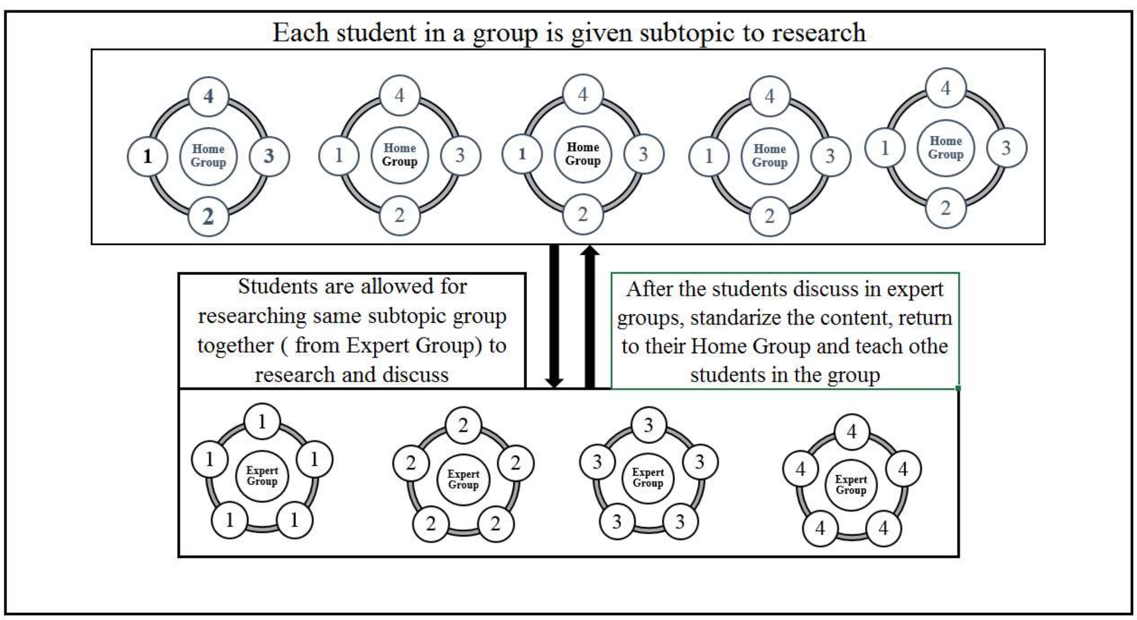
After the class is separated into home groups, the study topic and approach is explained to the students. Students are informed that the group they are currently sat with will be responsible for teaching them one segment or selection.

Pupils are then told to leave their home group and join a group known as their expert group, which consists of other pupils allocated to the same reading segment or selection. They are instructed to either start reading aloud on their own or in pairs. Once the reading is over, the group has to discuss their segment, complete their direction sheet. Finally, experts should be ready to present in the home group with the proper plan and ideas with the materials.

At the end, after regrouping with their home groups, the students are given the task of instructing their respective home groups in the reading segment or selection. The indication that every pupil is accountable for mastering the content is emphasized. They should decide how to arrange and summarize the knowledge they have learned. Students could be given a visual organizer, for example, or told to make a poster to present to the class as a whole. The Jigsaw method as described by (Jeppu et al., 2023) can be illustrated as,

Figure 1
Jigsaw Method

Note. Adapted from Jeppu et al. (2023).



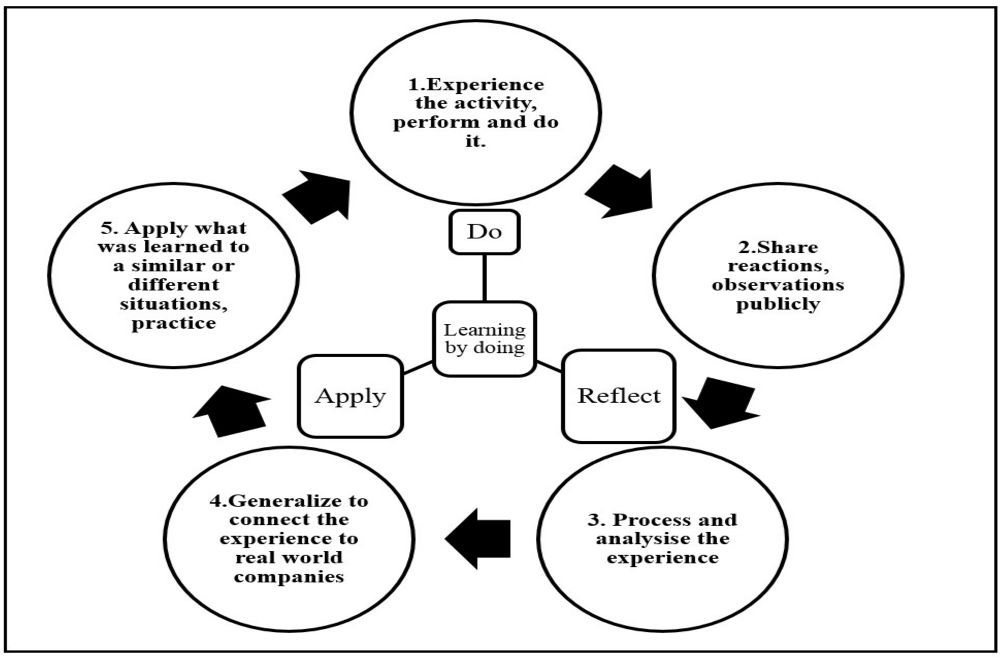
Dewey Learning by Doing

Dewey emphasized that the educational environment should be viewed as a social institution by asserting that social interactions are the primary means of effective instruction (Flinders & Thornton, 2013). Dewey saw education as a lifelong process, not just preparation for the future (Flinders & Thornton, 2013, p. 35; Gutek, 2014). This perspective distinguished Dewey from philosophers who advocated for traditional classroom settings. Dewey's viewpoint deviated from that of conventional classrooms since he thought that learning environments should reflect real-world circumstances. According to him, learning activities for kids should be flexible and interchangeable across different social contexts (Dewey, 1938; Gutek, 2014). Dewey objected to the rapid introduction of excessive academic content, particularly when it was isolated from children's social lives. He saw this kind of instruction as unethical (Flinders & Thornton, 2013). Jigsaw method also enjoys the social context for collaboration and is against of the old fashioned stereotyped lecture method and foster the active learning environment for learners.

Figure 2

Dewey Model of learning by doing

Note. Adapted from Main (2023).



Many of the assumptions that educators hold about student learning are in line with Dewey's thinking, according to educators who value learner-centered approaches (Schiro, 2013). John Dewey's social learning theory and other educational concepts are put into reality in classrooms that place a high priority on learner-centered techniques. Dewey argued that (as cited in Williams, 2017) the classroom is a social space where kids can work together as a community to solve problems and engage in collaborative learning. Instead of depending only on teacher-imposed knowledge and teacher-directed activities, children are seen as unique individuals in these educational contexts, actively involved in developing their own knowledge through personal meaning (Schiro, 2013). Children will be observed in these classes actively solving problems using practical approaches and learning via hands-on experiences.

Data Analysis Procedure

The data analysis in this study consisted of both quantitative and qualitative approaches to ensure a comprehensive understanding of the effectiveness of the Jigsaw learning method. For the quantitative analysis, the pre-test and post-test scores of both the experimental and control groups were examined using descriptive statistics, including mean, standard deviation, and variance, to summarize the performance data. Additionally, an independent samples t-test was employed to determine whether there was a statistically significant difference between the mean achievement scores of the two groups. The significance level was set at $p < 0.05$, allowing the researcher to assess the effectiveness of the Jigsaw method compared to the traditional lecture-based approach.

For the qualitative analysis, data collected from classroom observations and interview transcripts were analyzed thematically. This process involved carefully reviewing the qualitative data to identify recurring patterns and themes related to student engagement, collaboration, and overall learning experiences. The identified themes were then coded and categorized to uncover deeper insights into how the Jigsaw method influenced classroom interactions and student learning outcomes. The thematic analysis enriched the quantitative findings by highlighting the observed behavioral and perceptual changes in students exposed to the Jigsaw approach.

Ethical Consideration

The study was conducted in adherence to ethical guidelines for educational research to ensure the rights and well-being of all participants. Informed consent was obtained from students, teachers, and school administrators after they were fully informed about the study's purpose, procedures, and any potential risks. Participation was entirely voluntary, and students were free to withdraw from the study at any time without facing any penalties. To maintain confidentiality, the identities of all participants were protected, and pseudonyms were used in the reporting of qualitative data such as interviews and classroom observations. These ethical considerations were strictly followed to promote transparency, trust, and integrity throughout the research process.

Results

The quantitative results of the study began with an analysis of the pre-test scores, which were used to assess the baseline academic performance of both the experimental and control groups. The mean score for the experimental group was 14.7 ($SD = 3.56$), while the control group had a mean score of 14.54 ($SD = 3.78$). These results indicate that there was no significant difference in the academic abilities of the two groups before the intervention, suggesting that both groups started at a relatively equal level in terms of prior knowledge of the selected Science and Mathematics topics.

Following the six-week intervention, the post-test results demonstrated a noticeable improvement in the academic performance of the experimental group compared to the control group. The experimental group achieved a mean score of 15.25 ($SD = 3.13$), whereas the control group scored a mean of 13.75 ($SD = 3.87$). An independent samples t-test was conducted to determine the significance of this difference, and the results confirmed that it was statistically significant ($t = 2.347$, $p < 0.05$). This finding indicates that the use of the Jigsaw learning method had a positive effect on the students' learning outcomes.

In addition to the improvement in mean scores, the analysis of pass rates provided further evidence of the Jigsaw method's effectiveness. The pass rate for the experimental group increased from 85% in the pre-test to 95% in the post-test. In contrast, the control group's pass rate remained unchanged at 85% across both tests. This improvement in the experimental group's pass rate suggests that the Jigsaw approach not only enhanced average academic performance but also helped more students meet the required achievement standards.

Qualitative Results

Classroom Observations:

The classroom observations conducted during the Jigsaw sessions revealed a noticeable increase in student engagement and collaborative behavior. Students were actively involved in the learning process, participating in group discussions, asking insightful questions, and explaining concepts to their peers. This high level of interaction suggested that the Jigsaw method created a dynamic and student-centered learning environment. Students appeared more confident and willing to contribute, indicating that the structure of the method encouraged responsibility and accountability for their own learning.

From the observation data, several key themes emerged. Active Engagement was evident as students consistently interacted with their peers and took initiative in discussions. Collaborative Learning stood out as students supported one another, solved problems as a team, and took turns teaching each other within their groups. Additionally, there was a noticeable Increase in Interest in Science topics, particularly during hands-on activities and peer-led teaching. These themes highlighted the effectiveness of the Jigsaw approach in promoting a more engaging and interactive classroom environment, which contributed to improved learning experiences and outcomes.

Interview Findings

The interviews conducted with students and the teacher provided deeper insights into the perceived effectiveness of the Jigsaw learning method. One prominent theme that emerged was Improved Understanding. Students shared that explaining Science and Mathematics concepts to their peers required them to study more thoroughly, which in turn led to a deeper and clearer understanding of the material. This peer-teaching aspect of the Jigsaw method encouraged active learning and reinforced their grasp of complex topics. Additionally, students expressed that learning from peers often made the content more relatable and easier to comprehend.

Another key theme was Increased Confidence, as many students reported feeling more self-assured in both learning and communicating Science and Mathematics concepts. They noted that the opportunity to lead discussions and teach others boosted their self-esteem and made them more comfortable participating in class. However, some challenges were also identified, particularly related to group dynamics. A few students pointed out issues such as unequal participation and difficulty in managing roles within the group. Despite these challenges, the overall feedback from interviews highlighted the positive impact of the Jigsaw method on both academic learning and personal development.

Discussion

The findings of this study demonstrate that the Jigsaw method is an effective teaching strategy for improving Science and Mathematics learning outcomes at the secondary level. The quantitative results showed a significant improvement in the experimental group's post-test scores compared to the control group, indicating that the Jigsaw method enhances academic achievement. These findings are consistent with previous studies, such as Karacop (2017) and Jafariyan et al. (2017), which also reported positive effects of the Jigsaw method on student learning.

The qualitative data provided additional insights into the mechanisms through which the Jigsaw method improves learning outcomes. The high levels of student engagement and collaboration observed during the Jigsaw sessions align with the principles of social constructivism, which emphasize the importance of social interactions in knowledge construction

(Vygotsky, 1978). The peer teaching component of the Jigsaw method was particularly effective in reinforcing students' understanding of Science and Mathematics concepts, as they had to explain the material to their peers.

However, the study also identified some challenges associated with the Jigsaw method. For example, some students struggled with group dynamics and ensuring equal participation among group members. These challenges highlight the need for careful planning and facilitation by the teacher to ensure the successful implementation of the Jigsaw method.

The findings of this study have important implications for educators and policymakers. The Jigsaw method offers a promising alternative to traditional lecture-based instruction, particularly in contexts where student engagement and collaboration are low. By integrating the Jigsaw method into the national curriculum and providing teacher training on collaborative learning strategies, policymakers can help improve the quality of Science and Mathematics education in Nepal.

Conclusion

This study provides compelling evidence supporting the effectiveness of the Jigsaw learning method in enhancing Science and Mathematics achievement at the secondary level. The significant improvement in the experimental group's post-test scores, along with increased pass rates and observed classroom engagement, indicates that the Jigsaw method positively impacts students' academic performance. The thematic analysis of observations and interviews further reinforces this conclusion, revealing that students experienced deeper conceptual understanding, increased confidence, and greater interest in learning Science and Mathematics. The method encouraged students to take active roles in their learning by teaching and learning from their peers, fostering not only cognitive development but also social and emotional growth.

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