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RESEARCH PAPER

Effect of Cooperative Learning on Academic Achievement among Biology Students at Secondary School Level

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ABSTRACT

Cooperative learning, a pedagogical approach where students collaborate, drawing from each other's experiences, was investigated for its effect on the academic performance of secondary-grade Biology students. The study was quantitative in nature employing experimental research, A-B-A-B design. An intact group of 40 students (26 males, 14 females) was selected as a sample of the study. Researchers developed the instruments that were repeated measure tests. All the tests were validated by four experts. Pilot testing was also done in order to assure reliability. Intervention was given to the students and test was conducted after completing each phase starting from baseline phase. Statistical analysis, including descriptive statistics and paired sample t-test was used to draw findings. Results indicated a statistically significant improvement in students' academic achievement across all post-baseline and intervention tests. The findings underscore the efficacy of cooperative learning in enhancing student learning outcomes. Educators are encouraged to incorporate this teaching technique to optimize student learning experiences.

KEYWORDS Academic Achievement, Biology, Cooperative Learning, Experimental Research, Secondary Grade Students

Introduction

Employing diverse teaching methodologies enhances the effectiveness of instruction, with researchers proposing various methods suitable for different subjects. Among these, cooperative learning stands out as a universally influential approach applicable across educational levels. In Pakistani institutions, conventional teaching methods such as problem-solving, lectures, demonstrations, and discussions are prevalent, meeting specific learner needs in classroom settings. However, recognizing the necessity for innovative techniques that cater to a broad spectrum of students, the cooperative learning method emerges as a comprehensive solution for both high-performing and average students.

Cooperative learning transcends educational levels, suitable for implementation in schools, colleges, and universities globally. Despite its universal applicability, resources on cooperative learning in teaching materials and teacher journals are scarce (Yu, 2013). Collaborative learning transforms classroom activities into both social and academic experiences, fostering positive relationships among learners. In the inherently diverse classroom, encompassing variations in gender, race, and learning styles, cooperative learning strategies facilitate cognitive, behavioral, and social interdependence (Johnson & Johnson, 1999).

Cognitive interdependence reflects collective self-representations, while behavioral interdependence strengthens bonds within a group. Social interdependence, integral to collaborative learning, fosters positive communication, individual accountability, interactive skills, and group formation. In the contemporary era, where student interactions are limited due to gadget dependency, cooperative learning emerges as a student-centric alternative to teacher-oriented methods, promoting a more amicable learning environment (Slavin, 2011).

Cooperative learning's impact has been observed across educational institutions, demonstrating its positive influence on achievement scores, academic self-concept, attitudes, retention, and social abilities. Language learning, in particular, necessitates a communicative environment where cooperative strategies facilitate peer interaction, fostering enhanced language skills and social communication abilities (Sharan & Sharan, 2011; Du, 2012).

Literature Review

Cooperative learning significantly enhances academic achievement, particularly in mathematics (Iqbal, 2004). Compared to traditional teaching methods, collaborative learning offers a robust strategy, assigning students individual responsibility for their learning tasks, and fostering a shared commitment among group members (Akhtar et al., 2012). Previous research consistently attests to the efficacy of cooperative learning in promoting deep learning and achieving high academic standards across various grades, especially in science classrooms (Johnson & Johnson, 1999; Lin, 2006; Lord, 2001; Vijayratnam, 2009; Wolfensberger & Canella, 2015). This approach encourages students to express and discuss their thoughts, enhancing higher-order thinking skills (Johnson, Johnson, & Smith, 2014).

Studies consistently demonstrate the positive impact of cooperative learning on students' English oral skills, reading comprehension, and writing (Pan & Wu, 2013). While most research has focused on elementary and middle school students, the current study delves into cooperative learning's effects on high school students in Lahore's private sector, where traditional teaching methods prevail. Recognizing the unique needs of this group, cooperative learning deserves special attention, as its effectiveness for younger students may not necessarily apply to older learners (Knowles, Holton & Swanson, 2012; Kagan, 2009).

Local studies, such as Iqbal's (2004) examination of cooperative learning in secondary school mathematics, consistently reveal its superiority over conventional teaching methods. Similarly, Bibi (2002) and Siddiqui (2012) report positive outcomes for ESL learners. Arbab's (2003) short experiment on general science students and Kousar's (2003) research on social studies students both affirm the positive impact of cooperative learning on academic achievement in the local context.

Cooperative learning not only enhances language and social skills but has become a widely adopted teaching methodology across education levels and subjects over the past 30 years (Bibi, 2002). Arbab's (2003) study on 9th-grade general science students confirms the advantages of group learning over traditional methods. Local research by Kosar (2003) and Parveen et al. (2011) consistently supports the positive impact of group work on academic achievement.

Cooperative learning, observed as more effective than conventional learning, proves beneficial for overburdened classes (Khan, 2008). It enhances learner motivation and

higher-order thinking, as noted by Hernandez (2002) and Herberyan (2007). Gillespie and Thomas (2006) affirm its positive influence on university students' academic achievement. In conclusion, cooperative learning leverages classroom diversity, encouraging students to learn from each other and fostering collaborative knowledge acquisition.

Utilizing cooperative learning to teach grammar significantly improves the academic achievement and language skills of students studying English at elementary and secondary levels (Bibi, 2002). Educationists emphasize that language learners must engage in the language for effective development. Cooperative learning, by increasing oral interactions and providing numerous opportunities for expression, contrasts with traditional teacher-centered approaches (Bibi, 2002). Iqbal (2004) asserts that this strategy is particularly effective for science and English compared to conventional teaching methods. Cooperative learning's prevalence in schools and university classrooms underscores its effectiveness (Gillespie & Thomas, 2006).

This research explores the implementation of cooperative learning methodologies and their impact on the academic achievement of secondary-level Biology students. The findings aim to raise awareness among teacher trainers, facilitating the application of cooperative learning insights to shape students' attitudes in future educators. The introduction of cooperative learning contributes to enhancing students' self-concept in the field of Biology and improving the academic achievement of secondary school students. The primary aim of the investigation was to evaluate how cooperative learning strategies impact the academic performance of 9th-grade students in Biology. Accordingly, a null hypothesis was formulated to guide the study.

H_{o1}. There is no significant effect of cooperative learning strategies on academic achievement of 9th grade Biology students.

Material and Methods

Aligned with a post-positivist research paradigm, the study employed a quantitative and experimental methodology. Utilizing a single-subject experimental research design (ABAB), the research proceeded through phases of baseline (A), intervention (B), withdrawal of intervention (A), and re-introduction of intervention (B). This approach was chosen to systematically examine the effects of cooperative learning on the academic achievement of high school Biology students.

Population and Sample

The research centered on secondary-level students attending private schools in the Lahore district as its target population. According to the Annual Status of Education Report (2018), the total enrollment in secondary-level private schools in Lahore was 99,430. To facilitate the study, a coeducational institution was selected. The sample consisted of a cohesive group of 40 students, comprising 26 males and 14 females, all drawn from the 9th grade specifically for this research.

Instrumentation

The research employed four repeated measure tests to assess the impact of cooperative learning on academic achievement throughout the experiment. Each test corresponded to the completion of a specific unit, and the researchers developed these tests based on a table of specifications. This table detailed the contents taught by the principal researcher. Following Bloom's cognitive domain taxonomy, each test incorporated knowledge, comprehension, and application level items, with weightages aligned to the

national curriculum of Biology (30%, 40%, and 30%, respectively, for each unit). The table of specifications, found in Appendix A, guided the test construction. Tests featured a mix of objective and subjective items, comprising 7 multiple-choice questions, 5 short answer questions, and 1 long-form question. All tests were 25 marks each, with a time limit of 40 minutes

Instrument validity was ensured through four subject experts—2 in Biology and 2 in educational research. Item analysis, covering difficulty and discrimination indices, was conducted. Rubrics were developed to enhance accuracy in scoring the subjective section. Content judgment involved Biology subject teachers at the secondary school level, and instrument adjustments were made based on expert opinions. Format errors, grammatical issues, and conceptual or technical errors highlighted by the experts were addressed.

Item analysis (item difficulty and discrimination) for the achievement test was done. Each item is evaluated based on its difficulty level and discrimination index, with accompanying remarks indicating whether the item was deemed suitable ("Considered") or unsuitable ("Discarded") for inclusion in the test. Item difficulty reflects the proportion of students who answered the item correctly, with higher values suggesting easier items. Item difficulty ranges from 0.42 to 0.82, indicating an acceptable level of difficulty. A value near 0 signifies a very challenging item, while a value near 1 suggests the item is relatively easy. Discrimination index measures the item's ability to differentiate between high and low achievers, with higher values indicating better discrimination. Discrimination index values fall between 0.20 and 0.67, demonstrating that all items exhibit high discriminating power. A value near 1 implies effective discrimination between higher and lower achievers. Items with high difficulty levels may signify challenges for students, while those with high discrimination indices effectively distinguish between achievers. Conversely, items with low discrimination indices may highlight flaws in item design. The analysis guides the refinement of test items to ensure they accurately assess students' comprehension of Biology concepts.

The reliability of the subjective section of the tests was assessed. Not all students were able to solve every question, and those questions unanswered by any student were excluded from the test. The remaining questions were retained for inclusion in the tests.

Intervention

The entire sample was subjected to an intact group format, receiving instruction through the ABAB withdrawal design. In this design, baseline treatments were iteratively applied, followed by the introduction of treatment. Subsequently, a secondary baseline phase ensued, leading to the initiation of a secondary treatment phase. The instructional approach employed for the group was the cooperative learning method, specifically the Jigsaw technique. The teaching covered four units, and a total of 22 lesson plans were devised. Assessments were conducted upon the completion of each unit, with the intervention extending over a 12-week period.

Results and Discussion

Following data collection, scores were organized into tables using appropriate research analysis techniques. Subsequently, the data underwent analysis to investigate the research hypothesis. Inferential statistics, specifically paired sample t-tests, were employed to determine the significant mean difference between students' scores.

Table 1
Mean Score of Tests after Baseline Phase 1 and Intervention Phase 1

Variables	N	Mean	SD	t-value	df	p
Test after baseline phase 1	40	13.9	3.73	10.7	39	0.000
Test after intervention phase 1	40	18.1	3.32			

To evaluate the impact of cooperative learning strategies on the academic achievement of 9th-grade Biology students, a paired-samples t-test was administered with a cohort of 40 participants. The analysis unveiled a statistically significant effect of cooperative learning on students' academic performance. Notably, the mean scores post-baseline phase 1 ($M = 13.9$, $SD = 3.73$) significantly increased to $M = 18.1$ ($SD = 3.32$) post-intervention phase 1, with a t-value of 10.7 and $p < 0.05$ (two-tailed) for 39 degrees of freedom. The mean score augmentation was 1.57, accompanied by a 95% confidence interval. Furthermore, the eta squared statistics (.74) indicated a substantial effect size (Cohen, 1988).

The attained significance level (p-value) led to the rejection of the null hypothesis, underlining a substantial influence of cooperative learning strategies on the academic achievement of 9th-grade Biology students, as substantiated by the notable difference in mean scores between the two testing phases.

Table 2
Mean Scores of Test after Intervention Phase 1 and Test after Baseline Phase 2

Variables	N	Mean	SD	t-value	df	p
Test after intervention phase 1	40	18.1	3.32	4.57	39	0.001
Test after baseline phase 2	40	15.6	3.48			

To evaluate the impact of cooperative learning strategies on the academic achievement of 9th-grade Biology students, a paired-samples t-test was administered with a cohort of 40 participants. The analysis revealed a statistically significant effect of cooperative learning on students' academic performance. This effect was evident in the test scores after intervention phase 1 ($M = 18.1$, $SD = 3.32$), which showed a notable increase compared to the test scores after baseline phase 2 ($M = 15.6$, $SD = 3.48$), with a t-value of 4.57 and $p < 0.05$ (two-tailed) for 39 degrees of freedom. The mean increase in scores was 2.21, supported by a 95% confidence interval. Moreover, the eta squared statistics (.34) suggested a moderate effect size (Cohen, 1988).

The attained significance level (p-value) led to the rejection of the null hypothesis, indicating a significant effect of cooperative learning strategies on the academic achievement of 9th-grade Biology students, as evidenced by the substantial difference in mean scores between the two testing phases.

Table 3
Mean Scores of Test after Baseline Phase 2 and Test after Intervention Phase 2

Variables	N	Mean	SD	t-value	df	p
Test after baseline phase 2	40	15.6	3.48	9.01	39	0.003
Test after intervention phase 2	40	19.8	2.48			

To assess the influence of cooperative learning strategies on the academic achievement of 9th-grade Biology students, a paired-samples t-test was conducted involving a total of 40 participants. The results demonstrated a statistically significant effect of cooperative learning on students' academic performance. This effect was evident in the test scores after baseline phase 2 ($M = 15.6$, $SD = 3.48$), which notably increased compared to the test scores after intervention phase 2 ($M = 19.8$, $SD = 2.48$), with a t-value of 9.01 and $p < 0.05$ (two-tailed) for 39 degrees of freedom. The mean increase in scores was 5.74, with

a 95% confidence interval. Additionally, the eta squared statistics (.67) suggested a moderate effect size (Cohen, 1988).

The obtained significance value (p-value) led to the rejection of the null hypothesis, indicating a significant effect of cooperative learning strategies on the academic achievement of 9th-grade Biology students, as evidenced by the considerable difference in mean scores between the two testing phases.

Table 4
Mean Scores of Test after Baseline Phase 1 and Test after Intervention Phase 2

Variables	N	Mean	SD	t-value	df	p
Test after baseline phase 1	40	13.9	3.73	13.3	39	0.006
Test after intervention phase 2	40	19.8	2.48			

To evaluate the impact of cooperative learning strategies on the academic achievement of 9th-grade Biology students, a paired-samples t-test was conducted with a total of 40 participants. The results revealed a statistically significant effect of cooperative learning on students' academic achievement, as shown in the test scores after baseline phase 1 (M = 13.9, SD = 3.73) and the test scores after intervention phase 2 (M = 19.8, SD = 2.48), with a t-value of 13.3 and $p < 0.05$ (two-tailed) for 39 degrees of freedom. The mean increase in scores was 1.78, supported by a 95% confidence interval. Additionally, the eta squared statistics (.81) indicated a large effect size (Cohen, 1988).

The obtained significance value (p-value) led to the rejection of the null hypothesis, suggesting a significant effect of cooperative learning strategies on the academic achievement of 9th-grade Biology students, as evidenced by the notable difference in mean scores between the two tests.

Discussion

The primary aim of this study was to assess the impact of cooperative learning on the academic achievement of secondary school Biology students using single-subject experimental research. The researcher employed achievement tests to evaluate students' academic performance through interventions involving cooperative learning strategies, specifically utilizing the Jigsaw method. The research instrument underwent validation and reliability checks, and inferential statistics (paired sample t-test) were employed for data analysis, revealing a significant difference in mean scores.

Significant effects of cooperative learning on students' academic achievement were evident across multiple test comparisons. These included comparisons between test scores after baseline phase 1 (M = 13.9) and after intervention phase 1 (M = 18.1); after intervention phase 1 (M = 18.1) and after baseline phase 2 (M = 15.6); after baseline phase 2 (M = 15.6) and after intervention phase 2 (M = 19.8); and finally, after baseline phase 1 (M = 13.9) and after intervention phase 2 (M = 19.8). In all cases, the significance values were less than 0.05 ($p < 0.05$), indicating statistically significant effects of cooperative learning on academic achievement.

These research outcomes align with existing literature, supporting the notion that cooperative learning positively influences students' academic achievement. Previous studies, such as those conducted by Bibi (2002) and Arbab (2003), demonstrated the benefits of group learning in improving English grammar and achieving better academic results in general science. Kosar's (2003) examination of 7th-grade Social Studies students also highlighted the superiority of cooperative learning over traditional methods. Similarly, Parveen, Mahmood, Mahmood, and Arif (2011) found collaborative learning to be superior

in enhancing the achievement of grade 8 Social Studies students. Gillespie and Thomas (2006) affirmed the positive influence of cooperative learning on university students' academic achievement.

Studies focusing on specific cooperative learning methods, particularly the Jigsaw method, consistently showed enhancements in English skills, reading comprehension, and writing (Pan & Wu, 2013). Perkins and Saris (2001) reported that students using the Jigsaw method performed better in exams compared to those receiving conventional lectures alone, emphasizing a 5% increase between pretest and posttest scores. Research findings suggest that the Jigsaw method engages students dynamically in the learning process, making them more comfortable with their assigned tasks (Artut & Tarim, 2007).

Conclusion

The research findings affirm that incorporating cooperative learning strategies into traditional learning environments positively impacts students' academic achievement. The assessment involved four tests, each administered upon completing a chapter, revealing variations in students' scores. A comparison of Test 1 with Test 2 indicated an increase in scores during the treatment phase, where cooperative learning strategies were employed. Conversely, Test 2 compared with Test 3 showed a decrease in scores as cooperative learning was not applied. Test 4, conducted during the treatment phase, demonstrated a subsequent increase in scores when compared with Test 3. Therefore, the conclusion is drawn that cooperative learning significantly influences students' academic accomplishments. Implementing cooperative learning strategies in the classroom setting can prove beneficial for student achievement.

Recommendations

Based on the research findings and conclusions, the following recommendations are proposed:

- Integrate relevant cooperative learning techniques into the national Biology curriculum, aligning them with specific topics within each chapter.
- Include specific teaching methodologies for particular topics in the Biology textbook, accompanied by instructions for teachers.
- Provide training to both public and private sector teachers on effectively managing class time and content coverage using cooperative learning strategies.
- Conduct workshops and seminars to emphasize the importance of employing cooperative learning strategies.
- Encourage teachers to incorporate cooperative learning strategies as activities in their classrooms to engage a maximum number of students in the learning process.

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