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Effect of Jigsaw Strategy on Academic Achievement and Motivation of Science Students: Evidence from Classroom Intervention

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Abstract

Effective instruction and learning in science subjects equip students with critical thinking skills, problem-solving abilities, and a profound understanding of the natural world. This knowledge empowers them to make informed decisions, foster innovation, and contribute to scientific progress for the benefit of society as a whole. The aim of this study was to compare the impact of lecture and jigsaw teaching strategies on the academic achievement and motivation of science students. Conducted as a quasi-experimental study, the research involved 52 elementary-grade students divided into two separate classrooms. Through random assignment, one classroom comprised the jigsaw group (25 students), while the other served as the lecture group (27 students). The intervention spanned a nine-week period. A self-developed test and an academic motivation scale were administered before and after the intervention to assess the effects of jigsaw instruction on students' achievement and motivation. The collected data underwent analysis using the Kolmogorov-Smirnov test, Shapiro-Wilk test, and independent sample t-test. The findings indicated a significant difference in the performance and motivation scores of science students between the experimental (jigsaw) and control (lecture) groups. In both instances, students taught using the Jigsaw technique exhibited greater improvement in their mean scores compared to those instructed through the traditional lecture method. As a conclusion, the study recommends the incorporation of the Jigsaw technique in classroom practices to enhance science education.

Keywords: *Jigsaw Strategy, Academic Achievement, Academic Motivation, Lecture Method, Science Education.*

Introduction

In contemporary education, the emphasis has shifted from rote memorization and information retention to the cultivation of information retrieval abilities and problem-solving aptitude among students. Several methodologies have been devised to enhance this approach and optimize the process of learning(Şengul & Katranci, 2014; Karacop & Diken, 2017). A pedagogical style characterized by the teacher-centered approach and depends on the passive transmission of knowledge fosters surface-level learning (Muenks et al., 2017).The findings of the studies indicate that students do not like traditional teaching approaches, such as lectures method, as they do not facilitate students' conceptual understanding,motivation, and learning (Sanaie etal., 2019). Globally, research on science education continually emphasizes on the learning conditions, teaching methods, and techniques that produce the most effective learning outcomes.Therefore, in order to promote effective learning outcomes, it is desirable for especially

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science educators to adopt a pedagogical approach that can be flexibly adapted to accommodate diverse cognitive styles (Karacop, 2017). In this context, Cooperative learning methods have been widely recognized as a highly effective approach for promoting motivation and facilitating meaningful learning (Drouet et al., 2023; Ullah et al., 2023).

The benefits of group projects and cooperative learning practices in the fields of science have been extensively documented for several years (Thurston et al., 2010; Day & Bryce, 2013).The cooperative learning technique offers the opportunity for learners to actively engage in cognitive, meta-cognitive and motivational aspects of learning, hence assisting them in establishing learning objectives. Consequently, individuals attain a sense of self-efficacy and experience an elevated degree of motivation and achievement (Fernandez, 2017; Ullah & Akbar, 2021).

Within this framework, the Jigsaw teaching strategy (JTS) stands out as a contemporary cooperative learning approach employed in science education. In response to the educational challenges identified by Aronson in 1970 (Ural, 2017), this approach was formulated. It entails grouping students into small teams comprising three to five diverse individuals. Each group member is assigned a particular topic to study ensuring the distribution of content across all participants during classroom sessions. Subsequently, students operate within two main groups: the primary groups and the jigsaw groups. The primary groups are fragmented, resembling pieces of a jigsaw puzzle, and students then join the resulting jigsaw groups. These jigsaw groups consist of individuals from various primary groups who collaborate in studying the same subject. Following their learning experience in a jigsaw group, students return to their primary groups to engage in discussions with members about the acquired material (Aydin & Biyikli, 2017).

To engage in the learning process, learners must be motivated and interested in the topic (Guiffrida et al., 2013). Individual techniques of teaching have minimal influence on motivation (Komarraju et al., 2014). Motivation is heavily influenced by the teacher's teaching approach. A learner-centered and adaptable instructor may help students learn and motivate. The Jigsaw strategy has been proven to improve academic achievement, motivation, and learning results more than the lecture technique (Safkolam et al.,2023; Abuhamda et al.,2020). Other research has found that using collaborative learning approaches as the strategy of Jigsaw, promotes academic motivation, improves progress and improves cooperation among learners (Obafemi et al., 2023).Literatures document the effects of jigsaw on the motivation and outcomes of school students (Drouet et al., 2023).Additionally, some studies also examined the impact of cooperative learning on student motivation (Yunita et al., 2020). In line with this; several studies also reported the effects of collaborative work on student activeness and motivation. Finally, the study concluded that the strategies based on collaborative approach increased students' academic motivation and achievement(Moonaghi, 2014; Komarraju & Nadler, 2013).Hence, the main objective of the study is to find out the effect of jigsaw technique on students achievement and motivation in science subject.

Hypotheses

The subsequent hypotheses were formulated and evaluated at a significance level of .05:

1. There is no statistically significant difference in the science achievement scores between students instructed through the Jigsaw Strategy and those taught using the Conventional Lecture Method.
2. There is no statistically significant difference in the Science motivation scores among students taught with the Jigsaw strategy compared to those instructed through the conventional lecture method.

Materials and Methods

The study used the pretest, posttest, control group design from one of the quasi-experimental designs. 52 Participants were selected purposively from two intact classes of 8th Grade. The allocation of each group to the intervention and lecture group was determined by a coin toss. The control group underwent instruction employing the conventional lecture technique, while the experimental group received teaching through the Jigsaw learning strategy.

Instruments

Data were collected using two research instruments. One research instrument was developed by the researchers and the other research instrument was adopted. The developed research instrument was in the form of a test. Test was developed by using the table of specification and Bloom taxonomy of educational objectives. Test consisted of 30 MCQs developed from the text book of grade 8^{th}. The adopted research instrument was Harter Academic Motivation Scale. Academic Motivation scale comprised of 33 statements, employing a five point Likert scale. Certain elements as 3, 5, 8, and 15, were reverse-scored. Both the instruments were employed to assess the students' achievement and motivation levels both before and after the intervention.

Pilot Testing

In order to maintain internal consistency, the Academic Motivation Scale underwent a pilot test with Grade 8 science students. Table 1 displays the Cronbach's alpha of the questionnaire.

Table 1: Cronbach alpha for Academic Motivation Scale.

S.#	Scale	Cronbach Alpha value
	Academic Motivation Scale	.83

The outcomes presented in Table 1 indicate that the Cronbach's alpha value of the Academic Motivation Scale exceeds 0.7, signifying a high level of internal consistency for the questionnaire.

We use confirmatory factor analysis for the construct validity of academic motivation instrument. The overall goodness of fit of the CFA is reported in table 2

Table 2: Goodness-of-fit indices for CFA.

Fit Statistics		Value
Likelihood ratio		
	χ^2/df	2.11
	$P > \chi^2$	.183
RMSEA		
95% CI, lower bond		.014
upper bond		.091
P(RMSEA<.05)		.14
Size of Residual		
SRMR		.012
CD		.812

Where "RMSEA= Root mean squared error of approximation, SRMR= Standardized root mean squared residual, CD= Coefficient of determination".
The goodness-of-fit indexes results are presented in Table 1, demonstrating that the overall model is a good fit. The null hypothesis of a good fit cannot be rejected based on the chi-square test ($p > .05$). The calculated values of chi-square and degrees of freedom (df) were also close to two ($\chi^2/df = 2.11$), further validating the overall model's good fit. The lower bound of RMSEA and upper bound of RMSEA values indicate that the model is a good fit. Similarly, SRMR was close to zero (SRMR = .012), reflecting a high degree of goodness of fit. Moreover, the coefficient of determination (CD = 0.81) reveals that 81 percent of the variation in the construct was explained by the specified indicators. Based on the results of the confirmatory factor analysis, this study retains all thirty-three items of the academic motivation instrument specifically designed for classroom interventions.

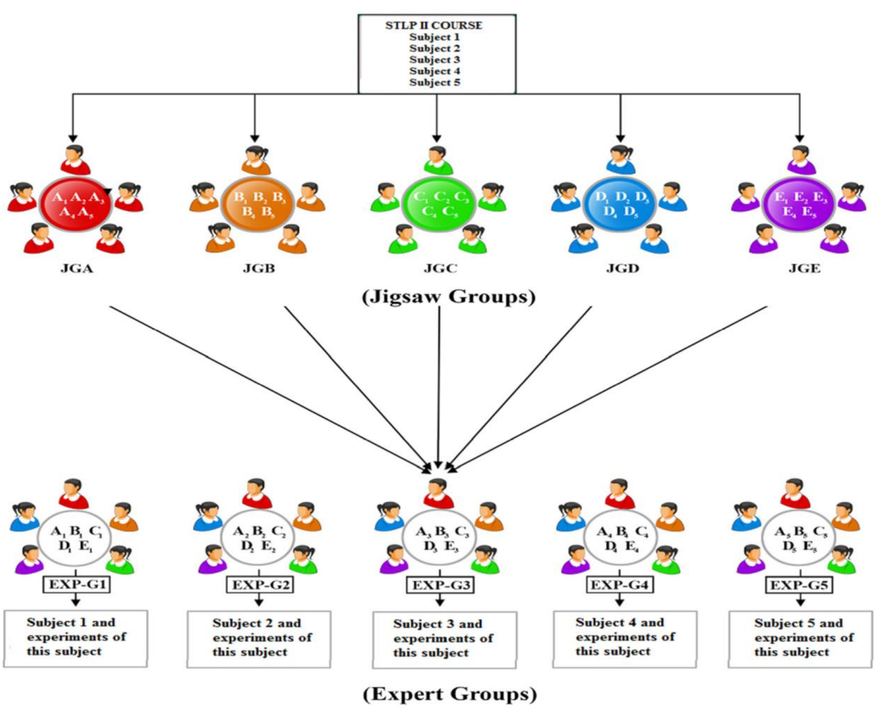
Intervention

The Test and Academic Motivation Scale were administered before and after the intervention to assess the impact of jigsaw instruction on students' achievement and motivation. To ensure the internal validity of the research, consistent teaching durations, reading materials, exams, and classroom settings were maintained. Both the experimental and control groups received instructions on the same day, albeit at different times, and the researcher emphasized the importance of avoiding bias.

The research spanned a nine-week period, with the pretest administered in the first week. Students taught using the jigsaw method were organized into five heterogeneous main groups, a common practice in elementary schools, with each group comprising five students. Conversely, students taught through the traditional grammar translation method were instructed as a whole class. To implement the intervention effectively and ensure balanced teams, the jigsaw teaching group's students were categorized as high, medium, and low achievers based on their pretest performance.

Each jigsaw group was assigned different topics. Students studied, presented, and discussed their topics with the class. During the discussion, the jigsaw group addressed questions from the class. Subsequently, the jigsaw groups dispersed like pieces of a jigsaw puzzle (Doymus, 2008; Goodwin, Miller & Cheetham, 1991)and students transitioned into these groups. Expert groups consisting of individuals from other jigsaw groups allocated the same material. After the presentation of all subtopics, one student from each jigsaw group formed Expert groups. The experts then returned to their jigsaw groups to teach their subtopics to other team members. This setting held students accountable for both individual learning and group achievement. The working order of the group is reflected in figure1.

Figure 1: Working Order in Cooperative Groups.



This process was repeated weekly throughout the study period. During each phase, the teacher played the role of a facilitator, providing assistance to students as needed. A post-test was administered to students after the intervention to assess the impact of jigsaw instruction on their achievement and motivation. The process of the intervention is shown in table 3

Table 3

G.	Pre-test	Intervention	Post-test
Exp.	$O_{1:}$ Test O2: Academic Motivation Scale	X_1 Jigsaw strategy	O_1: Comprehension test O2: Academic Motivation Scale
Ctrl.	O_1 :Test O2: Academic Motivation Scale	X_2Traditional Method	$O_{1:}$ Test O2: Academic Motivation Scale

Fig1. The process of the study.

Results

The study employed the independent sample t-test to check the mean difference between the groups. Before employing the test, the normality of data is tested using Kolmogorov-Smirnov (KS) and Shapiro-Wilk (SW) tests.

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The results of normality test for pre-test and post-test scores are reported in table1.

Table 4: Tests of Data Normality.

Variables	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	***df***	***p***	***Statistic***	***df***	***p***
Score in Pre-test	.113	52	.212	.912	52	.333
Scores in Post-test	.125	52	.215	.132	52	.422

Table 4 illustrates that the results from both tests employed to assess data normality are statistically insignificant ($p > .05$). This suggests that the sample follows a normal distribution, as the null hypothesis, indicating normality of the data, is not rejected.

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Table 5: Tests of Data Normality of Pre and Post Test.

Variables	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	***df***	***P***	***Statistic***	***df***	***p***
Pre-test scores	.187	52	.190	.985	52	.370
Post-test scores	.088	52	.085	.981	52	.196

Table 5 illustrates that the results from both tests employed to assess data normality are statistically insignificant ($p > .05$). This suggests that the sample follows a normal distribution, as the null hypothesis, indicating normality of the data, is not rejected.

Hypothesis One

There is no significant difference in the science achievement scores of students taught with Jigsaw-Strategy and Conventional Lecture Method.

Table 6: Results of the Difference in Mean Scores of Science Achievement in Pre-Test and Post-Test.

Tests	Groups	*N*	*M*	*SD*	*t-value*	*p-value*
Pre-test	Experimental	25	17.46	3.31	.44	.479
	Control	27	17.58	3.42		
Post-test	Experimental	25	24.96	3.14	6.16	.001
	Control	27	20.41	4.82		

Thetable 6 presents the outcomes of an independent sample t-test on the data. In Table 2, the average pre-test scores for both groups are nearly identical (control=17.58; experimental=17.46). Additionally, with a t-value of -0.44 and p-value of .479 ($p > .05$), there is no significant difference in pre-test of the science achievement among the both groups. Participants instructed with the jigsaw strategy and those with the conventional method exhibit comparable scores, leading to a failure to reject the null hypothesis.

However, a significant difference emerges between the groups when examining the average post-test results in Table 2 (control=20.41; experimental=24.96). Moreover, with a t-value of -6.16 and p-value of .001 ($p < .05$), there is a notable discrepancy in science achievement post-test of both groups, favoring the experimental group. In conclusion, it can be reasonably affirmed that students taught using the jigsaw method demonstrated higher performance in science achievement tests than students taught with conventional method.

Hypothesis2

There is no significant difference in the Science motivation scores of students taught with Jigsaw strategy and conventional lecture method.

Table 7: Results of the Difference in Mean Scores of Motivation in Pre-Test and Post-Test.

Test	Groups	*N*	*M*	*SD*	*t-value*	*p-value*
Pre-test	Experimental	25	44.71	6.55	78	1.33
	Control	26	45.81	5.87		
Post-test	Experimental	25	61.21	8.63	6.02	.001
	Control	26	52.24	6.86		

Table 7 reveals a slight disparity in the pre-test motivation scores between both groups (control=45.81; experimental=44.71). However, with a t-value of -0.78 and p-value of 1.33 ($p > .05$), there is no noteworthy distinction in the pre-test motivation scores of both groups.

On the other hand, Table 7 indicates a significant contrast in the average post-test scores of both groups (control=52.24; experimental=61.21). Furthermore, with a t-value of -6.02 and p-value of .001 ($p < .05$), a significant difference is evident in the post-test motivation scores of both groups, favoring the experimental group. These findings lend support to the assertion that the implementation of the jigsaw teaching strategy enhances students' motivation in the science subject.

Discussion

The study's results indicated that employing a jigsaw puzzle as a cooperative learning tool proves to be a successful teaching strategy. The effectiveness of this strategy in enhancing students' science achievement aligns with the findings of(Goodwin et al., 1991) and (Ojekwu & Ogunleye, 2020), who observed similar positive outcomes in diverse contexts. The data further revealed that the jigsaw puzzle learning technique surpassed the traditional lecture method in promoting student success (Juweto, 2015; Drouet et al., 2023).This superiority may stem from the integration of individual, small group, and whole group activities inherent in the Jigsaw learning processes.

The study's results find support in scientific education research, particularly in the realms of laboratory instruction and cooperative learning. Other studies (Goodwin et al., 1991) have also noted higher development of learners' scientific process skills using laboratory methods. The present study's outcomes resonate with the research conducted by (Adesoji et al., 2015), exploring the impact of cooperative learning practices on student chemistry achievement. According to their findings, the cooperative learning technique is advantageous in enhancing students' success in chemistry.

Moreover, the study revealed that the jigsaw puzzle learning technique heightened students' interest and motivation in the science subject. A substantial difference in interest scores emerged between students taught by the jigsaw puzzle technique and those instructed through the traditional lecture method. This difference can be attributed to the active engagement fostered by the learning process and the appeal of Jigsaw group activities. This aligns with the findings of (Darlington, 2015; Sanaie et al., 2019), which underscore the significance of a hands-on approach in teaching and the efficacy of such strategies in boosting students' interest.

Conclusions and Recommendations

According to the study's findings, the jigsaw technique proved highly beneficial in elevating students' achievement in the Science subject and enhancing their motivation for the subject. These findings suggest that Science educators should incorporate cooperative learning techniques, with a specific emphasis on the jigsaw strategy, more regularly in the classroom. This approach aims to elevate student engagement and active participation, thereby contributing to advancements in their Science achievement and fostering sustained interest in the subject.

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