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DEEP LEARNING-BASED JIGSAW: BOOSTING STUDENT ENGAGEMENT AND PERFORMANCE IN STATISTISC LEARNING

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ABSTRACT
Learning statistics remains a persistent challenge for many junior high school students due to abstract concepts and limited engagement in traditional classrooms. Therefore, improving students' understanding and motivation in statistics learning requires innovative learning models that promote active, meaningful participation. This study investigates the impact of a novel deep learning-based Jigsaw model on Grade VIII students' engagement and statistics learning outcomes at SMPN 2 Mojosari. Integrating principles of mindful, meaningful, and joyful learning, the model emphasizes understanding, application, and reflection to foster deeper cognitive engagement. Using a quantitative one-shot case study design with 32 students, data were gathered through student activeness questionnaires and statistics achievement tests. Findings reveal that this approach significantly enhances student activeness, promoting collaboration and critical thinking during discussions, presentations, and reflections. Most students demonstrated medium to high engagement levels, while average learning outcomes surpassed the school's minimum mastery criteria. Given the urgent need to improve statistical literacy and student motivation in junior high schools, the deep learning-based Jigsaw model offers a promising, effective alternative strategy to traditional teaching methods. This research contributes valuable evidence supporting innovative, student-centered learning in mathematics education.

Introduction

Educational quality plays an important role in determining the quality of human resources of a nation. Education not only shapes intellectually intelligent individuals but also contributes to creating a peaceful, open to change, and democratic society (Fadilla, 2023). To realize these grand objectives, the educational system needs continuous improvement through innovations in curriculum, learning strategies, and evaluation methods relevant to the demands of the 21st century. In the context of the 21st century, the learning process is required to transform from conventional approaches focused on knowledge transfer to deeper and more meaningful approaches. Deep learning invites students to be actively involved in learning processes that are not only enjoyable but also conscious and meaning-oriented (Quinn & Fullan, 2017). Thus, students are expected to comprehensively understand concepts, connect them to real life, and reflect to develop their potential continuously (Hattie & Zierer, 2017). Such learning experiences enable the formation of critical thinking abilities, collaboration, and active knowledge construction (Pellegrino & Hilton, 2013).

However, the reality of mathematics learning in Indonesia shows that major challenges are still faced. Based on the PISA 2018 results, Indonesia's position in mathematics is still low, ranking 73rd out of 81 participating countries (PISA, 2019). Similar results were also shown by the TIMSS 2011 survey which placed Indonesia in 44th position out of 46 countries (Mullis et al., 2020). These achievements indicate that mathematics learning has not fully provided meaningful experiences and tends to remain procedural.

School observations show that mathematics learning is still largely dominated by lecture methods, with teachers as the center of information and students only passively receiving material. As a result, students find it difficult to understand concepts and tend to consider mathematics a difficult subject (Anjariyah et al., 2024). Such non-meaningful learning encourages students to merely memorize formulas without understanding the concepts behind them, which ultimately impacts low reasoning abilities and mathematical problem-solving skills (Indriani et al., 2021). In response to these challenges, a learning approach that encourages active student involvement while applying deep learning principles is needed. One effective alternative is the Jigsaw cooperative learning model. In this model, students work in small groups, exchange information, and are responsible for their group members' understanding (Slavin, 2012). Research shows that cooperative learning models have positive impacts on students' mathematics learning outcomes, particularly at the junior high school level (Firdaus & Murtafiah, 2024). The advantage of the Jigsaw model lies in its ability to build positive interdependence among group members, so that each student has an important role in achieving collective success (Dinda Aulia Rahmi et al., 2023).

The integration of deep learning principles in the Jigsaw model can strengthen learning effectiveness. Deep learning requires students to engage in cognitively challenging activities, collaborate with peers, and reflect on their learning processes (Darling-Hammond et al., 2020). Deep learning in education relates to how teachers provide learning experiences and create learning atmospheres that encourage student understanding, stimulate higher-order thinking skills, and enable knowledge application in various real situations (Mustaghfirin & Zaman, 2025; Suyanto et al., 2025). Deep learning produces a holistic framework for improving educational quality (Feriyanto & Anjariyah, 2024). When applied in the Jigsaw model, this principle encourages students not only to learn material individually but also to teach and discuss concepts with other group members, making understanding deeper and more meaningful.

Statistics learning as one branch of mathematics has special characteristics that require appropriate learning approaches. Statistics involves data collection, processing, analysis, and interpretation that requires critical and analytical thinking abilities (Garfield et al., 2015). Concepts in statistics such as central tendency measures, dispersion, and data presentation need to be understood deeply by students so they can apply them in real situations in their daily lives. Observation results at SMPN 2 Mojosari Mojokerto show that the learning approaches used are still traditional. The teaching and learning process is dominated by lecture methods and problem exercises, while students more often become passive information recipients. This impacts low student participation levels and unsatisfactory learning outcomes. Not infrequently, students also show reluctance to actively participate in discussions or present answers in front of the class.

As stated by (Sadeghi et al., 2021), the use of inappropriate learning models can hinder students' mathematical ability development. Therefore, innovative and enjoyable learning approaches are needed so that the learning atmosphere becomes more lively and encourages students to be actively involved, think creatively, and work together. One approach considered potential is the Jigsaw cooperative learning model combined with deep learning principles. In this context, active student involvement becomes an important indicator of learning success. Active students tend to understand material more easily and show improved learning outcomes (Murni, 2021). The Jigsaw model allows students to act as both learners and teachers in small groups, strengthening responsibility and facilitating understanding through discussion and collaboration. This activeness appears from student involvement in group discussions, willingness to learn independently, and ability to explain material to friends.

Based on the conditions described, there is a clear gap between the ideal conditions of mathematics learning and the reality in the field. On one side, 21st-century learning requires students to be active, creative, and able to understand concepts deeply. On the other side, mathematics learning, particularly statistics, is still dominated by conventional approaches that result in low learning outcomes and student activeness. This gap shows the need for research that examines the effectiveness of innovative learning models to overcome these problems.

The main problems identified in this research include low student participation in statistics learning, including lack of initiative in class discussions and reluctance when asked to present answers. Additionally, student learning outcomes also show suboptimal achievements, as shown by international data such as PISA and TIMSS, as well as school observation results that show weak understanding of basic statistical concepts. On the other hand, the learning approaches used by teachers are still teacher-centered and have not accommodated meaningful and reflective learning principles.

To answer these challenges, this research offers an alternative approach through implementing the Jigsaw cooperative learning model integrated with deep learning principles. This model is chosen because it can build individual and group responsibility in a balanced way, encouraging active participation from every student. Deep learning also helps students understand material not only theoretically but also applicatively and meaningfully. It is hoped that the combination of both approaches can create more active and comprehensive learning experiences, particularly on statistics material.

Previous studies have widely examined either the Jigsaw cooperative model or deep learning principles separately, but research that integrates both within the context of statistics learning remains limited. Most studies have focused on improving students' achievement in general mathematics topics, while few have explored how deep learning principles—such as reflection, meaningful engagement, and collaboration—can be embedded in the Jigsaw process to promote active participation and deeper conceptual understanding. This study therefore presents a novel contribution by combining deep learning and Jigsaw strategies into a unified instructional framework designed specifically for statistics learning. The integration of these approaches is expected to transform passive, procedural learning into an active, reflective, and student-centered experience that strengthens both engagement and comprehension.

This research aims to examine the extent to which implementing the deep learning-based Jigsaw model can improve activeness and learning outcomes of Grade VIII students at SMPN 2 Mojosari Mojokerto. Additionally, this research also tests whether there are significant differences between students who learn with this innovative model and those who follow conventional learning. Through these research results, it is hoped that new insights can be obtained in developing mathematics learning models more suitable to current needs and student characteristics.

Method

This research employed a quantitative approach and utilized a one-shot case study design to investigate the impact of implementing Jigsaw cooperative learning, combined with deep learning approaches, on student engagement and learning outcomes in statistics topics. The quantitative approach was chosen because it enables the researcher to objectively measure the magnitude of change resulting from the treatment using numerical data and statistical analysis. Through quantitative methods, causal relationships between the learning model and student outcomes can be identified more accurately, allowing the findings to be generalized within similar educational contexts (Creswell, 2014).

This study took place at SMPN 2 Mojosari, Mojokerto Regency, in the 2024/2025 academic year. All Grade VIII students served as the population, and the research sample was selected using multistage random sampling, where Class VIII-G with 32 students was designated as the experimental class.The research implementation followed a one-shot case study design, where subjects were given treatment (X) in the form of implementing a Jigsaw model based on deep learning principles, then observation (O) was conducted to measure their activeness and learning achievements. The deep learning principles applied were oriented toward learning experiences that raise awareness, are meaningful, and enjoyable, involving processes of understanding, applying, and reflecting on statistics material. The Jigsaw model used followed steps as explained by Rusman (2018), including expert group discussions, group presentations, and learning reflection.

Three types of instruments were developed in this research: student learning activeness questionnaires, teacher activity observation sheets, and learning outcome tests. Observation sheets were designed to observe the conformity of the learning process with deep learning-based Jigsaw model syntax. The activeness questionnaire was compiled referring to five indicators: student enthusiasm, interaction with teachers, group cooperation, discussion activeness, and participation in concluding learning. Meanwhile, learning outcome tests were made based on statistics learning objectives aligned with competency indicators. Data were collected through three main techniques: observation during the learning process, filling out learning activeness questionnaires by students after learning completion, and giving written tests at the end of sessions as post-tests. Observation results were utilized to ensure the learning model was implemented according to procedures.

Activeness data analysis was conducted using percentage formulas, namely $P = (a/b) \times 100\%$, with P as percentage, a is the score obtained by students, and b is the maximum score. Activity level interpretation categories refer to criteria by Wahab & Rosnawati (2021), namely: 1%-25% (very low), 26%-50% (low), 51%-75% (medium), and 76%-100% (high). Meanwhile, student learning outcomes were analyzed using one-tailed t-tests to compare student average scores with Minimum Mastery Criteria values at 5% significance level ($\alpha = 0.05$). Statistical calculation steps followed guidelines from Sudjana (2022), including calculation of means, standard deviations, and hypothesis testing with the formula $t = (\bar{x} - \mu_0)/(s/\sqrt{n})$, using t-student distribution with $df = (n-1)$.

Results and Discussion

Research Results

1. Student Learning Activeness Data

Information about student learning activeness was collected through questionnaire distribution after implementing Jigsaw cooperative learning with deep learning approaches.

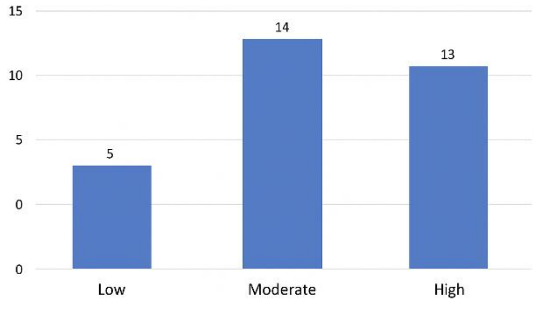

Figure 1. Distribution of Student Learning Activeness

Based on questionnaire analysis results, visualization of student activeness levels is displayed in Figure 1. From a total of 32 students who participated in the research, most students showed medium activeness levels, namely 14 students (43.8%). Meanwhile, students categorized as very active were also quite numerous, namely 13 students (40.6%). Only a small portion, 5 students (15.6%), still showed low learning activeness levels. These results reflect increased student participation during the learning process

2. Student Learning Outcome Data

Student academic abilities were measured using final tests (post-tests) after they participated in deep learning-based Jigsaw cooperative learning. To test the effectiveness of this model, statistical analysis was conducted with one-tailed hypothesis testing, with hypotheses H_0, H_1, and testing criteria:

H_0: $\mu = 78$ (student learning outcome average equals 78)

H_1: $\mu > 78$ (student learning outcome average is greater than 78)

Reject H_0 if t_calculated $\geq t_{1-}\alpha$, accept H_0 otherwise.

Based on statistical analysis, t_calculated and t_table values were obtained as follows:

t_calculated = $(\bar{x} - \mu_0)/(s/\sqrt{n})$
= $(82.69 - 78)/(11.52/\sqrt{32})$
= 2.31

t_table = $t_{1-}\alpha = 1.70$ (with df = 31)

From calculation results, it can be seen that the t_calculated value of 2.31 is higher than the t_table value of 1.70. Therefore, H_0 is rejected. This means that at 5% significance level ($\alpha = 0.05$), the average student learning outcomes after participating in learning are significantly higher than the reference number 78. This concludes that the implemented learning has positive impacts on student learning achievements

Discussion

1. Effect of Deep Learning-Based Jigsaw Model on Student Activeness.

The results of this study reveal that using Jigsaw cooperative learning combined with deep learning approaches provides positive contributions to increasing student activeness in statistics learning. Based on obtained data, 84.4% of students showed activeness levels in medium to high categories, while only 15.6% of students were still in the low category. This finding aligns with comprehensive systematic reviews by Vives et al. (2025), which reflect more than four decades of Jigsaw model implementation since it was first developed. That study confirmed that the Jigsaw model remains relevant and effective for encouraging student activeness in various learning contexts.

The success of the Jigsaw model in increasing student activeness can be viewed from the social constructivism theory perspective introduced by Vygotsky and Luria (1978). This view is strengthened by recent studies from Chen (2025), who stated that cooperative learning strategies like Jigsaw have strong transformative power because they are based on deep constructivism philosophy. In this approach, students not only become information recipients but actively form understanding through meaningful and collaborative social interactions.

The Jigsaw model creates learning structures that require each student to be responsible for certain material parts and then teach them to their group members. This process naturally encourages students to be active in learning because they have clear individual responsibilities, consistent with individual accountability concepts in cooperative learning (Johnson & Johnson, 2009). Recent research in medical education by Alharbi et al. (2024) shows that the Jigsaw method produces higher academic performance levels compared to traditional small group discussions, confirming this model's effectiveness in increasing active student participation.

Student activeness in the dominant medium category can be explained through the Zone of Proximal Development theory from (Vygotsky & Luria, 1978) strengthened by recent neuroeducation research from (Decety et al., 2004). They showed that cooperative learning activates neural networks related to social-cognitive processing, supporting student transitions from actual abilities to potential abilities through scaffolding provided by peers

2. Effect of Deep Learning-Based Jigsaw Model on Student Learning Outcomes.

Statistical data processing results indicate that implementing Jigsaw cooperative learning combined with deep learning approaches significantly contributes to improving student learning achievements in statistics subjects. The average score obtained by students, 82.69, significantly exceeds the comparison value of 78, based on significance tests at 0.05 confidence level.

This improvement can be understood through several theoretical foundations relevant to recent research findings. First, the Jigsaw model encourages positive interdependence among students, as explained in cooperative learning theory by Johnson and Johnson (2009). This positive interdependence not only strengthens academic outcomes but also enriches students' social and emotional skills in learning processes (Johnson & Johnson, 2009). Second, deep learning approach integration also provides reflective thinking structures, enabling students to build stronger and more meaningful conceptual understanding. This approach encourages high cognitive involvement and develops critical thinking abilities and personal meaning-making toward learning material. Recent research by (C. M. Chen & Huang, 2024) shows that the Jigsaw method in programming learning in metaverse virtual spaces produces significant improvements in conceptual understanding and problem-solving abilities. This is relevant to statistics learning that requires deep conceptual understanding to apply abstract concepts in various contexts.

Recent research results (Liu et al., 2024) show that deep learning integrated with digital technology proves capable of strengthening students' long-term memory, with improvements up to 35% compared to conventional approaches. Although this research uses digital technology, the same deep learning principles apply in the context of deep learning-based Jigsaw applied in this research.

The relatively large standard deviation (11.52) shows variation in student learning achievements. This variation can be explained by differences in students' initial abilities, learning styles, and adaptation levels to new learning models. Recent meta-analysis research by (Alvarado Rodriguez & Rosado Cusme, 2023) shows that learning outcome variations in cooperative learning are influenced by factors such as students' metacognitive abilities, intrinsic motivation, and quality of social interactions in groups

3. Relationship Between Activeness and Learning Outcomes in Jigsaw Model Context.

The relationship between activeness and learning outcomes in this study reveals pattern similarities with previous findings on active learning theory strengthened by recent neuroeducation research. fMRI studies conducted by (Decety et al., 2004) revealed that active learning activates prefrontal cortex areas related to high-level information processing and long-term memory formation.

The Jigsaw structure that requires each student to become an "expert" in certain topics encourages activeness because students must prepare to teach their friends. This process involves deep learning because students must understand concepts well, not just memorize. Recent study results conducted by Venkatramanan et al., (2021) show that learning by teaching approaches in digital environments can significantly increase students' critical thinking abilities, up to 42 percent higher than conventional learning methods.

In statistics learning context, recent research by (Garfield & Ben-Zvi, 2007) shows that cooperative approaches in statistics learning produce significant improvements in statistical literacy and students' statistical reasoning abilities. They found that students learning through group discussions and peer teaching showed deeper conceptual understanding of concepts such as distribution, probability, and statistical inference.

4. Digital Technology and Hybrid Learning Perspectives

Recent developments in education show the importance of technology integration in cooperative learning. Research by (Gudoniene et al., 2025) shows that the Jigsaw model implemented in hybrid learning environments (combination of face-to-face and digital) produces student engagement improvements up to 38% compared to traditional implementations.

Although this research was conducted in traditional settings, these findings provide important implications for developing deep learning-based Jigsaw models in the future. Digital platform integration can strengthen collaborative aspects and facilitate more comprehensive learning process documentation.

5. Theoretical and Practical Implications

Findings in this research provide empirical evidence strengthening the relevance of cooperative learning theory (Johnson & Johnson, 2009) and deep learning approaches (Marton & Säljö, 1976) in mathematics teaching contexts, particularly on statistics material. Data shows that most students (84.4%) are at medium to high activeness levels, accompanied by significant learning outcome improvements. This suggests that collaboration between both approaches can optimally support more meaningful learning processes.

These findings are also strengthened by systematic review results from Martínez et al. (2023), which conclude that cooperative learning has large effects on student learning outcomes (Cohen's d = 0.76), especially in fields requiring deep conceptual understanding like mathematics and science.

From field implementation perspectives, these results show that implementing Jigsaw models integrated with deep learning principles can be utilized by teachers as powerful methods for building optimal student learning involvement. Research by Xu & Brown (2016) even revealed that teachers implementing Jigsaw models with adequate professional development support succeeded in improving student learning performance up to 28% in just one semester.

Conclusion

Referring to research findings and discussions that have been examined and strengthened by current literature (2020-2025), it can be concluded that implementing Jigsaw cooperative learning integrated with deep learning approaches has positive and significant effects in improving activeness and student learning outcomes on statistics material. Data shows that most students (84.4%) are in medium to high activeness categories, accompanied by statistically significant learning outcome improvements (average score 82.69 compared to comparison value 78; t-calculated = 2.31 > t-table = 1.70; $p < 0.05$). These results confirm that cooperative learning based on deep learning approaches can optimize mathematics learning processes more comprehensively. When deep learning principles—namely mindfull, meaningful, and joyful—are present in learning, students not only understand concepts conceptually but can also apply and reflect on them in broader contexts. The Jigsaw model proves to be an effective facilitator for creating collaborative and deep learning atmospheres, particularly in understanding statistical concepts. Furthermore, these findings align with current research trends showing that the Jigsaw model remains relevant in the digital era. Its ability to be combined with educational technology makes it a strategic choice in answering 21st-century learning challenges, especially for Generation Z. Therefore, this model has great potential for continued development in adaptive and transformative learning innovation contexts.

In future studies, it is recommended to expand the implementation of the deep learning-based Jigsaw model to different mathematical topics and educational levels to examine its consistency and adaptability. Further research can also integrate digital learning platforms or gamification elements to strengthen collaboration and reflection in online or hybrid learning environments. In addition, mixed-method approaches may be used to gain deeper insights into how students construct understanding and engage emotionally during deep learning-based cooperative activities. Such extensions will contribute to developing more comprehensive, technology-oriented frameworks for meaningful mathematics learning in the 21st century.

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