

Application of the Jigsaw Cooperative Learning Model Assisted by Solar System Scope Simulation to Improve Learning Outcomes of Junior High School Students

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Abstract: Science learning on the subject of Earth and the solar system requires learning strategies that can improve students' conceptual understanding so that their learning outcomes improve. This study aims to analyze student learning outcomes using jigsaw cooperative learning assisted by Solar System Scope simulations to improve junior high school students' learning outcomes on the subject of Earth and the Solar System. This study uses a pre-experimental, one-group pre-test-post-test design. Student learning outcomes were measured using pre- and post-tests with a sample of 32 students from class VII-F MTs Negeri 3 Surabaya, and analysed using N-gain and the Shapiro-Wilk normality test. The statistical test used was a non-parametric test, namely the Wilcoxon test. Student learning outcomes increased, yielding an N-gain score of 0.77, interpreted as "High". The normality test showed that the data were not normally distributed, so the Wilcoxon test was used. The Wilcoxon test results showed a significant difference after jigsaw cooperative learning assisted by solar system scope simulations. Based on these results, jigsaw cooperative learning, supported by solar system scope simulations, is effective in improving student learning outcomes in Earth and solar system material.

Keywords: Cooperative Jigsaw; Earth and Solar System; Learning Outcomes; Solar System Scope.

Introduction

Natural sciences are essentially a representation of simplified natural principles or laws. Concepts in natural sciences are presented through abstract symbols. Science education emphasizes the development of three key aspects, namely attitude, knowledge, and skills, the application of which begins to be specifically focused on the junior high school level. The science learning process involves active interaction between students, teachers, and various learning media related to the natural environment [1]. Science education also emphasizes process involvement and direct experience, making students more motivated to participate in science learning. This attitude fosters a spirit of learning, enabling students to contribute to improving their understanding of the material in class [2]. The reality is that science learning in the classroom has not been optimal. Based on observations from February to March at MTs Negeri 3 Surabaya, there are still obstacles in the science learning process, including material that students find difficult, a lack of student activity in listening to explanations during learning, The learning model used focuses on teachers who only apply learning using the lecture method, where the learning process is dominated by the delivery of information from teachers to students and emphasizes memorization. The material presented is unvaried and does not develop, leading to boredom and low student engagement in science learning. These conditions indicate that the lecture method often used by teachers has not been able to improve student learning outcomes, even though science learning is designed to be more interesting, interactive, and provide space for direct experience, so that students can more easily master abstract science concepts [3]. Pre-research data indicate that student

learning outcomes in science subjects, including Earth and the solar system, remain inadequate. The average score obtained by students on Earth and solar system material is 58.2, with a minimum passing score of 80.

Based on research, improving student learning outcomes can be achieved by applying innovative learning models and using engaging, varied media to support the learning process [4]. The use of varied and appropriate learning models can encourage improved student learning outcomes, reduce passive learning tendencies, increase student motivation, and enable students to interact directly with the learning environment [5]. The jigsaw cooperative model is seen as an effort to improve student learning outcomes [6]. In the jigsaw cooperative learning model, complex material is divided into simpler parts, and students are placed in cooperative learning groups [7]. The implementation of learning using the jigsaw cooperative model consists of three stages: initial, expert, and final, which are divided into seven implementation steps. This learning process includes: (1) orientation, (2) formation of home groups, (3) division of material, (4) formation of expert groups, (5) discussion with home groups, (6) presentation of group results, (7) evaluation and group awards [8].

Research shows that Jigsaw's effectiveness in improving cognitive learning outcomes is not yet optimal [9]. This study reveals that cooperative jigsaw only yields moderate improvement in learning outcomes, with an N-gain score of 0.58. These results indicate that although the cooperative jigsaw model can aid learning, it still has limitations when applied without adequate visual media support, especially for material that requires spatial understanding. This condition shows the need for innovation in the application of the cooperative jigsaw model by

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utilizing interactive digital media. One medium that has the potential to overcome these obstacles is the solar system scope simulation.

Applying the Jigsaw cooperative model in science learning can significantly improve student learning outcomes because students are actively involved in the discussion process and teach each other the material in groups, using digital simulation media [10]. This approach has also been proven effective in helping students understand abstract concepts. Combining cooperative learning models with simulation media can yield better results than using either method alone [11]. The research shows that the application of cooperative learning supported by interactive simulation media can significantly improve student learning outcomes, as students not only collaborate but also gain visual learning experiences that aid their understanding of concepts.

Effective learning should provide students with opportunities to actively construct knowledge through meaningful experiences. One of the theories underlying this approach is constructivist learning theory. Constructivist theory views knowledge as not only acquired through the process of memorizing concepts or facts, but also built gradually through experience and interaction with the environment, so that students can develop understanding and create meaning in the learning process [12]. In constructivist learning, students are required to think when solving problems, finding ideas, and making decisions so that they can construct new knowledge that is more meaningful and able to remember concepts for a longer period of time and apply them in various situations [13].

The use of solar system scope simulations as technology-based learning media provides interactive visualizations of the movements of planets, Messier objects, and the ability to explore various objects in the solar system. In addition, there is also a planet exploration feature that helps students learn the characteristics of each planet in detail, thereby helping students understand abstract concepts more easily [14]. The combination of the jigsaw cooperative learning model with the solar system scope simulation is expected to create a more dynamic, innovative, and effective learning environment. The integration of the jigsaw cooperative model with the solar system scope simulation is expected to maximize the jigsaw cooperative learning process while improving students' cognitive learning outcomes, exceeding the moderate improvement found in previous studies.

Based on the background described above, the researcher sought to conduct a study on the learning outcomes of junior high school (MTs) students in science, titled "Application of the Jigsaw Cooperative Learning Model Assisted by Solar System Scope Simulation to Improve Junior High School Students' Learning Outcomes." The purpose of this study is to analyze student learning outcomes after being trained with the application of the Jigsaw cooperative learning model, assisted by solar system scope simulations

Research Methods

This study used students from class VII-F MTsN 3 Surabaya City. Sampling in this study used the purposive sampling technique. The criteria for selecting the sample

class were characteristics aligned with the requirements for implementing the Jigsaw cooperative learning model, assisted by solar system scope simulations. The criteria for selecting the sample included students' readiness to participate in interactive learning, their initial understanding of science material, and the availability of facilities and infrastructure to support technology-based learning.

The study used a pre-experimental design. This research design is classified as an experimental study without control variables, so there remains the possibility that external variables may influence the dependent variable. The absence of control variables in this type of study is due to the non-random selection of the research sample. This research design is a one-group pretest-posttest design because the sample was not randomly selected and the study was influenced only by independent variables, without control variables. In this research design pattern, there are assessments that will be used, namely the condition before treatment (pre-test) and the condition after treatment (post-test) [15]. The treatment given in this study was the application of a jigsaw cooperative learning model assisted by a solar system scope simulation.

Student learning outcomes were assessed through pre- and post-tests comprising four essay questions on Earth and the solar system. Each question was assessed using a rubric based on conceptual accuracy, completeness of answers, and the student's ability to explain the concepts.

$$\text{Value} = \frac{\text{Score obtained}}{\text{Maximum score}} \times 100$$

Student learning outcomes were analyzed using Normalized Gain. Normalized Gain was used to determine the improvement in student learning outcomes after teaching using the jigsaw cooperative learning method, assisted by the Solar System Scope simulation. The learning model and solar system scope simulation media were considered effective if the Normalized Gain score was greater than or equal to 0.3.

Next, the significance of the increase between the pre-test and post-test results was analyzed using inferential statistics, which began with testing the hypothesis prerequisites first. The hypothesis prerequisite test applied was a normality test, which aimed to determine whether the data obtained had a normal distribution or not [16]. The Shapiro-Wilk normality test was used because the sample size was less than 50. The analysis was conducted using IBM SPSS at the 0.05 significance level. The test results were determined by comparing the significance value obtained with the predetermined significance value ($\alpha=0.05$). This decision was made: if the calculated Shapiro-Wilk significance value was > 0.05 , then H_0 was accepted and H_1 was rejected; or if the data were normally distributed. Conversely, if the calculated Shapiro-Wilk significance value was < 0.05 , then H_0 was rejected and H_1 was accepted, or the data was not normally distributed. If the normality test results indicate normality, proceed with parametric statistical techniques, namely the paired t-test. If the data are not normally distributed, proceed with nonparametric statistical techniques, namely the Wilcoxon test [17].

The Wilcoxon test is used when the normality test indicates that the data are not normally distributed. This test aims to determine whether the study shows an effect

consistent with the formulated hypothesis. The decision rule for the Wilcoxon test in SPSS is to compare the asymp.sig value with 0.05. If $asympt.sig < 0.05$, then H_1 is accepted and H_0 is rejected. Meanwhile, if $asympt.sig > 0.05$, then H_1 is rejected and H_0 is accepted.

Results and Discussion

Student learning outcomes were analyzed using Normalized Gain to determine the improvement in student learning outcomes. Before the learning process began, students were given a pre-test sheet containing four essay questions about Earth and the solar system. The purpose was to determine the students' initial abilities. The post-test, which contained four essay questions similar to those in the pre-test, was administered after two learning sessions to determine the students' final abilities. In addition, to determine whether there was a significant improvement in learning outcomes, an inferential statistical test was conducted. The pre-test was conducted on January 9, 2026, and the post-test on January 23, 2026.

Based on student learning outcome data, there are three assessment criteria: low, moderate, and high. Low learning outcomes are indicated by students with an N-gain score below 0.3, meaning no students showed significant

improvement. Nine students ($0.7 > (<g>) \geq 0.3$) fell into the moderate category. Students in the high category have an N-gain score above 0.7, totalling 23 students, indicating a significant improvement after participating in learning activities.

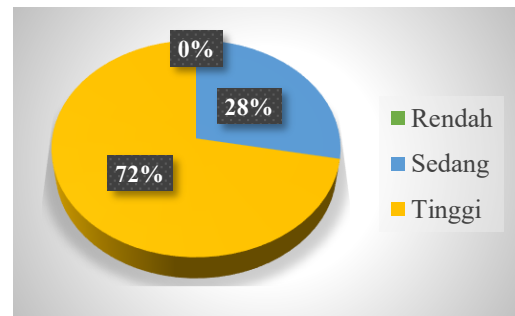


Figure 1. N-gain Acquisition Diagram for All Students.

Based on Figure 1, the percentage of students who obtained low criteria was 0%. The medium N-gain criteria was 28% for 9 students, and the high N-gain criteria was 72% for 23 students. The N-gain analysis, which measures the improvement in students' abilities per sub-material, is presented in Table 1.

Table 1. N-gain Per Sub-Material

Sub-material	Number of questions	Average		N-gain	Criteria
		Pre-test	Post-test		
Eight Planets in the Solar System	2	17	83	0.80	High
Other Celestial Objects	2	28	79	0.71	High

Based on Table 1, the pre-test and post-test results for Earth and solar system material were obtained. There were two sub-topics analyzed, namely the eight planets of the solar system and other celestial bodies. Each sub-topic had data covering pre-test and post-test scores, averages, N-gain scores, and criteria indicating an increase in student understanding. The sub-material on the eight planets of the solar system showed a significant increase, with a pre-test average score of 17 and a post-test average score of 83. The N-gain obtained was 0.80, which falls within the "high" criteria. In the sub-material on other celestial bodies, the average pre-test score was 28, and the average post-test score increased to 79. The N-gain obtained was 0.71, which falls within the "high" criteria. Both sub-materials meet the high criteria, indicating that students have made excellent progress in their understanding of them.

Next, the normality test assesses whether the data are normally distributed, using IBM SPSS Statistics version 25 at the 5% significance level ($\alpha = 0.05$). The normality test in this study is based on the Shapiro-Wilk test because the sample size is less than 50. The results of the normality test analysis are presented in Table 2.

Table 2. The Normality Test

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.170	32	.019	.915	32	.015
Posttest	.202	32	.002	.859	32	.001

Based on the normality test in Table 2, the results for the two data groups, namely the pre-test and post-test, are

shown. The Shapiro-Wilk normality test results show a significance value of 0.015 (smaller than 0.05), indicating that the pre-test data is not normally distributed. The post-test normality test results show a p-value of 0.001 (smaller than 0.05), indicating that the data are not normally distributed. Overall, both the pre-test and post-test indicate that the data do not meet the normality assumption. Based on the normality test results, the data are not normally distributed, so the analysis continues using a nonparametric test, namely the Wilcoxon test.

The normality test indicated that the pre-test and post-test values were not normally distributed, so a non-parametric test, namely the Wilcoxon test, was used to test the hypothesis. In this study, the Wilcoxon test was conducted in SPSS. The results of the Wilcoxon test are shown in Tables 3 and 4.

Table 3. Wilcoxon Rank Test Results

	N	Mean	Sum of
		Rank	Ranks
Posttest - Negative Ranks	0 ^a	.00	.00
Pretest Positive Ranks	32 ^b	16.50	528.00
Ties	0 ^c		
Total	32		

- a. Post-test < Pre-test
- b. Post-test > Pre-test
- c. Post-test = Pre-test

Based on the Wilcoxon Signed-Rank Test, the pre-test and post-test scores of the 32 subjects differed significantly. Table 3 shows that none of the subjects had negative scores;

all 32 subjects had positive scores with an average score of 16.50. These results prove that there was a difference between the pre-test and post-test scores. This shows that the majority of students improved their scores between the pre-test and post-test. The significance of the students' learning outcomes is presented in Table 4.

Table 4. Overall Wilcoxon Test Results

Post-test - Pre-test	
Z	-4.940 ^b
Asymp. Sig. (2-tailed)	.000

The statistical value with asymptotic significance (2-tailed) is 0.000. The post-test results show a significant increase compared to the pre-test, as the obtained value is smaller than the predetermined significance level ($\text{sig} < 0.05$). This shows that applying the jigsaw cooperative learning model, supported by the solar system scope simulation, affects students' science learning outcomes. The treatment applied in this study resulted in a significant increase in student learning outcomes.

Student learning outcomes were obtained from pre-tests conducted before treatment and post-tests administered after two meetings using the jigsaw cooperative learning model. Learning outcomes are the abilities achieved by students after participating in learning activities [18]. Based on the data obtained from this study, learning outcomes in Earth and solar system material increased. This statement is supported by the N-gain analysis of pre-test and post-test scores, which shows that the average N-gain was 0.77 in the "high" category. This shows that students' learning abilities increased when they were given jigsaw cooperative learning assisted by Solar System Scope simulations. The high N-gain score indicates that the learning model used in this study is very feasible and effective in improving student learning outcomes in Earth and Solar System material [19].

Significant improvement in student learning outcomes is influenced by the application of the jigsaw cooperative learning model supported by simulation media. Through this learning method, students are actively involved in group work with role-sharing, which encourages them to understand and convey concepts independently. In addition, the teacher's role as a facilitator provides direction during the discussion, enabling students to optimally develop their cognitive abilities and achieve learning objectives. These conditions affect student learning outcomes. This is in line with research by [20] which shows that the jigsaw-type cooperative model influences student learning outcomes.

This improvement in learning outcomes is related to the learning process that involves students playing an active role in constructing knowledge through learning experiences and interactions with peers. This is supported by [21] constructivist learning theory, which states that students' understanding is formed through learning experiences and student involvement in the learning process [12]. Based on the view, jigsaw cooperative learning encourages students to construct knowledge through a process of discovery. Students study parts of the material that have been given in expert groups, then place the new information in the context of their previous experiences to convey it to their original groups [21]. This process helps students connect new information with prior knowledge, so that their

understanding of the solar system concept is formed gradually and more deeply.

According to Vygotsky, improvements in student learning outcomes result from social interaction during the learning process. Discussions and cooperation among students with varying levels of understanding can help them share knowledge and support one another in understanding the material presented. Such interactions help students develop their understanding, especially when learning is supported by solar system scope simulations that present material visually and align with the learning context of Earth and the solar system.

Improving student learning outcomes is also related to Deci and Ryan's Self-Determination Theory. The jigsaw cooperative learning model assigns roles and responsibilities to each student, making them an expert on the material they have learned. This role provides students with the opportunity to manage their own learning methods and convey their understanding to their home group, thereby fulfilling their need for learning independence (autonomy). Students' success in understanding and explaining the material to their peers fosters self-confidence and a sense of competence. The interactions that occur during group discussions strengthen students' social relationships and create a supportive learning atmosphere (relatedness). [22]. Fulfilling the psychological needs of autonomy, competence, and relatedness increases student engagement in the learning process and directly contributes to improved learning outcomes [23].

A worksheet also plays a supporting role in the implementation of learning models. The use of LKM makes the learning process more focused and easier for students to work on the given problems. A worksheet serves as a learning guide for students in understanding the steps of learning activities systematically [24]. It can trigger the emergence of students' potential in the learning process. A worksheet helps students identify and develop their abilities and supports the concept development process during learning activities, thereby improving student learning outcomes [25].

Improved student learning outcomes are also influenced by learning media that support the learning process [26]. Solar system scope simulations help students understand Earth and the solar system through attractive, easy-to-understand visual displays, enabling them to learn abstract concepts more clearly. Using the solar system scope provides an interactive, contextual learning experience. Students can observe the solar system model and learn about other celestial objects, thereby deepening their understanding. This increased engagement and understanding in learning has a direct impact on improving student learning outcomes. Solar system scope simulations are effective in helping to improve student learning outcomes in science learning [14].

The N-gain values indicate that 9 students had a moderate N-gain and 23 had a high N-gain. These results indicate that most students experienced significant improvement in learning outcomes after implementing the jigsaw cooperative learning model, assisted by the solar system scope simulation. The differences in the criteria for improvement in student learning outcomes indicate variations in students' understanding of the material provided by the teacher during the learning activities. Some students

were not accustomed to working together in groups, so they needed time to adjust to jigsaw cooperative learning. In addition, some students were also unfamiliar with the use of the solar system scope simulation learning media, so they did not utilize the media optimally. Students who are not accustomed to using simulation media can also affect learning activities [27].



Figure 1. Solar system scope simulation home screen display

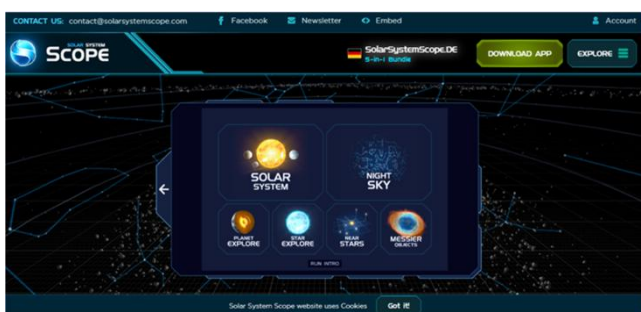


Figure 2. Solar system scope simulation menu display

Based on the N-gain score per material, the improvement in learning outcomes for the eight planets of the solar system material was great. These results show that, in general, students can understand the material well through the visualizations and information provided in the solar system scope simulation. The correlation between the high N-gain per material and the variation in N-gain per student indicates that differences in learning outcomes are more influenced by each student's readiness and involvement in learning. These results demonstrate that the improvement in student learning outcomes resulting from the application of the jigsaw cooperative learning model, assisted by the solar system scope simulation, aligns with the research objective: to improve student learning outcomes through the application of the jigsaw cooperative learning model.

Conclusion

Based on the results of the study, the application of the Jigsaw cooperative learning model assisted by the Solar System Scope simulation in class VII-F MTs Negeri 3 Surabaya proved to be effective in improving students' cognitive learning outcomes on the subject of Earth and the solar system, with an average N-gain of 0.77 (high category) and the Wilcoxon test showing a significant difference ($p < 0.05$). Most students were actively involved and responded positively to the learning process, demonstrating high

motivation and engagement. These results emphasize the importance of integrating collaborative learning structures with interactive simulation media to facilitate the understanding of abstract concepts. The pedagogical implications of this study include strengthening collaboration among students, utilizing digital media for concept visualization, and the potential for curriculum development and science learning innovation. For further research, it is recommended to expand the application to other subjects or higher-order thinking skills and to consider a design with a control group.

Author's Contribution

F. Alifatul was responsible for all stages of the research, from conceptualization, methodology, data collection, statistical data analysis, interpretation of results, and writing the manuscript. Martini, as the supervising lecturer, provided methodological guidance and input on data analysis and article writing.

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