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The Effectiveness of Digital Learning with the Application of Solar System Scope on the Understanding of Solar System Material Concepts in Grade VI Elementary School Students

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Abstract: This study aimed to evaluate the effectiveness of the Solar System Scope application in enhancing sixth-grade students' understanding of solar system concepts. The research was conducted at SDN Pademangan Timur 05, Jakarta, involving 31 students from class VI. A one-group pretest-posttest design was used, in which students took a pre-test before and a post-test after using the application during learning. Data were collected through written tests to assess conceptual understanding, and were analyzed using descriptive and inferential statistics. The findings showed that the average pre-test score was 2.09 (41.8%) and the average post-test score increased to 4.56 (91.2%), resulting in an average improvement of 2.47 points. Statistical analysis indicated a significant difference between pre-test and post-test results ($p < 0.05$). These results suggest that the Solar System Scope application significantly improves students' understanding of abstract astronomical concepts. Its interactive 3D visualization supports more effective science learning in elementary classrooms. The study highlights the potential of digital media as a valuable tool to support science education at the primary level.

Keywords: Application; Digital; Science; Solar system; Visualization

Introduction

Along with global developments and technological innovations that have emerged along with the Industrial 4.0 era, the world of education is required to adapt to rapid technological developments. One of the big challenges in 21st century learning is how to facilitate learners to be able to understand concepts in depth with a relevant and engaging approach (Mansyur et al., 2024). This is especially important in the learning of Natural Sciences , which emphasizes the process of scientific thinking and the skill of understanding natural phenomena rationally. For this reason, innovation in the use of media and technology-based learning strategies is an urgent need (Febianti & Sukmawati, 2024; Hartomo & Sukmawati, 2024; Lestari et al., 2024).

Basic education has a very crucial role in building a foundation of knowledge for students, especially in the subject of Natural Sciences (Qadir et al., 2022). One of the topics studied in grade VI of elementary school is the solar system, which includes understanding planets, satellites, and the movement of celestial bodies. This material is often abstract, so it is often difficult for children to understand concepts that they cannot see directly (Sari et al., 2019). Thus, a learning method is needed that is able to provide real visualization and interactive learning experiences (Aulia et al., 2024; Latifah et al., 2024; Sukmawati, 2021; Sukmawati & Sari, 2024).

Based on previous research, the majority of students, which is more than 75%, are used to using gadgets every day and are able to operate them without

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significant difficulties. This suggests that the integration of digital devices into the learning process will most likely not pose any technical barriers for them (Sati et al., 2024). This opens up opportunities for educators to improve the learning process that is more interactive and means utilizing technological devices that have become part of students' daily habits (A. Fitria & Sukmawati, 2024; Sulistiani & Sukmawati, 2024; Wahjusaputri et al., 2022).

Along with technological developments, digital-based education is an effective choice to improve the quality of science learning. The Solar System Scope app is a digital tool that offers 3D simulations of the solar system, allowing learners to explore space objects virtually (Rahman, 2024). It is hoped that this can deepen students' understanding of the solar system through exploratory and visual means. Several previous studies have revealed that the use of interactive digital media contributes to deepening students' understanding of material that is unreal or abstract, revealing that the use of digital applications as a learning tool can encourage motivation and understanding of science concepts (Salomo Leuwol et al., 2023). Sarnoto et al. (2023) it also states that multimedia simulations are effective in understanding various astronomical phenomena. However, research that specifically evaluates the effectiveness of Solar System Scope applications at the elementary school level is still relatively limited.

In addition, research by Fauzi et al. (2023), shows that the application of learning using the directed inquiry method with the help of the Solar System Scope application has been proven to have made a real positive contribution to the achievement of student learning outcomes on the topic of the solar system. These findings indicate that the integration of digital media in teaching strategies can have a positive influence on the understanding of scientific concepts.

By utilizing the Solar System Scope application, students can observe celestial objects directly by simply pointing their digital device at the position of the celestial body they want to observe. This application allows the timing and location of observations, so that observations can be carried out flexibly, both during the day and at night (Muthi'ah & Sukmawati, 2023; Sukmawati & Wahjusaputri, 2024; Wahjusaputri et al., 2024).

The ability of students who are skilled enough in using digital devices also supports this activity, even giving them the opportunity to be directly observed by students outside the formal education area. Through this application, students can also learn various characteristics of the observed celestial bodies, such as color, shape, size, revolution time, and physical structure (Izzati & Sukmawati, 2024; Putri & Sukmawati, 2024; Sukmawati, 2020).

Based on this, this research was conducted to analyze the level of utilization of the Solar System Scope application that can help students in grade VI of elementary school in understanding material about the solar system. It is hoped that the results of this study can provide real benefits for teachers in choosing appropriate learning aids, as well as adding to the literature on the use of digital applications in basic science education.

Method

This study adopted a pre-experimental design using a one-group pre-test–post-test structure (O_1 X O_2), which differs from a quasi-experimental design. Here, only one class was measured before and after receiving the intervention, without a control group (Dewi M et al., 2023).

Table 1. The One-Group Pretest-Posttest Design

Group	Pre-test	Treatment	Post-test
Experiment	O_1	X	O_2

In this design, one group of students underwent an initial test (pre-test) to measure the level of understanding of the concept before receiving treatment. Then, students experience treatment through learning using the Solar System Scope application, and then are given a final test (post-test) to find out changes in concept understanding after learning takes place (Saputri & Sukmawati, 2024; Sukmawati & Rahmiati, 2024, 2024).

The study population comprised all sixth-grade students at SDN Pademangan Timur 05, Jakarta. A purposive sampling method selected class VI A (31 students) as the study sample, due to its homogeneous characteristics and suitability for digital learning. According to Hanifah, purposive sampling is a sample selection technique that is carried out for certain reasons that are in line with the goals and targets of the research (Hidayaturohman et al., 2021). This class was used as an experimental group that received a digital learning treatment with the Solar System Scope application.

The primary instrument for data collection was a multiple-choice test developed to measure cognitive levels from application to creation (C3–C6). The items underwent validity and reliability testing through item analysis and Cronbach's alpha to ensure their quality Data collection is carried out through three main stages. The first stage is the implementation of the pre-test, which is the provision of initial tests to students before learning begins. The second stage is the implementation of learning using the Solar System Scope application interactively, where students are given the opportunity to explore the visualization features in the application.

The third stage is the implementation of a post-test, which is given after learning to measure the extent to which students' understanding of concepts improves after receiving treatment (Ifdaniyah & Sukmawati, 2024; Istiqomah & Sukmawati, 2023; Kusnadi & Sukmawati, 2023).

Data analysis consisted of several stages. First, descriptive statistics (including mean, median, mode, and standard deviation) provided insight into pre- and post-test score distributions (Fitria & Sukmawati, 2022; Novianti et al., 2023; Ramadhani & Sukmawati, 2022). To capture individual and group changes beyond descriptive trends, a Rasch model stacking analysis was conducted: pre- and post-test data were vertically combined (stacked) and analyzed via WINSTEPS, enabling observation of both ability shifts and item-level stability (Kusnadi & Sukmawati, 2023).

In the implementation of this study, the stacking test was used as a data analysis technique to observe the shift in the level of students' understanding that occurred during the learning process based on pre-test and post-test scores. The stacking test is an analysis method applied to assess the difference in students' abilities between the circumstances before and after being given intervention in the teaching and learning process (Sukarelawan et al., 2024). The logit values derived from students' attitude scale scores were analyzed to identify shifts in student attitudes following the implementation of the treatment (Sukmawati & Nurliana, 2023).

This technique provides a visual and numerical picture of improving students' conceptual abilities. This analysis was conducted to see changes in individual and group scores more comprehensively. With stacking, you can see a pattern of increase, decrease, or stagnation of each student. This technique not only displays the results in the form of statistical numbers, but also presents a communicative visual picture of the effectiveness of learning using the Solar System Scope application.

Thus, the stacking test helps researchers in concluding how much changes in concept understanding occurs, as well as providing a comprehensive picture of the impact of treatment visually and systematically. This aims to identify the influence of treatment on improving the understanding of concepts from students.

Result and Discussion

This study aims to assess how much the effect of the use of the Solar System Scope application on the mastery of concept understanding in solar system material among grade VI elementary school students. This research focuses on efforts to examine the extent to which students' understanding experiences differences before and after the learning process with the help of digital media.

The use of appropriate learning media is one of the keys to creating an effective learning process, especially in abstract science materials such as the solar system. In this study, the Solar System Scope application was proven to make a real contribution to improving students' understanding of concepts. This application provides a three-dimensional visual simulation that allows learners to explore and understand complex concepts such as the order of the planets, the movement of celestial bodies, the structure and characteristics of celestial bodies, as well as the relationship between rotation and revolution with the phenomena of day and night in a more real and fun way (Nurliana & Sukmawati, 2023; Sukmawati et al., 2022; Sukmawati et al., 2023).

The effectiveness of using the Solar System Scope application can be seen through learning results that show a significant increase in concept comprehension scores after students receive learning using Solar System Scope media. By utilizing the interactive features offered by this medium, learners can build an understanding actively and contextually. This approach is in line with the principle of constructivistic learning, where students do not just receive information, but also shape their knowledge through real learning experiences (Fauziah & Sukmawati, 2023; Sukmawati et al., 2021).

Table 2. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	44.35	31	11.672	2.096
	Posttest	84.84	31	6.768	1.216

In the early stages, students are given pre-test to see the extent of their initial mastery of solar system matter. The results of the pre-test show that most students have not fully understood the main concepts, such as the order of the planets, the differences in the characteristics of celestial bodies, and the influence of celestial body movements on phenomena that occur on earth (Sukmawati, 2023; Sukmawati et al., 2021). After that, learning is carried out using the Solar System Scope application, which allows students to explore the solar system through three-dimensional interactive simulations.

Based on the results of descriptive statistical analysis, there was an increase in the average score from the pretest to the posttest. The average pretest score was 44.35 with a standard deviation of 11.67. After the treatment was given, the posttest average increased to 84.84 with a lower standard deviation of 6.77. A total of 31 participants took part in both measurements. In addition, the standard error of the mean also decreased from 2.10 in the pretest to 1.22 in the posttest. This decrease indicates that the posttest results were more consistent among the participants. Overall, these findings suggest an improvement in learning outcomes following the implementation of the intervention.

The outcome of the paired samples correlation analysis between pretest and posttest scores showed a correlation coefficient (r) of 0.030 with a sample size of 31 participants. The significance level (p-value) obtained was 0.872. Although the correlation coefficient is positive, it is extremely close to zero, indicating a negligible or nearly nonexistent linear relationship between the two sets of scores. Furthermore, the p-value far exceeds the conventional threshold of 0.05, suggesting that the correlation observed is not statistically significant. Therefore, it can be concluded that no meaningful association exists between the pretest and posttest results in this data set.

Table 3. Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pretest & Posttest	31	.030	.872

Table 4. Paired Sample Test

	Mean	Std. Deviation	Std. Error Mean	95% CI Lower	95% CI Upper	t	df	Sig. (2-tailed)
Pretest- Posttest	-40.484	13.314	2.391	-45.367	-35.600	-16.930	30	.000

The paired sample t-test analysis between pretest and posttest scores revealed a statistically significant difference. The mean difference was -40.484, indicating that the posttest scores were considerably higher than the pretest scores. This difference was accompanied by a standard deviation of 13.314 and a standard error of the mean of 2.391. The 95% confidence interval for the mean difference ranged from -45.367 to -35.600, which excludes zero—further confirming that the change in scores is significant. The t-value obtained was -16.930 with 30 degrees of freedom, and the significance level (2-tailed) was 0.000. Since the p-value is well below 0.05, it can be concluded that the improvement in scores after the treatment was not due to chance, but reflects a statistically meaningful enhancement in student performance.

Based on the analysis table 5, these results reflect that the majority of students' knowledge about the basics of the solar system is still not optimal and is relatively low. Their pre-test scores highlighted notable gaps not just in recall, but in conceptual depth—suggesting that traditional instruction methods were insufficient in helping them grasp intricate topics such as planetary orbits, rotations, and spatial relationships (Cruz et al., 2025).

After participating in interactive lessons delivered through the Solar System Scope application, students were given a post-test of equivalent difficulty. These results showed a marked and meaningful uptick in performance. The significant rise in post-test scores clearly indicates that student understanding had improved by the conclusion of the intervention (Zahara et al., 2020).

Table 5. Analysis of Posttest and Pretest Results

Entry	Pre-Test	Post-Test	Pre-Test Post-Test	Information
1	-1.35	2.59	3.94	Increase
2	-0.2	1.38	1.58	Increase
3	-0.46	1.38	1.84	Increase
4	0.56	2.59	2.03	Increase
5	-0.46	1.7	2.16	Increase
6	-1.03	2.59	3.62	Increase
7	0.3	1.7	1.4	Increase
8	0.3	1.38	1.08	Increase
9	-0.46	3.37	3.83	Increase
10	-0.46	2.59	3.05	Increase
11	-0.46	2.09	2.55	Increase
12	-1.71	2.59	4.3	Increase
13	-0.46	3.36	3.82	Increase
14	0.82	3.37	2.55	Increase
15	0.3	1.7	1.4	Increase
16	-0.2	2.09	2.29	Increase
17	0.3	2.09	1.79	Increase
18	0.05	2.59	2.54	Increase
19	-0.74	1.09	1.83	Increase
20	0.82	3.37	2.55	Increase
21	-0.46	2.09	2.55	Increase
22	-0.46	2.59	3.05	Increase
23	-1.35	2.09	3.44	Increase
24	-0.46	1.7	2.16	Increase
25	0.05	3.37	3.32	Increase
26	-0.74	1.7	2.44	Increase
27	0.05	2.09	2.04	Increase
28	-0.2	2.09	2.29	Increase
29	0.82	1.7	0.88	Increase
30	-0.74	2.09	2.83	Increase
31	0.05	1.38	1.33	Increase

This increase is not only shown by the overall average, but is also seen in almost all individuals. Of the 31 students, all of them experienced an increase in post-test scores compared to pre-test scores. Individual increases range from 0.88 to 4.30 points. This fact shows that the Solar System Scope application is able to have an equal positive impact on all students in understanding solar system material. Not only has the number increased, but the quality of students' answers has also improved. Students who previously only memorized the names of the planets, after learning were able to logically explain the process of revolution and rotation of the planets, as well as their impact on the change of time and seasons on Earth.

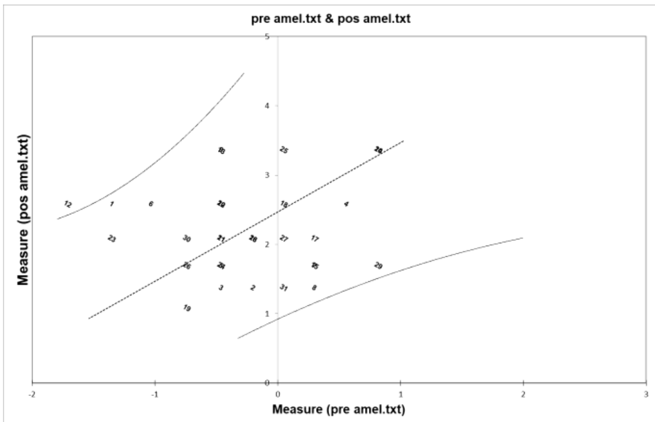

Figure 1. Graph of improvement of pre-test and post-test results

To find out the distribution of improved concept understanding in more detail, students were grouped into three categories, namely high (≥ 3.00), medium (1.50-2.99), and low (< 1.50). The analysis showed that 9 students (32.26%) fell into the high category, indicating that their scores jumped by more than three points. 17 students (58.06%) were in the medium category, reflecting a steady and consistent increase, while 5 students (9.68%) were in the low category, showing some improvement but not as significant.

This distribution confirms that the majority of students experienced a very good improvement in understanding, and some even recorded remarkable increases. The largest group and the medium category demonstrate that the Solar System Scope application successfully guided students from initial limited understanding to a better level, though there remains room for further growth. Students in the low category, though few, still demonstrate that the learning method facilitated progress, albeit at a slower pace; these students may benefit from additional support or tailored instructional strategies.

Furthermore, this pattern of distribution shows the overall effectiveness of the application: nearly 90% of students achieved substantial improvement (medium and high categories), while fewer than 10% showed minimal gains. These findings reinforce the argument that visual and interactive media, such as Solar System Scope, significantly enhance student comprehension of abstract concepts. These findings indicate that the learning process with digital applications is not only effective for certain students, but also inclusive and can be enjoyed by different types of learning.

Based on the data in the table, students who are classified as high are students in entries 1, 7, 10, 11, 14, 23, 24, 26 who obtained >3.00 and students in entry 12 obtained the highest results of 4.3. Although there is still one student whose understanding of the concept has only changed slightly, namely in entry 29, where the result he obtained was only 0.88, but this still shows an improvement.

This increase in student participation is in line with teaching methods that make students the center of attention in the teaching and learning process (student-centered learning). When students are given the opportunity to explore material through engaging media, they become more responsible for their own learning process. In this context, Solar System Scope provides a learning experience that is exploratory, individualized, and interactive. This is in accordance with the results of a study carried out by Putri et al. (2022), which shows that the use of interactive digital media such as Solar System Scope and Book Creator is able to increase attention, active participation, and general performance of elementary students in mastering science learning objectives.

The improvement indicates that the Solar System Scope application is effective in helping students understand abstract material. The findings by Putri et al. (2022) support this statement, where they conclude that the application of digital media in science learning can have a great influence on improving students' mastery of concepts. Similar research by Fauzi et al. (2023), also corroborates the results of this study, where learning tools based on visualization are stated to be able to strengthen students' understanding of certain scientific concepts. Other research also shows that this media increases students' overall activeness and understanding (Khatimah et al., 2023).

The app's advantage lies in its visual capabilities that are close to a real experience. Learners not only read or view images, but they can also manipulate the view of the solar system, zooming, rotating, and exploring the planet's position and orbital trajectory. This makes the learning process more engaging and easier to understand, especially for elementary school students who usually prefer learning methods that involve vision and physical activity.

The app provides an engaging learning experience in a visual and interactive way, giving students the opportunity to get to know and explore the solar system. This learning model supports a constructivist approach, in which students play an active role in building their own knowledge based on the learning experiences they gain directly.

Figure 2. Implementation of the use of solar system scope applications in learning activities

With the results obtained, it can be said that the Solar System Scope application makes a real contribution in deepening students' understanding of the concept of the solar system. This is proof that the use of appropriate digital media plays a very important role in overcoming obstacles in learning, especially in science materials that are difficult to understand only through verbal explanations or printed media.

Conclusion

This study demonstrates that the use of the Solar System Scope application significantly enhances Grade VI students’ understanding of solar system concepts. Quantitative analysis reveals that all 31 students showed measurable gains, with 90.3% achieving moderate to high improvements. Statistical analysis using a paired-sample t-test confirmed that this improvement is significant ($p < 0.05$). Furthermore, the logit values obtained from pre-test and post-test scores transformed via Rasch stacking analysis clearly reflect meaningful shifts in students’ conceptual competence. This approach converts raw scores into logit estimates, showing that those beginning with lower proficiency made notable progress, while those already performing well maintained or improved further. These findings collectively affirm that technology enhanced, visual learning tools such as Solar System Scope can effectively strengthen students’ conceptual grasp in elementary science, benefitting learners across the performance spectrum.

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Author Contributions
The entire process in this research, starting from the preparation of research designs, the implementation of field activities, data collection and processing, to the writing and preparation of scientific articles is a full contribution of AZS. Activities such as instrument validation, analysis of learning outcomes with a quantitative approach, and manuscript revision are also carried out independently by the author.

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