Improving Primary Students' Understanding of Environmental Science Phenomena through the I-SETS Approach

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Abstract. This study aims to examine the effect of the I-SETS approach (Islamic–Science, Environment, Technology, Society) on primary school students' science learning outcomes. The study was motivated by the need for science instruction that is more contextual, meaningful, and capable of connecting scientific concepts with Islamic values, environmental issues, technological experiences, and students' social realities. A quantitative method with a quasi-experimental design was employed, involving two classes: one experimental class taught using the I-SETS approach and one control class taught through conventional instruction. Data were collected through pre-tests and post-tests, supported by classroom observations and student response questionnaires. Statistical analyses were conducted to compare learning outcomes between the two groups. The results indicate that the experimental class achieved a much higher post-test score compared to the control class. Statistical testing revealed a highly significant difference between the groups, and the effect size demonstrated a very strong impact of the I-SETS approach on students' understanding of changes in the state of matter. The findings highlight that integrating Islamic values, scientific concepts, environmental phenomena, technology, and social contexts creates more meaningful learning experiences and enhances students' cognitive, emotional, and spiritual engagement. The study concludes that the I-SETS approach offers a strategic alternative for improving science learning quality in primary schools, particularly in Islamic educational settings. Further research is recommended to apply this approach to other topics and with broader experimental designs to strengthen the evidence.

1 Introduction

The development of science, technology, information, and communication in the 21st century requires educational institutions to adapt their learning processes to the needs of the times [1]. Education is no longer just about transferring knowledge, but must be able to form a young generation that thinks critically, creatively, and adaptively to change [2]. 21st century teachers are required to play the role of facilitators who encourage students to actively build knowledge through communication, collaboration, and the use of technology [3]. In this context, educational technology is an important opportunity for elementary schools to

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improve the quality of learning and overcome various obstacles that arise in the learning process [4]. However, studies have shown that technology integration alone is not enough to improve the quality of learning if it is not accompanied by a contextual and meaningful approach for elementary school students. It is at this point that learning strategies that are able to connect science with the environment, values, and technology become increasingly relevant. The integrated learning approach has proven to be effective in strengthening the understanding of science concepts, as shown by STEM research on prospective teacher students, so that holistic approaches such as I-SETS have great potential to be applied in elementary schools.

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However, the use of technology does not always run effectively. Teachers still face challenges in integrating them into meaningful learning and in accordance with the characteristics of students. Science learning, as one of the subjects that emphasizes observation, experimentation, and inference, requires strategies that encourage active engagement and deep understanding of concepts [5]. The empirical nature of science requires teachers to develop innovative approaches that are able to connect scientific concepts with students' real experiences [6]. Thus, this problem shows the need for a learning approach that not only utilizes technology, but also integrates students' empirical experiences, values, and social contexts simultaneously. Similar challenges were also found in the digitization of HOTS-based assessments in elementary schools, where teacher readiness and limited infrastructure are the main obstacles to improving the quality of science learning [7], so that learning innovations still require contextual approaches such as I-SETS.

Science education in various countries, including the Netherlands, is designed to not only equip students with basic scientific concepts, but also foster scientific inquiry skills, curiosity, and interest in science and technology [8]. In line with that, science learning in Indonesian elementary schools is also directed to achieve learning outcomes in the cognitive, affective, and psychomotor domains, as well as fostering students' scientific attitudes and spiritual awareness as part of the goals of national education and Islamic values [9]. A number of previous studies have integrated Islamic values in science learning and shown a positive influence on the meaning of concepts, motivations, and student learning outcomes. However, most of the research focuses on the middle class or highlights specific aspects such as religiosity or scientific attitudes, not yet on a thorough integration that combines science, environment, technology, society, and Islamic values simultaneously.

However, various studies show that the quality of science learning in Indonesia still faces obstacles. Indonesia's low performance in PISA assessments has been consistent over the past fifteen years, reflecting students' weak conceptual understanding and their low ability to relate science concepts to daily life [10]. This condition emphasizes the importance of a learning approach that is able to contextualize science concepts while integrating values, environment, and technology. This condition is even more challenging at the lower grade level of elementary school, where students' science literacy skills are still developing and require a more contextual approach and close to their life experiences. The latest textbook

analysis also shows that the uneven distribution of SPS and HOTS indicators in elementary school science materials [11], so a more conceptually rich learning approach such as I-SETS is needed.

Based on a preliminary study in grade III of Madrasah Ibtidaiyah Muhammadiyah Terpadu Harapan Magelang City, several problems were found that strengthened the urgency of learning innovation. First, the quality of science learning is still dominated by lecture methods, with limited variations in educational game activities and simple projects. The teacher also said that the science material in grade III is considered complex so that students need intensive repetition to understand the concept in its entirety. Learning evaluation is still limited to simple reflection so that it does not comprehensively describe conceptual understanding. This situation shows that the learning approach used has not been able to build a deep conceptual understanding as required in science learning. Teachers' weaknesses in understanding the concepts of SPS and HOTS [12] also contributes to the low quality of science learning in primary schools, so an integrative approach such as I-SETS is needed to help teachers connect science with social, technological, and value contexts.

Second, the learning approach used has not integrated Islamic values into the material. Religious values only appear in the beginning and end of learning activities through prayer, not yet related to the phenomenon of science that is being studied. The teacher admitted that the I-SETS (Islamic–Science, Environment, Technology, Society) approach had never been used, but showed interest when given an explanation of the concept. So far, the integration of Islamic values in science has been mostly carried out at the MTs or junior high school level, while at the elementary school level, especially the lower grades, there have not been many studies that have tested the effectiveness of its integration. In addition, most research focuses only on the integration of religious values, not yet on comprehensive approaches such as I-SETS which include the other four dimensions.

Third, student learning outcomes in science subjects are still not optimal. Based on score data, around 40% of students have not reached the Minimum Completeness Criteria, and some of them require remedial. Teachers assessed that learning outcomes were influenced by the lack of the use of innovative media, learning approaches that were not fully in accordance with student characteristics, and the lack of learning support from the home environment. This shows the need for a learning model that not only presents concepts, but is also able to stimulate student engagement through the integration of their values, experiences, and social contexts.

The findings show that science learning in grade III still needs to be developed to be more contextual, meaningful, and able to integrate aspects of science, technology, spiritual values, and community needs. The I-SETS approach offers the potential to answer these needs because it connects the concept of science with Islamic values, environmental phenomena, technological developments, and students' social lives. Through this approach students not only learn concepts, but also develop ecological awareness, thinking skills, and spiritual understanding as part of their identity. Although various studies have examined the integration of Islam or SETS separately, there have not been many studies that systematically combine the two in low-grade science learning, so the I-SETS approach offers a new contribution in the context of madrasah education.

Departing from these conditions, this study was conducted to empirically test the influence of the application of the I-SETS approach on the science learning outcomes of grade III students on relevant learning materials. This research is expected to contribute to the development of integrative learning models in elementary schools, especially in madrasas that have strong religious education characteristics. This study specifically aims to test the influence of the I-SETS approach on the science learning outcomes of grade III students through a comparison between the experimental class and the control class. Thus, this study

provides empirical evidence regarding the effectiveness of the I-SETS approach in improving students' conceptual understanding.

2 Methods

This study uses a quantitative approach with a quasi-experiment design of the Non-Equivalent Control Group Design, because the randomization of subjects cannot be done completely in the school context. Two classes with relatively equivalent initial characteristics were selected as the research group. One class was designated as an experimental group that received learning using the I-SETS approach, while the other class became a control group that received conventional learning. Treatment was given during four meetings on material changes in the shape of objects, and the effectiveness of the approach was evaluated through a comparison of pre-test and post-test scores.

The independent variable of the study is the application of the I-SETS approach, while the bound variable is the science learning outcomes measured through cognitive tests. The I-SETS approach is defined as a learning model that integrates Islamic values, science concepts, environmental issues, technological relevance, and social context in active learning activities. The learning outcomes refer to the mastery of students' concepts after the learning takes place. The research instruments include multiple-choice tests, learning implementation observation sheets, and student response questionnaires. All instruments are tested for validity, reliability, difficulty, and differentiation to ensure measurement quality.

The research population included all students in the madrassas where the research was conducted, and the sample was selected through purposive sampling, resulting in two classes with a total of 46 students. The data was analyzed through a series of statistical procedures, starting from normality and homogeneity tests to ensure the fulfillment of parametric assumptions. Initial ability equivalence was tested using the Independent Samples T-Test on the pre-test score, while the effect of the I-SETS approach was evaluated through the same test on the post-test score. The increase in each group was analyzed using the Paired Samples T-Test. The magnitude of the effect of the treatment was calculated using Effect Size (Cohen's d) to provide a pedagogical interpretation of the research results.

All analyses were conducted using the Jamovi application, which provides statistical test features, table visualization, and effect size calculation automatically to support comprehensive reporting of results and replication of future research.

3 Results and discussion

3.1 Research results

Descriptive analysis was carried out to obtain an overview of the initial and final abilities of students in both groups show in **Table 1**. Overall, the average pretest score of all students was 53.3 with a standard deviation of 9.37. After the learning took place, the average posttest score increased to 79.9 with a standard deviation of 16.2. This improvement shows that both the experimental class and the control class experience improved learning outcomes after the learning process. The descriptive results indicate that the experimental group showed a gain of 35.8 points (from 57.4 to 93.2), while the control group improved by 17.3 points (from 49.3 to 66.6). This indicates that the learning improvement in the experimental class was approximately twice that of the control group

The differences in development between groups were more evident in the analysis per class. The control class showed an increase from the average pretest of 49.3 to 66.6 in the posttest. Meanwhile, the experimental class experienced a much higher increase, from an

average pretest of 57.4 to 93.2 on the posttest. The following table presents the descriptive statistics of both groups. The posttest mean difference between groups was 26.6 points, with the experimental group showing lower score variability (SD = 7.58) compared to the control group (SD = 10.36), indicating more consistent learning outcomes.

Table 1. Descriptive statistics of pretest and posttest

	Group	N	Mean	Median	SD	SE
Pretest	Control	23	49.3	53.0	8.32	1.74
	Experiment	23	57.4	60.0	8.71	1.82
Posttest	Control	23	66.6	66.0	10.36	2.16
	Experiment	23	93.2	93.0	7.58	1.58

Fig. 1 visually demonstrates the sharper increase in posttest scores of the experimental group compared to the control group, indicating stronger learning gains after the implementation of the I-SETS approach.

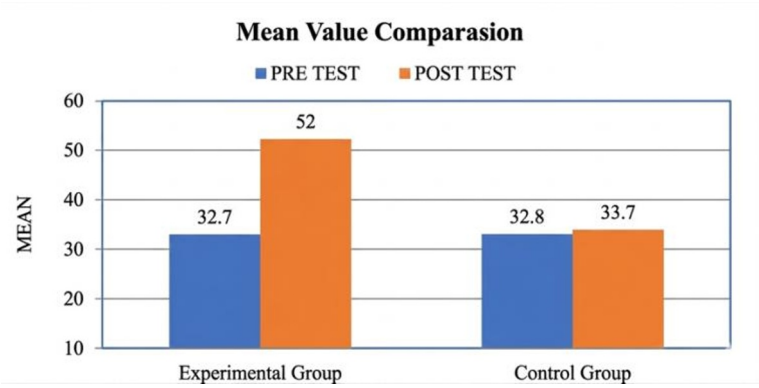

Fig. 1. Pretest and posttest comparison

The normality test using Shapiro Wilk showed that the pretest ($p = 0.027$) and posttest ($p = 0.004$) values were below 0.05. However, parametric analysis can still be performed given the balanced sample count and the relatively robust nature of the t-test against violations of normality assumptions. Although the Shapiro Wilk test indicated non-normality ($p < 0.05$), the use of parametric tests was justified due to equal sample sizes ($n = 23$ per group) and the robustness of the t-test under balanced conditions.

Furthermore, the variance homogeneity test using Levene's Test showed that the variance of the two groups was homogeneous, both in the pretest ($p = 0.906$) and posttest ($p = 0.103$). These results are shown in **Table 2**.

Table 2. Normality and homogeneity test results

	Pretest	Posttest
N	46	46
Missing	0	0
Mean	53.3	79.9
Median	53.0	80.0
Standard Deviation	9.37	16.2
Minimum	33	46
Maximum	80	100
Shapiro-Wilk W	0.944	0.920
Shapiro-Wilk p	0.027	0.004

Initial competency testing through the Independent Samples T-Test showed that there was a significant difference between the experimental and control classes in the pretest value (t = -3.24; p = 0.002). The pretest difference showed a mean gap of 8.1 points, with a moderate effect size (Cohen's d = 0.95), indicating that the experimental group had slightly higher initial ability. The average pretest of the experimental class is higher than that of the control class. However, this difference does not interfere with the analysis of effectiveness because the measurement of the effect of treatment focuses more on the comparison of posttest results. The test results are presented in Table 3.

Table 3. Results of the t-test in the pretest and posttest

		Statistic	**df**	**P**	**Mean difference**	**SE difference**		**Effect Size**
Pretest	Student's t	-3.24	44.0	0.002	-8.13	2.51	Cohen's d	-0/954
Posttest	Student's t	-9.93	44.0	<.001	-26.57	2.68	Cohen's d	-2.928

Note. $H_{a\ \mu Control \neq \mu}$

Further tests on posttest values using the Independent Samples T-Test showed a very significant difference between the two groups (t = -9.93; p < 0.001). The average posttest score of the experimental class (93.2) was much higher than that of the control class (66.6), with an average difference of 26.57 points. Cohen's effect size value of d of -2.928 indicates that the I-SETS approach has a very large effect on improving student learning outcomes.

The posttest analysis revealed a mean difference of 26.57 points, with the experimental group achieving a mean score of 93.2 compared to 66.6 in the control group. The effect size (Cohen's d = 2.928) indicates an extremely strong practical effect, suggesting that the I-SETS approach contributed substantially to students' conceptual mastery. According to Cohen's criteria, this effect size exceeds the threshold for a large effect (d > 0.8), demonstrating a highly meaningful educational impact. **Fig. 2** illustrates the magnitude of the treatment effect, demonstrating that the I-SETS approach produced a very large practical impact on student learning outcomes.

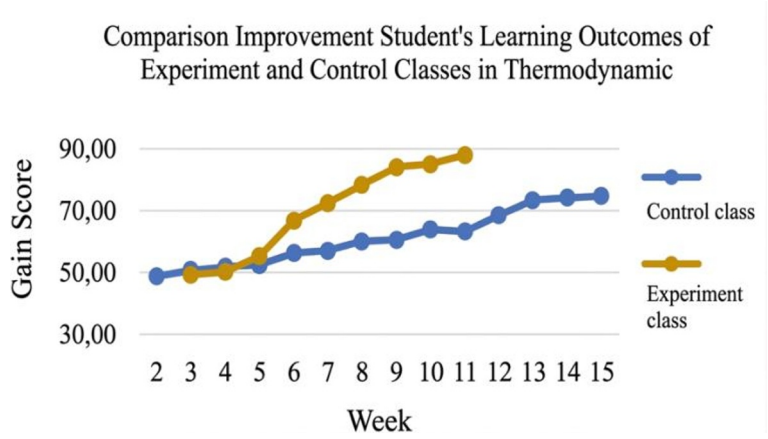

Fig. 2. Effect size visualization

Overall, the statistical findings consistently show higher learning gains, stronger effect magnitude, and more stable performance among students taught using the I-SETS approach.

3.2 Discussion

The significant improvement found in this study suggests that the I-SETS approach supports meaningful learning by connecting scientific concepts with students' spiritual,

environmental, technological, and social experiences. The large difference in posttest values between the experimental and control classes, as well as the effect size values in the very large category, show that the influence of this approach is not only statistically significant, but also pedagogically strong. These findings indicate that the integration of elements of Islam, science, environment, technology, and society provides a more meaningful learning space for elementary school students.

One of the reasons why the I-SETS approach has a great influence is because the integration of Islamic values in learning allows students to see the phenomena of science as part of God's power and greatness. This is in line with the findings which shows that the integration of Islamic values is able to increase the meaning of learning and encourage higher learning outcomes [13]. In third-grade students, the relationship between religious values and scientific phenomena provides an emotional and spiritual context that reinforces the understanding of concepts.

This can be interpreted as an increase in emotional engagement and personal relevance, which strengthens students' cognitive processing and long-term conceptual understanding. The findings of this study are also in line with previous SETS research which emphasized the importance of environmental, technological and social life contexts in science learning. Shows that SETS-approached learning modules improve critical thinking skills because students learn through real-life situations involving the environment and technology [14]. In this study, students of the experimental class were also able to relate the concept of changing the shape of objects to everyday experiences, such as melting ice or evaporating water, so that abstract concepts became more concrete and easier to understand.

This finding is consistent with the developmental characteristics of primary students, who learn more effectively through concrete and contextual experiences. Technology integration through the use of digital simulations and technology-based media also plays a role in increasing students' interest and understanding. From a pedagogical perspective, technology acts as cognitive scaffolding that helps students visualize abstract science phenomena and reduces cognitive load during learning. Emphasizing that science learning in the digital era requires the integration of technology to provide an interactive and contextual learning experience. In this context, the I-SETS approach provides a bridge between science concepts, religious values, technology, and the environment, so that learning becomes more comprehensive.

Interestingly, the difference in initial ability in the pretest did not weaken the effectiveness of I-SETS learning; In fact, the much greater improvement in the experimental classroom shows that this approach is able to provide an acceleration of conceptual understanding, even for students with moderate initial abilities. This reinforces the findings [15] that the integration of Islamic values through the stories of Muslim scientists is able to strengthen the understanding of science and encourage conceptual change in students. This indicates that the I-SETS approach may serve as an equalizing learning strategy, allowing students with different initial abilities to achieve comparable conceptual understanding.

The theoretical contribution of this study lies in integrating spiritual, environmental, technological, and social dimensions into a single science learning framework for lower-grade primary education. In addition, the very large effect size value shows that I-SETS is not just an alternative approach, but has the potential to become a strategic learning model in the context of Islamic madrassas and elementary schools. What makes this study different is the integration of the five domains of I-SETS that are applied simultaneously, not only Islamic science or SETS, as commonly found in previous research.

Overall, the I-SETS approach is proven to not only improve learning outcomes, but also foster environmental awareness, technological literacy, social understanding, and students' spiritual values. Thus, this approach is worthy of being applied more widely and tested in other science materials to obtain a more comprehensive picture of its effectiveness in

developing science literacy and student character. Despite the strong findings, this study is limited by the relatively small sample size and short intervention duration. Future studies should investigate the long-term impact of the I-SETS approach across different science topics and broader educational settings.

4 Conclusions and suggestions

This study proves that the I-SETS approach has a very strong influence on improving students' science learning outcomes. The integration of Islamic values, science concepts, environmental contexts, the use of technology, and social reality is able to create more meaningful and relevant learning for elementary school students. Through the linkage between scientific phenomena and everyday life, this approach not only strengthens the understanding of the concept of change in the form of objects, but also develops students' emotional, spiritual, and cognitive engagement. The effectiveness shows that the holistic character of I-SETS is a major factor in its success, in line with previous research that emphasizes the importance of integrating religious and cultural values in science learning. However, this study makes a new contribution by showing that the five components of I-SETS can be applied effectively at the lower grade level of primary schools with a very strong pedagogical impact. These findings confirm that I-SETS can be an alternative learning model to improve the quality of science learning in madrassas or Islamic-based elementary schools. In addition to making a theoretical contribution, this research also has practical implications for teachers in developing science learning that is contextual, spiritual, and adaptive to technological developments. Follow-up research can expand the topic of the material, use more robust experimental designs, and evaluate the impact of I-SETS on science literacy, critical thinking skills, and problem-solving. Thus, this study opens up a new direction of development for science learning that is more integrative and relevant to the demands of 21st century education.

References

1. Kirkwood, A.; Price, L. Adaptation for a Changing Environment: Developing Learning and Teaching with Information and Communication Technologies. *Int. Rev. Res. Open Distrib. Learn.* **2006**, *7*, 1–14.
2. Hilton, M.L.; Pellegrino, J.W. *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century*; National Academies Press, 2012; ISBN 0309256526.
3. Häkkinen, P.; Järvelä, S.; Mäkitalo-Siegl, K.; Ahonen, A.; Näykki, P.; Valtonen, T. Preparing Teacher-Students for Twenty-First-Century Learning Practices (PREP 21): A Framework for Enhancing Collaborative Problem-Solving and Strategic Learning Skills. *Teach. Teach.* **2017**, *23*, 25–41.
4. Spector, J.M. An Overview of Progress and Problems in Educational Technology. *Interact. Educ. Multimed. IEM* **2001**, 27–37.
5. Ann Haefner, L.; Zembal-Saul, C. Learning by Doing? Prospective Elementary Teachers' Developing Understandings of Scientific Inquiry and Science Teaching and Learning. *Int. J. Sci. Educ.* **2004**, *26*, 1653–1674.
6. Henze, I.; Van Driel, J.H.; Verloop, N. Experienced Science Teachers' Learning in the Context of Educational Innovation. *J. Teach. Educ.* **2009**, *60*, 184–199.
7. Nugroho, I.; Wilujeng, I.; Pujaningsih, P. Digital Transformation of HOTS Assessment in Elementary School Science Learning: Technological Challenges, Human Resource Readiness, and Contribution to SDG's Achievement. In Proceedings of the E3S Web of

Conferences; EDP Sciences, 2025; Vol. 622, p. 3004.
8. Abd-El-Khalick, F.; Boujaoude, S.; Duschl, R.; Lederman, N.G.; Mamlok-Naaman, R.; Hofstein, A.; Niaz, M.; Treagust, D.; Tuan, H. Inquiry in Science Education: International Perspectives. *Sci. Educ.* **2004**, *88*, 397–419.
9. Sutiana, D.; Nugraha, M.S. Integration of Islamic Values and Science in Islamic Primary Schools: A Philosophy of Science Approach. *J. Elem. Educ. Res. Pract.* **2025**, *1*, 21–34.
10. Sholikah, L.; Pertiwi, F.N. Analysis of Science Literacy Ability of Junior High School Students Based on Programme for International Student Assessement (PISA). *INSECTA Integr. Sci. Educ. Teach. Act. J.* **2021**, *2*, 95–104.
11. Nugroho, I.; Wilujeng, I.; Pujaningsih, P.; Iman, M.S.; Witanti, W.; Arifah, A. Analysis of HOTS Content in the Science Process Skills Students' and Teachers' Handbook of the Merdeka Curriculum. In Proceedings of the 5th Borobudur International Symposium on Humanities and Social Science 2023; Atlantis Press, 2024; pp. 1143–1154.
12. Nugroho, I.; Wilujeng, I.; Pujaningsih, P. How Elementary Science Teachers' Understand Perform Science Process Skills and HOTS. In Proceedings of the 5th Borobudur International Symposium on Humanities and Social Science 2023; Atlantis Press, 2024; pp. 159–165.
13. Purwati, N.; Zubaidah, S.; Corebima, A.D.; Mahanal, S. Increasing Islamic Junior High School Students Learning Outcomes through Integration of Science Learning and Islamic Values. *Int. J. Instr.* **2018**, *11*, 841–854.
14. Yulianti, D.; Herpratiwi, H. Development of a Science, Environment, Technology, and Society-Based Learning Module to Foster Critical Thinking in Elementary Students. *J. Educ. Learn.* **2024**, *18*, 1372–1384.
15. Safkolam, R.; Khumwong, P.; Pruekpramool, C.; Hajisamoh, A. Effects of Islamic Scientist History on Seventh Graders' Understandings of Nature of Science in a Thai Islamic Private School. *J. Pendidik. IPA Indones.* **2021**, *10*, 282–291.