Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Developing the CEFTHI Model through a Needs Analysis of Citizen Science and Future Thinking in Integrated Science and Social Studies Primary Education

Kiki Fatmawati

kikifatmawati.2024@student.uny.ac.id

Yogyakarta State University

E. Kus Eddy Sartono

Yogyakarta State University

Woro Sri Hastuti

Yogyakarta State University

Wahyudin Noor

Institut Agama Islam Negeri Syaikh Abdurahman Siddik Bangka Belitung

Juhji Juhji

Universitas Islam Negeri Sultan Maulana Hasanuddin Banten

Almira Ghaisani El Juhji

Syarif Hidayatullah State Islamic University Jakarta

Prasart Nuangchalerm

Mahasarakham University

Research Article

Keywords: CEFTHI Model, Citizen Science, Future Thinking, Primary Education, NNS Learning

Posted Date: November 18th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11100182/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Natural and Social Sciences (NSS) in elementary education still face challenges, including fragmentation between natural and social sciences and limited integration of inquiry-based and future-oriented learning. Although approaches such as citizen science, experiential learning, and episodic future thinking have been widely recognized for their potential to increase student engagement, their integration into NSS learning has not been systematically incorporated into a comprehensive pedagogical framework. This study aims to identify the empirical needs of teachers and students as a basis for developing the CEFTHI (Citizen Science Project–Episodic Future Thinking Integration) model in NSS learning in Islamic Elementary Schools. This study used a quantitative descriptive design involving 75 teachers and 158 fourth-grade students from eight Islamic Elementary Schools in Jambi City. Data were collected through a structured questionnaire, validated using Aiken's V, and tested for reliability using Cronbach's Alpha. Then, they were analyzed descriptively using the mean, standard deviation, and percentage. The results of the study indicate that teachers have a conceptual understanding of environment-based learning and citizen science, but experience limitations in implementing inquiry- and project-based learning, and still have low levels of future-thinking integration in learning. Meanwhile, students show very high environmental awareness and readiness for active learning, but have limited exposure to citizen science and structured future-thinking activities. This study concludes that there is a significant gap among awareness, pedagogical practices, and learning needs, underscoring the urgency of developing the CEFTHI Fmodel as an integrative, contextual, and sustainability-oriented learning framework in primary education. This study is situated within the CEFTHI model, which uniquely integrates citizen science projects and episodic future thinking into a contextual, inquiry-oriented, and sustainability-focused framework for NSS learning in Islamic elementary schools.

1. Introduction

Integrated learning of Natural and Social Sciences in elementary education is increasingly recognized as an effective approach to developing meaningful conceptual understanding and 21st-century skills in students (Bonney et al., 2016; Braz Sousa et al., 2020; Lin et al., 2024). In addition, integrating experiential learning approaches provides students with opportunities to connect academic concepts with real experiences through reflection and collaborative activities (James et al., 2020; Morris, 2020; Zhang et al., 2024). Developing future thinking skills is also an important part of modern education because it helps students understand the long-term impacts of human actions on the environment (Atance & O'Neill, 2001; Chan & Erduran, 2025; Rasa et al., 2022). The integration of these approaches contributes to strengthening learning that is more contextual, participatory, and sustainability-oriented.

Although various innovative learning approaches have been widely introduced in elementary education, their implementation in Natural and Social Sciences learning still shows significant limitations in classroom practice, especially in consistently operationalizing inquiry-based learning (Kirschner et al., 2006; Lazonder & Harmsen, 2016). Teachers still experience a gap between their conceptual understanding of inquiry-based learning, such as citizen science, and their ability to implement it

effectively in learning activities, which is in line with the finding that teachers' pedagogical design capacity is often the main obstacle to learning innovation (Darling-Hammond et al., 2020; Mishra & Koehler, 2006).

In addition, students have a high level of environmental awareness. However, they lack adequate learning experiences in citizen science and structured future-thinking activities, even though the literature shows the importance of episodic future thinking in building anticipatory reasoning about sustainability issues (Atance & O'Neill, 2001; Lee et al., 2020; Mróz & Ocetkiewicz, 2024). Learning in Natural and Social Sciences also tends to be fragmented between the two, thus hindering the development of a complete interdisciplinary understanding, as criticized in the socio-scientific science education literature (Ban & Mahmud, 2023; Högström et al., 2025; Viehmann et al., 2024). This condition indicates that no learning model systematically integrates citizen science, experiential learning, and episodic future thinking within a pedagogical framework such as CEFTHI.

This research is important because there is a significant gap between the demands of inquiry-based, future-oriented Natural and Social Sciences learning and the fragmented, still-unable-to-systematically-integrate citizen science, experiential learning, and future thinking in elementary schools. This research proposes developing the CEFTHI model as an innovative pedagogical framework that integrates citizen science, experiential learning, and episodic future thinking to strengthen interdisciplinary, contextual, and sustainability-oriented learning. This study aims to identify the empirical needs of teachers and students as a basis for developing the CEFTHI model in Science learning in Madrasah Ibtidaiyah.

2. Methodology

2.1 Research Design

This study used a quantitative descriptive design as the needs analysis stage to develop the Citizen Science Project–Episodic Future Thinking Integration (CEFTHI) model in Natural and Social Sciences learning. This design was used to identify empirical learning needs, without testing the intervention's effectiveness. The analysis focused on teaching practices in the Natural and Social Sciences, students' environmental awareness, teachers' readiness for innovative learning, and the need for an integrative, future-oriented learning framework in Madrasah Ibtidaiyah.

2.2 Participants

This research was conducted at eight Islamic primary schools (Madrasah Ibtidaiyah) in Jambi City, Indonesia, under the oversight of the Teacher Working Group. A deliberate sampling method was used to select schools that offered instruction in Natural and Social Sciences, had fourth-grade pupils, and permitted research. The cohort comprised 75 educators and 158 fourth-grade pupils. Educators were chosen for their active participation in the teaching of Natural and Social Sciences, whereas students were selected for their suitability for environmental inquiry-driven learning tasks and initiatives.

2.3 Instruments and Data Collection

Data were collected through two organized surveys. The educator survey comprised 24 Likert-scale questions (1 = strongly disagree to 4 = strongly agree), whereas the pupil survey featured 25 binary items (yes/no). The tools assessed educational circumstances in Natural and Social Sciences, ecological consciousness, involvement in environmental initiatives, engagement with citizen science education, and prospective thinking. Content validity was evaluated by four specialists using Aiken's V, and reliability was assessed using Cronbach's Alpha ($\alpha > 0.70$). Prior to data collection, permission to conduct the study was obtained from the principals of the participating schools. Participation was voluntary. The introductory section of the educator questionnaire informed educators that participation was voluntary and that completion of the questionnaire indicated their willingness to participate without coercion. For the minor student participants, consent was obtained from their parents or legal guardians. The student questionnaire was distributed through the parents' groups and completed by students with parental assistance to ensure that the questionnaire items were clearly understood. Parents were instructed to assist only with item clarification and not to direct or influence students' responses. Participant responses were treated confidentially and reported only in aggregate form.

2.4 Data Analysis

An analysis of the data was conducted using Jamovi software. Aiken's V was used to assess the instrument's validity, while Cronbach's Alpha was used to assess its reliability. Descriptive statistics, including means and standard deviations for instructor data and percentages for pupil responses, were used to uncover patterns in Natural and Social Sciences learning strategies, ecological awareness, and teacher readiness. The outcomes are construed as empirical validation of the CEFTHI model formulation, rather than as inferential generalization.

3. Results

This investigation aims to uncover the empirical demands that underpin the formulation of the CEFTHI (Citizen Science Project–Episodic Future Thinking Integration) model in Islamic Elementary Schools. The conclusions are divided into four analytical segments: the validity and reliability of instruments; evaluation of teacher needs; evaluation of student needs; and a cross-analysis of responses from both teachers and students. The data is presented using a descriptive survey framework, which reports descriptive statistics, including average scores, standard deviations, and the percentage breakdown of replies.

3.1 Validity and Reliability of Instruments

Before field deployment, the research tool was assessed by specialists to confirm content pertinence and language suitability. Content validity was evaluated using Aiken's V coefficient, and internal consistency reliability was assessed using Cronbach's alpha. The findings indicated that every item exceeded the minimum acceptable standards for validity and reliability, affirming the instrument's psychometric robustness for use in the primary research.

Table 1

Validity and Reliability of Research Instrument Content

Instrument	Number of Items	Aiken's V Range	Validity Decision	Cronbach's Alpha	Reliability Decision
Teacher requirements assessment survey	24	0.917-1.000	Valid	0.830	Reliable
Student assessment survey	25	0.917-1.000	Valid	0.982	Reliable
Source: Researcher data analysis (2026)					

The instrument validation outcomes indicated robust content validity and high internal consistency across all metrics. Expert evaluations yielded Aiken's V values of 0.917-1.000, affirming strong item pertinence, while reliability analysis yielded Cronbach's Alpha coefficients of 0.830 (teacher instrument) and 0.982 (student instrument), indicating good to excellent reliability. These findings demonstrate that both tools are appropriate for extensive descriptive analysis during the needs assessment stage.

3.2 Teacher Needs Analysis

The teacher questionnaire was administered to 75 MI teachers to examine the current condition of IPAS learning, students' environmental awareness, teacher readiness, and the need for an innovative learning model. The descriptive analysis is presented in Table 2.

Table 2
Teacher Responses on Needs Analysis

No	Statement	Mean	SD
1	Relating IPAS to environmental issues	3.29	0.632
2	Involving students in environmental activities	2.61	0.543
3	Learning is still dominated by theory	2.55	0.552
4	Environmental awareness is not optimal	2.80	0.493
5	Knowing the citizen science concept	2.92	0.514
6	Understanding citizen science practice	2.95	0.462
7	Knowing the benefits of citizen science	3.15	0.356
8	Need training in citizen science	2.80	0.637
9	Never implemented citizen science	3.13	0.414
10	Difficulty designing projects	3.11	0.481
11	Need implementation guidance	2.28	0.627
12	Asking students to imagine future impact	3.03	0.328
13	Rarely using future thinking	3.17	0.446
14	Need EFT integration strategy	3.25	0.438
15	Need project-based innovation	2.60	0.593
16	Need a contextual learning model	2.72	0.605
17	Teaching IPA and IPS separately	3.12	0.492
18	Students struggle to connect concepts	2.89	0.535
19	Need an integrated learning model	2.63	0.588
20	Environmental awareness is still low	2.72	0.559
21	Low student participation	2.95	0.432
22	Learning, not fostering awareness	2.93	0.553
23	Uneven learning outcomes	2.72	0.559
24	Students tend to memorize concepts	2.95	0.432
Source: Researcher data analysis (2026)			

Descriptive analysis of teachers' responses (N = 75) revealed that science learning was partly contextualized through environmental issues (M = 3.29), but teaching practices remained theory-

dominated, with limited student engagement in environmental activities (M = 2.61) and limited implementation of project-based learning approaches. Teachers also reported limited experience with citizen science practices (M = 3.13) and challenges in designing project-based learning activities (M = 3.11), alongside a strong need to integrate episodic futures thinking into Natural and Social Sciences teaching (M = 3.25). These patterns indicate a gap between conceptual awareness and the capacity to implement pedagogically.

3.3 Student Needs Analysis

The student questionnaire was administered to 158 fourth-grade students. Because the instrument used dichotomous responses, results are reported using mean scores and percentages of “yes” responses. Descriptive results are presented in Table 3.

Table 3

Student Responses on Needs Analysis

No	Statement	Mean	SD
1	Learning is linked to the environment	0.994	99.4
2	Participation in environmental activities	0.924	92.4
3	More theory than practice	0.671	67.1
4	Understanding environmental importance	1.000	100.0
5	Knowing citizen science	0.684	68.4
6	Understanding citizen science practice	0.551	55.1
7	Desire for ecological initiatives	0.956	95.6
8	Revel in environmental exploration	0.981	98.1
9	Requested to envision prospective ecological circumstances	0.677	67.7
10	Infrequent anticipatory exercise	0.487	48.7
11	Want future-oriented learning	0.930	93.0
12	Desire experiential learning through practical projects	0.975	97.5
13	Demand participatory learning techniques	0.975	97.5
14	Study Science and Social subjects independently	0.468	46.8
15	Challenges in linking ideas	0.658	65.8
16	Desire cohesive education	0.722	72.2
17	Have faith in coexistence with the natural world	0.994	99.4
18	Environmental responsibility	1.000	100.0
19	Know the human impact on the environment	0.994	99.4
20	Understand categories of garbage	0.905	90.5
21	Accountable for ecological stewardship	0.981	98.1
22	Avoid littering	0.962	96.2
23	Engage in sanitation efforts	0.867	86.7
24	Recall the acquisition of knowledge effectively	0.842	84.2
25	Integrate education with everyday experiences	0.892	89.2

Source: Researcher data analysis (2026)

The replies from students (N = 158) exhibited uniformly elevated levels of environmental consciousness and a robust inclination towards experiential learning. Almost all pupils acknowledged the significance of environmental conservation (100%) and conveyed a sense of duty towards ecological sustainability (100%), while also exhibiting considerable enthusiasm for environmental initiatives (95.6%) and experiential learning opportunities (97.5%). Nonetheless, engagement with citizen science education (55.1%) and organized, prospective reflection (48.7%) was limited, highlighting a disparity between awareness and instructional engagement with interactive teaching methods and future-oriented thinking.

3.4 Cross-Analysis of Teacher and Student Responses

An examination of teacher and student data uncovered both aligned and divergent trends, providing an extensive overview of the implementation of environmentally focused Natural and Social Sciences education. Both groups agreed that environmental issues have been integrated into Natural and Social Sciences learning through the use of contexts and examples close to students' daily lives. However, this integration still tends to focus on linking material to the environment and has not yet developed systematically into inquiry-based learning or projects that encourage active student involvement. Furthermore, a gap was found between students' high environmental awareness and their level of participation in environmental conservation activities, which teachers still considered limited. These results suggest that the primary obstacle is not insufficient environmental consciousness but rather the absence of educational frameworks that can translate this understanding into tangible, sustainable practices.

Conversely, both educators and learners acknowledged the significance of more dynamic, contextualized, participative, and substantive learning. Educators acknowledged the need to incorporate citizen science and forward-thinking perspectives, yet encountered challenges in implementing them. Conversely, pupils demonstrated significant readiness to participate in environmental initiatives and collaborative learning experiences. Moreover, both data sources indicated a disconnect between the scientific and social aspects of learning in the Natural and Social Sciences, as evidenced by distinct pedagogical approaches and students' challenges in understanding their interconnections. These results offer compelling empirical support for the necessity of a more organized, integrated, experiential, inquiry-driven learning framework in Natural and Social Sciences that cohesively links scientific and social dimensions within sustainable environmental education.

4. Discussion

This research provides empirical support for the need to develop a comprehensive CEFTHI (Citizen Science Project–Episodic Future Thinking Integration) educational framework for instruction in the Natural and Social Sciences in Islamic Elementary Schools (*Madrasah Ibtidaiyah*). However, the curriculum emphasizes fostering critical thinking, environmental awareness, inquiry-driven education, and 21st-century competencies. Educational practices continue to fall short of meeting curricular expectations, educators' instructional skills, and students' educational experiences. These results suggest that, while students demonstrate significant capacity and understanding of environmental

concerns, they have not been afforded sufficient opportunities for genuine scientific inquiry or organized forward-thinking endeavors. This scenario aligns with findings from other studies indicating that science and social science education in elementary schools remain disjointed, focused on content transmission, and insufficiently equipped to integrate inquiry-based experiences with social contexts and environmental sustainability (Högström et al., 2025; Nolan & Zeidler, 2025).

In contrast to traditional educational methods focused on knowledge dissemination, a comprehensive model integrating citizen science with episodic future thinking offers greater potential to foster deep conceptual understanding, anticipatory reasoning, and student involvement in addressing real-world challenges. Participation in citizen science projects, according to Ballard et al. (2024) and Hadjichambi et al. (2023), was able to improve environmental literacy, science identity, and student engagement in the scientific investigation process; meanwhile, according to Chan and Erduran (2025) and Lee et al. (2020), the futures thinking approach has been proven to strengthen futures literacy, the ability to anticipate long-term consequences, and sustainability-oriented decision-making. The findings of this study not only confirm constructivist critiques of the dominance of transmissive learning practices despite decades of educational reform but also demonstrate that the integration of citizen science and episodic futures thinking through the CEFTHI model has the potential to be a more relevant pedagogical alternative to bridge the gap between curricular objectives, student needs, and the demands of 21st-century sustainability education.

On the other hand, teacher data indicate a significant gap between pedagogical awareness and the implementation of classroom learning. Although teachers demonstrated a relatively good understanding of integrating environmental issues (M = 3.29) and the concept of citizen science (M = 2.92–3.15), learning practices remained dominated by theory-based approaches and information delivery. This situation suggests that educators' theoretical understanding has not been fully applied to teaching methods that involve students in genuine scientific inquiries. These findings strengthen the argument that the success of education reform is determined not only by mastery of the material but also by teachers' ability to effectively integrate content knowledge, pedagogy, and learning contexts as described in the Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge frameworks (Graham, 2011; Hanifah et al., 2025; Koehler et al., 2013; Voogt et al., 2013; Wahyuni et al., 2024). Recent research also shows that teachers often experience difficulties in implementing inquiry- and project-based learning due to limited pedagogical support, limited experience with learning design, and complex curriculum demands (Fry et al., 2025; Nguyen, 2025; Wilson et al., 2025).

Compared to the contemporary constructivist paradigm, the learning practices identified in this study still tend to be oriented towards a teacher-centered epistemology (teacher-centered learning) rather than towards learning that places students as the primary actors in the knowledge-construction process. According to constructivist theory, knowledge develops through active interactions between individuals and their environment, through exploration, meaning negotiation, and social reflection (Bodie & Jones, 2015; Brooks, 2006; Mitry, 2021; Vagele-Kricina, 2021). Therefore, the limited implementation of project-

based learning and investigation indicates that students' opportunities to build conceptual understanding through direct experience remain limited.

Furthermore, the limited use of project-based learning suggests that the principles of experiential learning have not been fully implemented in the Natural and Social Sciences. According to Morris (2020), Meaningful learning occurs through a cycle of concrete experiences, reflection, abstract conceptualization, and active experimentation. However, the dominance of theory-based learning indicates that students act more as recipients of information than as explorers and problem-solvers. However, recent research shows that authentic learning experiences involving environmental projects, citizen science, and futures thinking activities can strengthen the connection between academic knowledge and real-life contexts while developing the sustainability competencies needed in the 21st century (Ballard et al., 2024; Bol & de Wolf, 2023; Chan & Erduran, 2025). Thus, the results of this study indicate the need to transform Natural and Social Sciences learning towards a more integrative, participatory, and future-oriented model to achieve sustainability education goals more effectively.

Student feedback demonstrated exceptionally high levels of environmental consciousness (100%) and robust preparedness for experiential education (95.6–97.5%). These results correspond with studies indicating that children cultivate early moral and cognitive awareness of environmental concerns when adequately directed (Du et al., 2024; Villanueva et al., 2018). Nonetheless, limited engagement in citizen science (55.1%) and sporadic future-oriented thinking (48.7%) underscore significant deficiencies in advancing future-focused cognition. Episodic future thinking is essential for allowing humans to envision future outcomes and make informed choices (Atance & O'Neill, 2001; Schacter et al., 2007, 2008; Suddendorf & Corballis, 2007). Their lack of early childhood education diminishes the chances of cultivating anticipatory reasoning and sustainability-focused cognition.

Multi-level scrutiny indicates structural convergence and division. Although teachers and students acknowledge environmental integration in Natural and Social Sciences, this integration remains superficial and epistemically meaningless. This reflects what Sadler et al. (2004) described as contextualized but unintegrated science learning, where real-world issues are used as illustrations rather than as a structure for inquiry. Furthermore, the mismatch between student enthusiasm and teacher-perceived participation reflects systemic barriers to implementing active learning approaches. This is consistent with Mincu (2013) and Bovill (2015), who report that education systems often struggle to align the demands of student-centered learning with teacher preparedness and institutional support.

The continuing separation between the Natural and Social Sciences further reinforces the fragmentation of the disciplines. The integrated learning literature emphasizes that complex socio-environmental problems require interdisciplinary reasoning rather than isolated disciplinary instruction (Zeidler et al., 2005). This supports the need for an integrated framework such as the CEFTHI model. The CEFTHI model is theoretically based on the integration of three complementary frameworks, namely: (1) citizen science pedagogy that emphasizes authentic participation in scientific inquiry and collaborative knowledge construction (Bonney et al., 2016), (2) episodic future thinking which increases an individual's

capacity to simulate future events mentally and enhances anticipatory decision making (Atance & O'Neill, 2001; Schacter et al., 2007), and (3) experiential constructivism, which conceptualizes learning as an active process of meaning-making through experience, reflection, and the ongoing reconstruction of knowledge (Morris, 2020). This amalgamation of frameworks addresses a significant deficiency in prevailing educational paradigms: the lack of an organized system linking experiential learning to future-focused thinking. Although citizen science fosters involvement in practical investigations, it frequently lacks organized forecasts of future developments. Conversely, episodic future thinking improves predictive cognition, although it is never integrated into genuine scientific investigation.

This investigation adds to the body of literature in three significant ways. First, it identifies threefold shortcomings in ecological awareness, instructional application, and prospective thinking skills in elementary education. Second, it introduces CEFTHI as a new integrative pedagogical model that combines citizen science and episodic futures thinking in science and science instruction. Third, it extends the inquiry-based and experiential learning framework by embedding future-oriented cognition as a core instructional component, rather than as a byproduct.

So far, this integration has not been systematically operationalized in integrated science-social studies education in primary schools, particularly in developing country contexts. This positions CEFTHI as a potentially transformative contribution to sustainability-oriented education. From a practical perspective, the findings highlight the need for structured teacher professional development in citizen science-based instructional design, future-oriented reflective pedagogy, and the implementation of an interdisciplinary science curriculum. From a policy perspective, curriculum reform should aim for an integrated socio-environmental learning framework aligned with UNESCO's sustainability education goals and 21st-century competencies.

5. Conclusion

This study concludes that the CEFTHI (Citizen Science Project–Episodic Future Thinking Integration) model has empirical justification and theoretical significance as an integrative pedagogical framework to bridge the gap between environmental awareness, learning practices, and future-oriented cognition in science learning in Islamic elementary schools, with findings indicating a mismatch between teachers' conceptual understanding of citizen science and the limitations of the implementation of inquiry-based and project-based learning, as well as a gap between students' high environmental awareness and low exposure to structured citizen science and episodic future thinking; however, this study has limitations due to its use of a self-report-based descriptive cross-sectional design that limits causal inference, its limited sample size of eight schools, thus reducing generalizability, and its failure to test the effectiveness of the CEFTHI model implementation in the classroom; therefore, future research is recommended to use experimental or design-based research, longitudinal studies, and mixed-methods approaches to evaluate the impact of CEFTHI implementation in more depth, test the sustainability of its effects on environmental literacy and future thinking skills, and assess its adaptability across various educational contexts.

Declarations

Program Studi Doktor Pendidikan Dasar, Fakultas Ilmu Pendidikan, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.

E. Kus Eddy Sartono, Woro Sri Hastuti

Program Studi Doktor Pendidikan Dasar, Fakultas Ilmu Pendidikan, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.

Wahyudin Noor

Institut Agama Islam Negeri Syaikh Abdurahman Siddik Bangka Belitung, Belitung, Indonesia

Juhji Juhji

Universitas Islam Negeri Sultan Maulana Hasanuddin Banten, Indonesia

Almira Ghaisani El Juhji

Universitas Islam Negeri Syarif Hidayatullah, Jakarta, Indonesia

Prasart Nuangchalerm

Mahasarakham University, Maha Sarakham, Thailand

Ethics approval and consent to participate

The study was reviewed by the Ethics Committee SUTHA, Universitas Islam Negeri Sulthan Thaha Saifuddin Jambi. Following its ethical review, the committee determined that the study met the criteria for exemption from full ethical review, as documented in the official ethical determination issued through the Research and Community Service Institute (LPPM), Universitas Islam Negeri Sulthan Thaha Saifuddin Jambi (Reference No. B-845/Un.15/L.II/PP.00.9/01/2026). The determination was issued following a review of the completed study and does not constitute retrospective ethical approval. Based on the review of the study document and procedures, the study was conducted in accordance with applicable ethical guidelines and regulations and the relevant principles of the Declaration of Helsinki. Informed consent to participate was obtained from all adult participants. For participate under the age of 16, informed consent was obtained from their parents or legal guardians. Participation was voluntary, participant confidentiality was maintained, and the findings were reported in aggregate form without personally identifiable information.

Conflict of Interest

We declare that we have no known financial conflicts of interest or personal relationships that could be construed as influencing the work reported in this paper.

Consent for Publication

Not applicable. The manuscript does not contain any personally identifiable information, images, or other individual-level information requiring consent for publication.

Funding

This research received no external funding.

Author Contribution

All authors contributed to the development and completion of this article in accordance with their respective roles. KF contributed to conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft, writing—review and editing, visualization, supervision, and funding acquisition. EKES contributed to conceptualization, methodology, formal analysis, investigation, writing—original draft, visualization, project administration, and funding acquisition. WSH contributed to formal analysis, investigation, writing—original draft, visualization, and project administration. WN contributed to formal analysis, resources, supervision, and funding acquisition. JJ contributed to resources, writing, review, and editing. AGEJ contributed to writing and editing. PN contributed to formal analysis, investigation, writing—original draft, and writing—review and editing. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work, ensuring its accuracy and integrity.

Acknowledgement

We want to thank the principals, teachers, and students of eight elementary Islamic schools in Jambi City, Indonesia, who participated in the research process leading to this publication. We also thank the coordinators of the Jambi City Madrasah Teacher Working Group for their active participation in data collection. We also extend our gratitude to all parties involved, both directly and indirectly, in this research.

Data Availability

The datasets generated and analyzed during the current study are not publicly available because they include responses from minor participants and are subject to confidentiality considerations. De-

identified data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to appropriate ethical and confidentiality considerations.

References

1. Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences*, *5*(12), 533–539. https://doi.org/10.1016/S1364-6613(00)01804-0
2. Ballard, H. L., Lindell, A. J., & Jadallah, C. C. (2024). Environmental education outcomes of community and citizen science: a systematic review of empirical research. *Environmental Education Research*, *30*(6), 1007–1040. https://doi.org/10.1080/13504622.2024.2348702
3. Ban, S., & Mahmud, S. N. D. (2023). Research and Trends in Socio-Scientific Issues Education: A Content Analysis of Journal Publications from 2004 to 2022. *Sustainability*, *15*(15), 11841. https://doi.org/10.3390/su151511841
4. Bodie, G. D., & Jones, S. M. (2015). Constructivism. In *The International Encyclopedia of Interpersonal Communication* (pp. 1–5). Wiley. https://doi.org/10.1002/9781118540190.wbeic085
5. Bol, E., & de Wolf, M. (2023). Developing futures literacy in the classroom. *Futures*, *146*, 103082. https://doi.org/10.1016/j.futures.2022.103082
6. Bonney, R., Phillips, T. B., Ballard, H. L., & Enck, J. W. (2016). Can citizen science enhance public understanding of science? *Public Understanding of Science*, *25*(1), 2–16. https://doi.org/10.1177/0963662515607406
7. Bovill, C. (2015). Learner-centred education in international perspective. Whose pedagogy for whose development? *International Journal for Academic Development*, *20*(3), 300–302. https://doi.org/10.1080/1360144X.2015.1066404
8. Braz Sousa, L., Fricker, S. R., Doherty, S. S., Webb, C. E., Baldock, K. L., & Williams, C. R. (2020). Citizen science and smartphone e-entomology enables low-cost upscaling of mosquito surveillance. *Science of the Total Environment*, *704*. https://doi.org/10.1016/j.scitotenv.2019.135349
9. Brooks, J. G. (2006). Constructivism. In *Encyclopedia of Cognitive Science*. Wiley. https://doi.org/10.1002/0470018860.s00503
10. Castro-Faix, M., Duncan, R. G., & Choi, J. (2021). Data-driven refinements of a genetics learning progression. *Journal of Research in Science Teaching*, *58*(1), 3–39. https://doi.org/10.1002/tea.21631
11. Chan, J., & Erduran, S. (2025). Future-Oriented Science Learning and its Effects on Students' Emotions, Futures Literacy and Agency in the Anthropocene. *Research in Science Education*, *55*(4), 899–919. https://doi.org/10.1007/s11165-024-10213-1
12. Dare, E. A., Keratithamkul, K., Hiwatig, B. M., & Li, F. (2021). Beyond Content: The Role of STEM Disciplines, Real-World Problems, 21st Century Skills, and STEM Careers within Science Teachers' Conceptions of Integrated STEM Education. *Education Sciences*, *11*(11), 737. https://doi.org/10.3390/educsci11110737

13. Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791
14. Du, J., Liang, Y., Guo, D., & Xiao, Y. (2024). The relationship between theory of mind and moral sensitivity among Chinese preschool children: the mediating role of empathy. *BMC Psychology*, *12*(1), 112. https://doi.org/10.1186/s40359-024-01600-4
15. Fry, K., Nakar, S., & Zorn, K. (2025). Professional learning interventions for inquiry-based pedagogies in primary classrooms: A scoping review. *Mathematics Education Research Journal*, *37*(4), 853–887. https://doi.org/10.1007/s13394-024-00516-x
16. Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education*, *57*(3), 1953–1960. https://doi.org/10.1016/j.compedu.2011.04.010
17. Hadjichambi, D., Hadjichambis, A. C., Adamou, A., & Georgiou, Y. (2023). A systematic literature review of K-12 environmental Citizen Science (CS) initiatives: Unveiling the CS pedagogical and participatory aspects contributing to students' environmental citizenship. *Educational Research Review*, *39*, 100525. https://doi.org/10.1016/j.edurev.2023.100525
18. Hanifah, U., Budayasa, I. K., & Sulaiman, R. (2025). Technology, pedagogy, and content knowledge in mathematics education: a systematic literature review. *Journal of Education and Learning (EduLearn)*, *19*(1), 579–586. https://doi.org/10.11591/edulearn.v19i1.21816
19. Högström, P., Gericke, N., Wallin, J., & Bergman, E. (2025). Teaching Socioscientific Issues: A Systematic Review. *Science & Education*, *34*(5), 3079–3122. https://doi.org/10.1007/s11191-024-00542-y
20. James, N., Humez, A., & Laufenberg, P. (2020). Using Technology to Structure and Scaffold Real World Experiential Learning in Distance Education. *TechTrends*, *64*(4), 636–645. https://doi.org/10.1007/s11528-020-00515-2
21. Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist*, *41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1
22. Koehler, M. J., Mishra, P., & Cain, W. (2013). What is Technological Pedagogical Content Knowledge (TPACK)? *Journal of Education*, *193*(3), 13–19. https://doi.org/10.1177/002205741319300303
23. Lazonder, A. W., & Harmsen, R. (2016). Meta-Analysis of Inquiry-Based Learning. *Review of Educational Research*, *86*(3), 681–718. https://doi.org/10.3102/0034654315627366
24. Lee, P.-S., Sung, Y.-H., Wu, C.-C., Ho, L.-C., & Chiou, W.-B. (2020). Using Episodic Future Thinking to Pre-Experience Climate Change Increases Pro-Environmental Behavior. *Environment and Behavior*, *52*(1), 60–81. https://doi.org/10.1177/0013916518790590
25. Lin, J.-H., Yang, S. C., & Lin, J.-Y. (2024). Fostering ecosystem understanding: The synergistic impact of inquiry-based instruction and information literacy. *Computers & Education*, *220*, 105125.

https://doi.org/10.1016/j.compedu.2024.105125

26. Mincu, M. (2013). Learner-centred education in international perspective. Whose pedagogy for whose development? *Comparative Education*, *49*(4), 537–539. https://doi.org/10.1080/03050068.2013.826047
27. Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record: The Voice of Scholarship in Education*, *108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x
28. Mitry, M. M. (2021). Translating Constructivism into Pedagogy from Philosophy to Practice: Active Project-Based Learning. *The International Journal of Humanities Education*, *19*(1), 39–51. https://doi.org/10.18848/2327-0063/CGP/v19i01/39-51
29. Morris, T. H. (2020). Experiential learning – a systematic review and revision of Kolb's model. *Interactive Learning Environments*, *28*(8), 1064–1077. https://doi.org/10.1080/10494820.2019.1570279
30. Mróz, A., & Ocetkiewicz, I. (2024). Anticipatory Thinking as a Key Competence in Management for Sustainability: The Results of Research Among Polish Teenagers. *Sustainability*, *16*(22), 10036. https://doi.org/10.3390/su162210036
31. Nguyen, A. Q. (2025). Pedagogical Approaches in STEAM Education. In *Transformative Approaches to STEAM Integration in Modern Education* (pp. 53–78). IGI Global. https://doi.org/10.4018/979-8-3693-7408-5.ch003
32. Nolan, E., & Zeidler, D. (2025). Cultivating critical reflection through socioscientific perspectives. *Disciplinary and Interdisciplinary Science Education Research*, *7*(1), 16. https://doi.org/10.1186/s43031-025-00136-w
33. Rasa, T., Palmgren, E., & Laherto, A. (2022). Futurising science education: students' experiences from a course on futures thinking and quantum computing. *Instructional Science*, *50*(3), 425–447. https://doi.org/10.1007/s11251-021-09572-3
34. Sadler, T. D., Chambers, F. W., & Zeidler, D. L. (2004). Student conceptualizations of the nature of science in response to a socioscientific issue. *International Journal of Science Education*, *26*(4), 387–409. https://doi.org/10.1080/0950069032000119456
35. Schacter, D. L., Addis, D. R., & Buckner, R. L. (2007). Remembering the past to imagine the future: the prospective brain. *Nature Reviews Neuroscience*, *8*(9), 657–661. https://doi.org/10.1038/nrn2213
36. Schacter, D. L., Addis, D. R., & Buckner, R. L. (2008). Episodic Simulation of Future Events. *Annals of the New York Academy of Sciences*, *1124*(1), 39–60. https://doi.org/10.1196/annals.1440.001
37. Stehle, S. M., & Peters-Burton, E. E. (2019). Developing student 21st Century skills in selected exemplary inclusive STEM high schools. *International Journal of STEM Education*, *6*(1), 39. https://doi.org/10.1186/s40594-019-0192-1
38. Suddendorf, T., & Corballis, M. C. (2007). The evolution of foresight: What is mental time travel, and is it unique to humans? *Behavioral and Brain Sciences*, *30*(3), 299–313. https://doi.org/10.1017/S0140525X07001975

39. Vagele-Kricina, A. (2021). E-Constructivism. In *Practical Perspectives on Educational Theory and Game Development* (pp. 130–147). IGI Global. https://doi.org/10.4018/978-1-7998-5021-2.ch006
40. Viehmann, C., Fernández Cárdenas, J. M., & Reynaga Peña, C. G. (2024). The Use of Socioscientific Issues in Science Lessons: A Scoping Review. *Sustainability*, *16*(14), 5827. https://doi.org/10.3390/su16145827
41. Villanueva, X., Villarroel, J., & Antón, A. (2018). Environmental Awareness and Its Relationship with the Concept of the Living Being: A Longitudinal Study. *Sustainability*, *10*(7), 2358. https://doi.org/10.3390/su10072358
42. Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological pedagogical content knowledge – a review of the literature. *Journal of Computer Assisted Learning*, *29*(2), 109–121. https://doi.org/10.1111/j.1365-2729.2012.00487.x
43. Wahyuni, S., Etfita, F., Dafit, F., & Asnawi, A. (2024). Unboxing the primary English teacher's TPACK profile: instrumental design and validation. *Journal of Education and Learning (EduLearn)*, *18*(3), 825–832. https://doi.org/10.11591/edulearn.v18i3.21780
44. Wilson, M. M., Zafar, F., & Nichol, C. (2025). Fostering Inquiry: The Impact of Cross-Curricular Professional Development on STEM Teacher Practices. *Education Sciences*, *15*(4), 421. https://doi.org/10.3390/educsci15040421
45. Zeidler, D. L., Sadler, T. D., Simmons, M. L., & Howes, E. V. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education*, *89*(3), 357–377. https://doi.org/10.1002/sce.20048
46. Zhang, Z., Bekker, T., Markopoulos, P., & Skovbjerg, H. M. (2024). Supporting and understanding students' collaborative reflection-in-action during design-based learning. *International Journal of Technology and Design Education*, *34*(1), 307–343. https://doi.org/10.1007/s10798-023-09814-0