Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar JPPGuseda

Volume 9 Issue 1 Year 2026 Pages 54 - 64
ISSN 2623-0941 | e–ISSN 2623-0232
https://jppguseda-fkip.unpak.ac.id
DOI: 10.55215/jppguseda.v9i1.26

Innovative Science Learning through the "Time Machine" Project: Fostering Causality Concepts and Ethical Actions in Elementary Education

Meirza Nanda Faradita[1], Hafidz Rosyidiana[2], Wahono Widodo[3], Hendratno[4]
meirzanandafaradita@um-surabaya.ac.id, h.rosyid2904@gmail.com, wahonowidodo@unesa.ac.id, hendratno@unesa.ac.id

[1]*Faculty of Education, Communication, and Science, Universitas Muhammadiyah Surabaya, Surabaya, Indonesia*
[2]*Faculty of Tarbiyah and Teacher Training, Universitas Islam Negeri Sayyid Ali Rahmatullah, Tulungagung, Indonesia*
[2]*Faculty of Mathematics and Sciences Education, Universitas Negeri Surabaya, Surabaya, Indonesia*
[4]*Faculty of Education, Universitas Negeri Surabaya, Surabaya, Indonesia*

*Correspondence to: *Meirza Nanda Faradita*
Universitas Muhammadiyah Surabaya
email: meirzanandafaradita@um-surabaya.ac.id

Abstract: This study aims to describe of implementing the "Time Machine" project in improving fourth-grade elementary school students' ability to analyze chain causality and ethical actions in science learning. This study employed a descriptive qualitative method conducted over one learning cycle at one of public elementary school, involving a fourth-grade homeroom teachers, students, and the school principal as research subjects. Data were collected through interviews and structured observations using an observation sheet as the primary instrument, supported by interview guidelines directed at the classroom teacher and principal. Data analysis followed the interactive model, encompassing three stages: data reduction, data display, and conclusion drawing. The results indicate that prior to the project implementation, students were only able to identify direct cause-and-effect relationships and limited their ethical judgments to simple right-or-wrong assessments. Following the implementation of the "Time Machine" project, students demonstrated a significant transition in causal reasoning, progressing from identifying immediate causes to constructing systemic causality by predicting chain consequences of actions on the present ecosystem. Furthermore, students' ethical discussions shifted from simple normative responses to in-depth consequentialist analysis, evidenced by their ability to evaluate the moral value of actions based on projected universal impacts. It is concluded that the "Time Machine" project is an effective and authentic learning framework that simultaneously supports the achievement of the critical reasoning and noble moral dimensions of the Pancasila student profile, in alignment with the demands of Indonesia's independent curriculum.

Keywords: causality concept; elementary education; ethical action; science learning

Article info: Submitted Dec 11, 2025 | Revised Mar 19, 2026 | Accepted Mar 28,2026

Recommended citation: Faradita, M. N., Rosyidiana, H., Widodo, W., & Hendratno, H. (2026). Innovative Science Learning through the "Time Machine" Project: Fostering Causality Concepts and Ethical Actions in Elementary Education. *Jurnal Pendidikan Dan Pengajaran Guru Sekolah Dasar (JPPGuseda)*, 9(1), 54-64. https://doi.org/10.55215/jppguseda.v9i1.26

Introduction

National education aims not only to develop students' intellectual abilities but also to shape character and responsible citizenship. This objective highlights the importance of ethical behavior and causal reasoning as fundamental components of character formation. In the context of educational axiology, causality is not merely understood as a logical relationship between cause and effect but also as a basis for moral responsibility and ethical decision-making (Smith, 2026; Liu, 2024). Students are expected to understand not only what happens but also why actions matter and what consequences they may produce. Strong causal reasoning enables learners to anticipate the future effects of present actions, an essential component of ethical literacy (Shavlik et al., 2022; Aylsworth & Castro, 2024). Likewise, ethical education requires students to evaluate actions based on their consequences and moral implications rather than simply memorizing rules (Joshi, 2026; Curren, 2017). Consistent with these goals, the Merdeka Curriculum promotes deep learning approaches that encourage students to engage in reflection, analysis, and contextual moral reasoning (Dewi et al., 2024; Kohn, 2024).

However, empirical observations in elementary schools reveal several challenges in achieving these objectives. Students frequently experience difficulties when learning concepts that require abstract reasoning, particularly in identifying causal chains and predicting delayed consequences of actions. When confronted with scientific or social problems, many students are only able to identify direct causes and effects and struggle to analyze broader implications. Their moral judgments also tend to remain at the level of simple right–wrong distinctions without deeper consideration of ethical dilemmas and social consequences. These difficulties are especially evident among low-achieving students, who often rely on surface-level observations and have limited ability to construct multi-step causal relationships (Sugiyono, 2021). As a result, science and social science learning often fail to foster higher-order reasoning, ethical reflection, and student engagement. Conventional instructional approaches such as lectures and simple case discussions appear insufficient to stimulate deeper causal and moral thinking.

Previous studies have highlighted similar concerns regarding the integration of ethical reasoning and scientific understanding in elementary education. Although the Merdeka Curriculum emphasizes critical reasoning and noble character through the Pancasila Student Profile, classroom practices often prioritize factual knowledge over ethical reflection (Luthfiyah et al., 2025). Research shows that environmental and social issues should be understood not only through scientific explanations but also through their ethical and social consequences (Dewi et al., 2024). Nevertheless, studies continue to report that ethical discussions in elementary classrooms remain superficial and rarely encourage students to reflect on the consequences of their decisions (Lubaba & Alfiansyah, 2022; Hassan et al., 2022). Furthermore, most research in science education focuses on conceptual understanding and cognitive outcomes, while value formation and ethical literacy receive less attention (Reyes & Villanueva, 2024; Freire et al., 2019). This situation creates a persistent pedagogical gap between the curriculum's expectations and actual classroom implementation.

Several instructional approaches have been proposed to address these challenges. Project-Based Learning (PjBL) has consistently been shown to improve students' critical thinking, conceptual understanding, and collaborative skills (Kokotsaki et al., 2016; Permatasari et al., 2025). Deep learning approaches also promote meaningful, mindful, and morally engaged learning experiences. In addition, studies have demonstrated that non-traditional stimuli and moral dilemmas can strengthen students' ethical reasoning more effectively than conventional learning activities (Haryono et al., 2025; Bîzoi & Bizoi, 2026). Despite these advances, research rarely integrates causal reasoning and ethical consequentialism within a single learning framework. Existing studies generally examine scientific reasoning and moral education separately, and there remains limited empirical evidence regarding how speculative or science-fiction-based projects can simultaneously promote scientific understanding and ethical reflection among elementary school students.

To address this research gap, the present study introduces the "Time Machine" Project, a project-based learning intervention that combines causal reasoning and ethical reflection through a science-fiction scenario. In this project, students are asked to imagine altering events in the past, such as saving dinosaurs from extinction, and then analyze the scientific, social, and ethical consequences of those actions in the present. The scenario encourages learners to explore complex chains of causality while simultaneously evaluating the moral implications of their decisions. Unlike conventional moral instruction, which often treats ethics as a separate subject, this project embeds consequentialist ethical reasoning directly into scientific inquiry. The use of an imaginary yet intellectually authentic context provides opportunities for students to engage in deep reasoning while maintaining high levels of curiosity and motivation.

The novelty of this study lies in its integration of a science-fiction-based "Time Machine" scenario with a Project-Based Learning framework to simultaneously develop systemic causal reasoning and consequentialist ethical reflection in elementary education. Unlike previous studies that examine these competencies independently, this research combines them within a single learning experience that aligns with the principles of deep learning and the goals of the Merdeka Curriculum. The study also contributes to the literature by introducing the concept of imaginary authenticity, in which fictional scenarios are used to stimulate rigorous scientific and moral reasoning. Therefore, this research aims to investigate how the Time Machine Project can foster elementary students' causal understanding and ethical literacy while supporting the development of the Critical Reasoning and Noble Character dimensions of the Pancasila Student Profile. The findings are expected to provide both theoretical and practical contributions to the development of innovative character-oriented science learning in elementary schools.

Methods

The type of research used in this study is qualitative research. Qualitative research is a naturalistic research method because it is conducted in a natural environment (Creswell, 2009; Sugiyono, 2021). The research design used in this study is descriptive qualitative research. According to (Creswell, 2009) The research design used in this study is descriptive qualitative. Data refers to the subject from which the data are obtained. The types of data used in this study are primary and secondary. This research was conducted at SDN Ploso V Surabaya, involving a fourth-grade teacher or homeroom teacher (GA) as the primary data source, and the principal (UK) and fourth-grade students as secondary data sources. The location was selected based on initial observation findings that indicated challenges in Phase B of Science learning, especially in materials requiring abstract reasoning. The identified phenomena in the field revealed that most students had low abilities in analyzing chain causality and tended to only understand cause and effect directly. In addition, discussions on ethics among students were still limited to simple right-wrong categories without involving in-depth analysis of moral dilemmas. The fourth-grade teacher participants were selected because of their position as the main implementer of learning who could provide comprehensive data on the effectiveness of the "Time Machine" project in stimulating students' speculative reasoning.

Data collection techniques are all the methods used by researchers to obtain and collect data in the field so that the research results can be useful (Faradita & Afiani, 2021; Sukmawati 2023). In this study, the techniques used were interviews and observations. Interviews were conducted with fourth-grade teachers and the principal, while observations were conducted to determine teacher creativity in video-based learning. Identifying the direct effect relationships of an event, analyzing multilevel causal chains, and predicting the long-term impact of a single variable change on the current ecosystem, recognizing moral dilemmas in scenarios, distinguishing between intention-based and impact-based ethical judgments, and disseminating the moral value of a decision based on its universal impact on the environment and society.

In this study, the researchers employed the data analysis technique model developed by Miles and Huberman Miles et al. (2014). The activities in qualitative research data analysis are carried out interactively and continuously until complete, so that the resulting data is saturated. The measure of saturation in the data is marked by the absence of new data or information. Researchers who use qualitative research must strive to collect data for as long as possible and intend to analyze it after leaving the field. However, this method is still wrong and not appropriate. Qualitative data collection must be immediately followed by the work of writing, editing, classifying, reducing, and presenting. The following is a diagram that explains the data analysis technique model according to (Miles et al., 2014) (**Figure 1**).

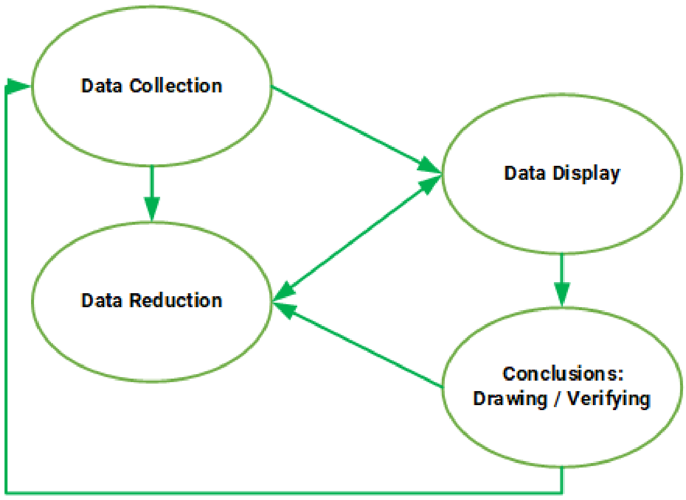

Figure 1. Miles and Huberman's data analysis model

Qualitative data in this study were analyzed using the interactive model proposed by Huberman and Miles (2002), which consists of three interconnected stages: data reduction, data display, and conclusion drawing/verification. The first stage, data reduction, involved selecting, simplifying, refining, and organizing the collected data by identifying information relevant to the research objectives, eliminating unnecessary or less relevant data, and supplementing data considered insufficient to support the analysis. This process enabled the researchers to focus on meaningful information and facilitate a deeper understanding of the phenomenon under investigation. The second stage, data display, involved systematically organizing and presenting the reduced data into meaningful categories and groupings to facilitate interpretation. In this stage, researchers actively arranged the data in forms such as descriptive narratives, charts, category relationships, flowcharts, and other visual representations to identify patterns, trends, and relationships within the data. The final stage, conclusion drawing and verification, focused on interpreting the findings and formulating conclusions in concise, clear, and understandable statements. To ensure the credibility and validity of the results, conclusions were continuously reviewed and verified throughout the analysis process. Through this iterative procedure, the qualitative analysis was expected to generate new insights and findings, including clearer descriptions of previously unexplored phenomena, explanations of causal relationships, or the development of emerging hypotheses and theoretical understandings.

Result and Discussion

The discussion of the results of this qualitative research focuses on the analysis of data obtained from interviews with the GA and the UK, as well as observations of the "Time Machine" Project activities. The analysis was conducted through data reduction, data presentation, and drawing conclusions, according to the Miles and Huberman model. The discussion is divided based on three research objectives. First, it examines how the Time Machine Project facilitated the development of students' causal reasoning through project-based activities involving hypothetical and science-fiction scenarios. Second, it explores how the project encouraged students to engage in ethical reflection and consequentialist thinking when faced with moral dilemmas embedded within the learning activities. Third, it analyzes students' responses and learning experiences throughout the implementation of the project, including their engagement, participation, and ability to connect scientific concepts with ethical considerations. Through this analysis, the study seeks to provide a comprehensive understanding of how project-based speculative learning can support the simultaneous development of causal reasoning and ethical literacy among elementary school students.

Mastering the Concept of Causality Through the "Time Machine" Project

The "Time Machine" project is proposed as a solution to stimulate speculative reasoning and consequentialist reflection in students, particularly to overcome their difficulties in analyzing chain causality delayed consequences (Martinez-Borreguero, et al 2020). The following science fiction scenario, which involves changing the past by preventing the extinction of the dinosaurs, is presented in the following learning scenario:

Table 1. PJBL Model Learning Scenario, with Time Machine Project

Project Aspects	Activity Description	Learning Objectives
Scenario Basics	Using science fiction scenarios, such as time travel to change the past (e.g., saving the dinosaurs).	Acts as an effective and authentic non-traditional stimulus to spark imagination and reasoning.
Focus on the Concept of Causality	Students are asked to design a time travel narrative and analyze the inevitable logical consequences (causality) for present-day life.	Overcoming students' difficulties in connecting chain causality (delayed consequences). Building strong causal mental models.
Causality Analysis Mechanism	Students create a flowchart that connects, Action (changing the past) Final Impact on the Present.	Facilitates the transition of reasoning from direct cause-effect identification to an understanding of systemic causality. Enhances higher-order causal reasoning.
Focus on Ethics of Action	The scenario intrinsically contains ethical dilemmas, for example, is it permissible to change the past for the better, even if it has a negative impact on the future?	Shifting students' ethical discussions from the realm of "simple right-wrong" to in-depth consequentialist analysis.
Implementation of Ethics	Students apply the principles of consequentialist ethics by evaluating the moral value of actions based on their projected universal impact, not just personal rules.	Supporting the implementation of a deep learning approach to ethics driven by the Independent Curriculum. Achieving the dimension of noble character.
Project Output	Students present tangible outputs, such as narrative prototypes, consequence presentations, or causality flowcharts.	Encourage active, collaborative learning and complex problem-solving Project-Based Learning - PjBL.

From **Table 1** above, it can be explained that the learning scenario using the PJBL model with the time machine project is as follows: the "Time Machine" project is structured around a science fiction scenario that functions as a powerful and authentic case study to stimulate students' imagination and higher-order reasoning. The primary objective of this scenario is to directly challenge students to analyze the long-term consequences of changing a single variable in history. As the trigger topic, students are asked to design a time travel narrative centered on a consequential historical event, for example, preventing the extinction of the dinosaurs, which serves as an intellectually rich starting point for causal and ethical exploration (Krajcik & Czerniak, 2018).

In terms of causal reasoning, the scenario deliberately forces students to transition from simple direct cause-and-effect thinking toward a deeper understanding of systemic causality. Students are first tasked with designing a narrative of an action that changes the past, then required to analyze the inevitable logical consequences of that action on present-day life. This process involves a ripple effects analysis, in which students must predict the delayed consequences of their chosen action on the current ecosystem. For instance, students are prompted to consider high-level causal questions such as what would have happened to the food chain today if dinosaurs had not become extinct, and what impact this would have had on human evolution or the very existence of humanity today (Cai, 2025)This depth of reasoning was confirmed through an interview with GA, who noted that following the project, students began reasoning at a significantly higher causal level, stating that if the dinosaurs had not gone extinct, humans would not exist, and therefore even a small change in the past carries enormous consequences for today's food chain and ecosystem.

Alongside causal reasoning, the scenario intrinsically embeds an ethical dilemma that transforms students' moral discussions into in-depth consequentialist analyses. At the heart of the project lies a fundamental ethical question: is it permissible to change the past for a perceived good, such as saving a species, even if it results in a negative impact on the future, such as the extinction of the human race? Through this dilemma, students are encouraged to evaluate the moral value of actions based on their projected universal impact, rather than relying solely on personal rules or simple right-or-wrong judgments. As a result, ethical discussions shift from surface-level responses such as "it shouldn't be done" toward deeper philosophical inquiry, with students asking whether their intentions, in the deontological sense, are sufficient to justify harmful outcomes from a consequentialist perspective (Leng, 2020).

As a Project-Based Learning (PjBL) activity, the "Time Machine" Project culminates in the production of tangible outputs that make students' reasoning visible and assessable. Students construct a flowchart that systematically connects their chosen action of changing the past with its primary consequences, secondary consequences, and final impact on the present. Additional outputs include narrative prototypes and consequence presentations that communicate students' causal and ethical analyses to their peers (Saglam, 2026; Xu, 2026). These outputs serve as concrete evidence that the project successfully facilitated the transition of students' reasoning from direct cause-effect identification to a comprehensive understanding of systemic causality, as further elaborated through the analytical reconstruction presented in **Table 2**.

Table 2. Level of Causal Reasoning Based on Initial Observations Before the Project and Observation Results After the Project

Causal Reasoning Level	Initial Observations Before the Project	Post-Project Observation Results
Low-Level Causality (Direct)	When asked about the impact of throwing away rubbish, children only answered that the environment becomes dirty.	Abandoned, replaced by chain analysis
High-Level Causality (Systemic)	Failing to predict the chain effects of an action.	Students are able to create a chart that connects the Final Impact Actions to the Present
Specific Example (Narrative)	-	They projected, "If dinosaurs hadn't become extinct, we wouldn't exist."

Based on **Table 2**, the findings indicate that the Time Machine Project functioned as a speculative simulation that transformed the abstract concept of causality into a concrete and meaningful narrative experience for students. Through the project activities, learners were required to imagine altering events in the past and then systematically analyze the resulting consequences in the present, thereby encouraging them to explore complex chains of cause-and-effect relationships. The Project-Based Learning (PjBL) framework played a crucial role in this process by engaging students in active problem-solving centered on a time-travel paradox, requiring them to formulate predictions, evaluate alternative outcomes, and justify their reasoning. Rather than passively receiving information, students actively constructed their understanding of causality by investigating how a single action could generate multiple interconnected consequences across different contexts and time periods. This learning process strengthened students' causal reasoning skills by enabling them to develop more sophisticated mental models of cause-and-effect relationships. These findings are consistent with the study which emphasizes the importance of hypothesis-based learning in fostering robust causal mental models and supporting deeper reasoning about the mechanisms underlying events and phenomena (Shavlik et al., 2022).

Strengthening Claims of Increasing Ethical Actions

This project successfully shifted students' ethical discussions into in-depth consequentialist analysis. Evidence of Project Results (Analytical Reconstruction) can be seen in the ethical dilemmas within the project, for example, is saving dinosaurs an ethical act if it means the extinction of humanity? serves as a trigger for in-depth reflection, which can be seen in the explanation of **Table 3**. Through these discussions, students were encouraged to evaluate the potential long-term consequences of their decisions rather than relying solely on simple notions of right and wrong. As a result, ethical reasoning became more contextual and reflective, enabling students to consider the broader impacts of actions on society, the environment, and future generations.

Table 3. Ethical Action Domains Before and After Project Implementation

Ethical Discussion Area	Before Project (Initial Observation)	After the Project (Observation & Interview Results)
Simple Ethics	Values and morality are limited to the realm of simple right and wrong.	Abandoned, students no longer just answer "that's not allowed".
Consequentialist Analysis	Does not involve in-depth analysis of moral dilemmas.	Students ask: "Do our intentions (deontological) justify bad outcomes (consequentialist)?"
Moral Focus	-	Students apply the principles of consequentialist ethics by evaluating the moral value of actions based on their projected universal impact.

It shows that through complex dilemmas that lack a single right-or-wrong answer, students are forced to apply ethical reasoning practically, rather than simply memorizing moral rules. This observation demonstrates the successful implementation of a deep learning approach to ethics, which aligns with the demands of the Independent Curriculum. This in-depth analysis supports the achievement of the Noble Morals dimension in the Pancasila Student Profile (Onaindia et al, 2018). The implementation of the "Time Machine" project proved effective in overcoming students' difficulties in connecting chain causalities (delayed consequences) as identified in initial observations. The concept of causality, which in an axiological context requires consideration of philosophical responsibility, was facilitated through speculative simulations.

Interviews with Class Teachers (GA) confirmed a significant change: "Previously, when asked about the impact of littering, the children simply answered, 'The environment becomes dirty.' After the time machine project, they thought further: 'If dinosaurs hadn't become extinct, we wouldn't exist. So, even small changes in the past have had a huge impact on the food chain and ecosystem today. This has reached a high level of causality (Russo et al., 2019; Bertolaso & Buzzoni, 2017). Observations show that the activity of designing a time travel narrative forces students to actively construct cause-and-effect relationships. Students create a flowchart that connects: Action (changing the past) Primary Consequences Secondary Consequences Final Impact on the Present. This aligns with the emphasis on the importance of hypothesis-based learning for building strong causal mental models (Shavlik et al., 2022). The "Time Machine" project acted as a non-traditional stimulus that transformed abstract causality into a concrete narrative experience. Students' causal reasoning progressed from simply identifying immediate causes to projecting future consequences of current actions, a key skill required for ethical literacy. This improvement was driven by the complex PjBL framework, in which they had to solve the problem of a time travel paradox, a process that significantly enhanced critical thinking skills (Kokotsaki et al, 2016).

While the findings of this study demonstrate that the "Time Machine" Project successfully facilitated the transition of students' causal reasoning from direct cause-effect identification to systemic causality, this outcome is not without contestation in the existing literature. Martinez-Borreguero et al. (2020) cautioned that recreational or imaginative project designs in primary science education, while engaging, do not always guarantee conceptual depth, as students may become absorbed in the creative narrative at the expense of rigorous scientific reasoning. This concern is partially echoed by Saglam (2026), who argued that causal reasoning in young learners is often superficial and heavily context-dependent, suggesting that gains observed within a specific imaginative scenario may not transfer to real-world causal reasoning tasks. Furthermore, Russo et al. (2019) argued that causality as a concept is fundamentally more complex in social and scientific contexts than it appears in controlled educational settings, implying that what students demonstrate as causal reasoning within a classroom project may not yet constitute genuine philosophical or scientific understanding of causality. These contrasting perspectives suggest that while the "Time Machine" Project shows promise in stimulating causal thinking, caution must be exercised in interpreting the depth and transferability of the causal reasoning gains observed in this study.

The finding that elementary school students were able to engage in consequentialist ethical analysis through the project also warrants critical examination against contrasting theoretical positions. Piaget's theory of moral development, as discussed by Curren (2017), suggests that children in the concrete operational stage, which typically encompasses elementary school age, are predominantly heteronomous moral reasoners who evaluate actions based on rules and authority rather than consequences or intentions. This developmental perspective raises important questions about whether the consequentialist reasoning observed in this study reflects genuine internalized ethical understanding or whether it represents guided, context-specific responses that were shaped by the structure of the project and the facilitation of the teacher. Similarly, Smith (2026) and Kachhiyapatel & Grossmann (2026) argued that moral reasoning is fundamentally grounded in sentiment and habit rather than rational deliberation, which challenges the assumption that a short-term project intervention can produce lasting shifts in students' ethical reasoning frameworks. These contrasting views do not invalidate the findings of this study but rather highlight the need to interpret the observed ethical reasoning gains as initial and emergent, rather than fully developed or independently sustained capacities.

Improving Understanding and Implementation of Ethical Actions

The second research objective was to describe the improvement in students' understanding of the ethics of their actions, particularly through the analysis of moral dilemmas and consequences. Findings indicate that the project successfully shifted students' ethical discussions from the realm of "simple right-wrong" to a deeper, consequentialist analysis. Interview data with the UK highlighted this development: "Students no longer simply answer 'that shouldn't be.' They now ask, 'Do our intentions (deontological) justify the bad outcome (consequentialist)?' The discussions became more philosophical. This reflects the success of the deep learning approach implemented by the teacher in character education. "Observations indicate that ethical dilemmas (e.g., is saving dinosaurs ethical if it means the extinction of humanity?) serve as triggers for in-depth reflection. This aligns with the findings. (Wasiyem et al, 2023) that the use of complex moral dilemmas improves elementary school students' ethical reasoning capacity. Students apply consequentialist ethical principles by evaluating the moral value of actions based on their projected universal impact, rather than on personal rules.

Application of deep learning through the Time Machine scenario, students can internalize the ethics of action (Winch & Campbell, 2020; Chowdhury, 2018). This project transforms ethical learning from a passive cognitive realm to a practical ethical reasoning experience. This in-depth analysis is highly relevant to science learning, which requires students to reflect on the moral responsibility they face in every decision they make toward the ecosystem and society (Walidin, et al 2025; Retno et al., 2025) while supporting the "Noble Moral" dimension of the Pancasila Student Profile. The results of the implementation exploration indicate that the "Time Machine" Project method is an effective, authentic learning framework, and aligns with the demands of the Independent Curriculum. The project's implementation through collaboration and classroom activities demonstrated high levels of student engagement and motivation. The use of science fiction as a case study successfully addressed the lack of creative stimulation reported in initial observations.

The project activities are multidisciplinary, integrating science concepts such as time, extinction, and the food chain. Social studies include social consequences, history, and responsibility. Interviews with the Class Teacher (GA) highlighted the flexibility of this method: "This PJBL allows us to integrate all aspects of science. The students work together, debate constructively about ethics, and must present tangible outcomes. This project satisfies the Critical Reasoning and Noble Moral dimensions simultaneously." The project method proved ideal because it allows students to work collaboratively to investigate complex problems (Kokotsaki et al, 2016; Hussein, 2021), The "Time Machine" project utilizes science fiction scenarios to create imaginary authenticity, which powerfully stimulates causal and ethical reasoning (Sulaiman & Fauzi, 2024). The active involvement of students in designing solutions and analyzing consequences confirms that effective science learning must be contextual, engaging, and multidisciplinary, in line with the philosophy of the Independent Curriculum.

The Relationship Between Deep Learning and the Results of the "Time Machine" Project

The "Time Machine" project represents a successful implementation of the deep learning approach in ethics and character education, particularly as promoted by the Independent Curriculum. This approach aims to ensure students are capable of ethical reflection and analysis on complex dilemmas, not simply memorizing moral rules (Walidin, et al 2025). The following explains the connection between deep learning and the project's outcomes: The relationship between the deep learning approach and the outcomes of the "Time Machine" Project can be examined through three interconnected dimensions. The first dimension concerns the transition from passive cognitive learning to practiced ethical reasoning. The Independent Curriculum's deep learning framework explicitly aims to encourage students to critically explore various scenarios and consider the cascading impacts of each choice, moving beyond surface-level moral memorization toward active ethical engagement. The "Time Machine" Project directly embodies this goal by shifting ethics learning from a passive cognitive realm, in which students merely receive and recall moral rules, to a space of practiced ethical reasoning in which students must actively grapple with complex dilemmas. The use of science fiction scenarios requiring students to confront the concept of universal responsibility toward the future and history proved to be an effective mechanism for achieving this transition. This aligns with Hassan et al. (2022), who argued that in-depth analysis prompted by complex project-based activities shifts ethics learning from simply knowing to genuinely practicing ethical reasoning in ways that conventional instruction cannot replicate.

The second dimension concerns the alignment between deep learning principles and consequentialist ethics. Deep learning, as a pedagogical approach, is closely aligned with the principles of consequentialist ethics in that both frameworks judge the value of actions based on their outcomes and broader impacts rather than on rigid rule-following. In this project, students demonstrated this alignment by applying consequentialist ethical principles to evaluate the moral value of their time travel decisions based on projected universal impacts, rather than relying solely on personal rules or intuitive right-or-wrong judgments. This was most evident when students began independently questioning whether their intentions, understood in the deontological sense, were sufficient to justify harmful outcomes from a consequentialist perspective. Weng et al. (2023) and Yew et al. (2018) supports this finding, noting that simulation-based deep learning actively encourages students to critically explore various scenarios, weigh the cascading impacts of each choice, and arrive at moral conclusions grounded in a comprehensive understanding of the consequences of actions rather than in abstract moral prescriptions.

The third dimension concerns the contribution of the project to the development of the Pancasila Student Profile. The application of ethical deep learning through science learning directly supports the achievement of two core dimensions of the Pancasila Student Profile, namely Noble Morals (*Berakhlak Mulia*) and Critical Reasoning (*Bernalar Kritis*). The "Time Machine" Project proved particularly valuable in this regard because it simultaneously addressed both dimensions within a single integrated learning experience. The improvement in students' causal reasoning, evidenced by their progression from identifying immediate cause-and-effect relationships to constructing systemic causal chains, reflects the achievement of the Critical Reasoning dimension. Meanwhile, the shift toward in-depth consequentialist analysis in students' ethical discussions demonstrates tangible progress toward the Noble Moral dimension. Beyond these two dimensions, the project also cultivated a deeper sense of moral responsibility in students, ensuring that they not only understood environmental problems such as waste pollution at a factual level but also actively reflected on their moral responsibility toward the ecosystem and future generations, consistent with the principles of consequentialism as emphasized in the context of contemporary Indonesian education (Kavita & Kumari, 2026; Janmaimool & Khajohnmanee, 2020).

Despite the encouraging findings presented in this study, several limitations must be transparently acknowledged to contextualize the scope and interpretability of the results. This study was conducted within a single classroom at one elementary school in Surabaya, involving a relatively small number of participants over a limited observational period. The descriptive qualitative design, while appropriate for capturing the richness and depth of students' reasoning processes, does not permit causal claims about the direct effect of the "Time Machine" Project on student outcomes, nor does it allow for statistical generalization to broader student populations. The heavy reliance on interview data from the classroom teacher and principal as primary sources of evidence introduces the risk of confirmation bias, as informants who were directly involved in implementing the project may have unconsciously reported outcomes in a more favorable light. Additionally, the observation sessions were conducted within the natural flow of classroom activities without standardized conditions, meaning that variations in teacher facilitation style, classroom dynamics, and student composition on any given day may have influenced the observed outcomes in ways that are difficult to isolate or control. The absence of a validated measurement instrument specifically designed to assess causal reasoning levels and ethical reasoning depth in elementary school students further limits the precision and replicability of the findings. Future studies would benefit from the development and validation of such instruments to enable more systematic and comparable assessments across different schools, grade levels, and learning contexts.

The findings of this study make several contributions to the theoretical landscape of elementary science education. First, this study reinforces Shavlik et al. (2022) theoretical framework on causal reasoning in children, demonstrating that speculative and hypothesis-based learning through science fiction scenarios can effectively accelerate the transition from direct cause-effect identification to systemic causal reasoning in elementary school students. The successful application of the "Time Machine" Project provides empirical support for the argument that children's causal mental models are not fixed but are highly malleable when exposed to appropriately designed imaginative stimuli. Second, this study contributes to the theoretical discourse on consequentialist ethics in education. Consistent with foundational theory of character education, the findings demonstrate that deep ethical reasoning moving beyond simple normative judgments toward consequentialist analysis can be cultivated in elementary-aged learners when learning is embedded within authentic, complex dilemmas rather than didactic moral instruction (Joshi, 2026; Curren, 2017). This challenges the assumption that consequentialist ethical reasoning is developmentally inaccessible to young learners. Third, the study extends the theoretical understanding of Project-Based Learning (PjBL) by illustrating that science fiction scenarios can function as a legitimate and powerful form of authentic context within the PjBL framework. This finding Krajcik and Czerniak's (2018) conceptualization of authentic problems in project-based science learning, suggesting that imaginary authenticity scenarios that are fictional yet intellectually genuine can be equally effective as real-world contexts in stimulating higher-order thinking.

From a practical standpoint, the findings offer several concrete directions for educators and curriculum developers. For classroom teachers, this study demonstrates that the "Time Machine" Project is a replicable and adaptable pedagogical tool for integrating causal reasoning and ethical reflection into elementary science learning. Teachers can adopt science fiction scenarios as entry points for complex discussions that simultaneously address cognitive and affective learning objectives, without requiring advanced resources or technology. For curriculum developers and policymakers, particularly within the framework of Indonesia's Independent Curriculum, this study affirms the value of deep learning approaches in achieving the Pancasila Student Profile dimensions of Critical Reasoning and Noble Morals. The project model demonstrated in this study can serve as a practical reference for designing learning modules that address both dimensions simultaneously through a single, integrated project activity (Dewi et al., 2024). For school principals and instructional supervisors, the findings highlight the importance of providing teachers with the autonomy and support to implement non-conventional learning stimuli. The success of this project was partly contingent on the teacher's creative flexibility in facilitating open-ended discussions and accepting responses that go beyond textbook answers. Professional development programs should therefore equip teachers with the competencies to facilitate ethical discourse and higher-order causal reasoning in the classroom (Luthfiyah et al., 2025).

Conclusion

The implementation of the "Time Machine" Project could construct the concept of causality and ethical action among fourth-grade elementary school students as evidenced through classroom observations and interview data analyzed using the Miles and Huberman interactive model. In terms of causal reasoning, the project facilitated a noticeable transition in students' thinking, from the ability to identify only direct cause-and-effect relationships toward the construction of systemic causal chains that connected past actions to their delayed consequences on the present ecosystem, thereby addressing the initial difficulty that low-ability students demonstrated in connecting multi-level causality in science and social science learning. In terms of ethical action, the project successfully shifted students' moral discussions from simple normative right-or-wrong judgments toward more reflective consequentialist reasoning, in which students began evaluating the moral value of decisions based on their projected universal impacts rather than personal rules alone, supporting the achievement of both the Critical Reasoning and Noble Moral dimensions of the Pancasila Student Profile within the Independent Curriculum framework. However, as this study was limited to a single classroom in one school using a descriptive qualitative approach without a control group or validated measurement instrument, future research is encouraged to employ mixed-methods or quasi-experimental designs with larger and more diverse samples across multiple school contexts, to develop and validate instruments specifically measuring causal reasoning levels and ethical reasoning depth in elementary students, and to explore the longitudinal sustainability of the reasoning gains observed through this project as students' progress to higher grade levels.

References

Aylsworth, T., & Castro, C. (2024). *Kantian ethics and the attention economy: Duty and distraction* (p. 275). Springer Nature.

Barkah, A. S., Nasution, R. R. B., Rahmawati, S., & Lasut, Y. I. (2025). Pengembangan kurikulum berbasis deep learning sebagai fondasi pendidikan adaptif dan responsif. *Jurnal Citizenship Virtues*, *5*(2), 124–131.

Bertolaso, M., & Buzzoni, M. (2017). Causality and levels of explanation in biology. In *Philosophical and scientific perspectives on downward causation* ,164-179.

Bîzoi, A. C., & Bizoi, C. G. (2026). Business ethics for industry 5.0: Creative pedagogies for human-centric futures. *The International Journal of Management Education*, *24*(1), 101316.

Cai, Y. (2025). *How to build a time machine?* [Master's thesis, Pratt Institute]. ProQuest Dissertations and Theses Global.

Chowdhury, M. (2018). Emphasizing morals, values, ethics, and character education in science education and science teaching. *MOJES: Malaysian Online Journal of Educational Sciences*, *4*(2), 1-16.

Creswell, J. W., (2009). *Research design: Qualitative, quantitative, and mixed methods approaches 3rd ed*. SAGE Publications, Inc

Curren, R. (2017). Why character education?. *Impact*, *2017*(24), 1-44.

Dewi, E. M. P., Qamaria, R. S., Widiastuti, A. A., Widyatno, A., Marpaung, J., Ervina, I., Hapsari, A. D., Juliadilla, R., Suwandi, Sari, R. P., Anggraini, H., Rustam, H. K., Pratama, B. D., Suprihatin, T., & Rachmawati. (2024). *Pendidikan Indonesia di era globalisasi: Tantangan dan peluang*. Nas Media Pustaka.

Faradita, M., & Afiani, K. (2021). Elementary teachers' perceptions of online learning during Covid-19 restrictions. *Profesi Pendidikan Dasar*, *8*(2), 182–187.

Freire, M., Talanquer, V., & Amaral, E. (2019). Conceptual profile of chemistry: A framework for enriching thinking and action in chemistry education. *International journal of Science Education*, *41*(5), 674-692.

Haryono, P., Judijanto, L., Panggalo, I. S., Wati, C. N., & Mawara, R. E. (2025). *Isu-isu kontemporer dalam pendidikan: Peran, peluang, dan tantangan dunia pendidikan modern*. PT. Sonpedia Publishing Indonesia.

Hassan, M., Wang, Y., Pang, W., Wang, D., Li, D., Zhou, Y., Xu, D. (2022). IPAS-Net: A deep-learning model for generating high-fidelity shoeprints from low-quality images with no natural references. *Journal of King Saud University - Computer and Information Sciences*, *34*(6, Part A), 2743–2757.

Hussein, B. (2021). Addressing collaboration challenges in project-based learning: The student's perspective. *Education Sciences*, *11*(8), 434.

Janmaimool, P., & Khajohnmanee, S. (2020). Enhancing university students' global citizenship, public mindedness, and moral quotient for promoting sense of environmental responsibility and pro-environmental behaviours. *Environment, Development and Sustainability*, *22*(2), 957-970.

Joshi, P. L. (2026). Cultivating character: A holistic framework for value-based education in schools. *Asian Education and Learning Review*, *4*(1), 3-3.

Kachhiyapatel, N., & Grossmann, I. (2026). The moral blueprint is not necessary for STEM wisdom. *Roeper Review*, *48*(1), 39-50.

Kavita, M., & Kumari, A. (2026). Environmental ethics and value in education. *Kavya Setu*, *2*(1), 45-53.

Kohn, P. (2024). *Simulations and role-plays: Enhancing decision-making and problem-solving skills. In elevating leadership: Innovative teaching methods for developing future leaders* (pp. 41-57). Emerald Publishing Limited.

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools*, *19*(3), 267-277.

Leng, L. (2020). The role of philosophical inquiry in helping students engage in learning. *Frontiers in psychology*, *11*, 449.

Liu, Q. (2024). The Critical Role and Impact of Axiology in Understanding the Interaction Between Consciousness and Culture. *Cultura: International Journal of Philosophy of Culture and Axiology*, *21*(1).

Lubaba, M. N., & Alfiansyah, I. (2022). Analisis penerapan profil pelajar pancasila dalam pembentukan karakter peserta didik di sekolah dasar. *EDUSAINTEK: Jurnal Pendidikan, Sains dan Teknologi*, *9*(3), 687–706.

Luthfiyah, H., Nusantara, T., Faizah, S., Kusumaningrum, S. R., & Mardhatillah. (2025). Implementation of deep learning in elementary school improving the effectiveness and quality of IPAS learning. *ELSE (Elementary School Education Journal): Jurnal Pendidikan dan Pembelajaran Sekolah Dasar*, *9*(2), 293–301.

Martinez-Borreguero, G., Mateos-Nuñez, M., & Naranjo-Correa, F. L. (2020). The teaching of basic science concepts in primary education: Design and use of recreational projects in formal contexts. *INTED2020 Proceedings*, 2006–2013.

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative data analysis* (3rd ed.). SAGE Publications.

Onaindia, E., Aineto, D., & Jiménez, S. (2018). A common framework for learning causality. *Progress in Artificial Intelligence*, *7*(4), 351–357.

Permatasari, A., Sopandi, W., Hendriawan, D., & Pujiasih, Y. (2025). The effectiveness of the project based learning (PjBL) model with a deep learning approach on the critical thinking skills of fifth grade students at SDN Pejaten 2. *In International Conference on Elementary Education*, *8*(1), 282-298.

Retno, R. S., Purnomo, P., Hidayat, A., & Mashfufah, A. (2025). Conceptual framework design for STEM-integrated project-based learning (PjBL-STEM) for elementary schools. *Asian Education and Development Studies*, *14*(3), 579-604.

Reyes, R. L., & Villanueva, J. A. (2024). Narrative-based concept representations: Fostering visual cognition in the introductory chemistry classroom. *Journal of Chemical Education*, *101*(3), 1106-1119.

Russo, F., Wunsch, G., & Mouchart, M. (2019). Causality in the social sciences: A structural modelling framework. *Quality & Quantity*, *53*(5), 2575-2588.

Saglam, Y. (2026). Pre-service teachers' scientific explanations of evaporation: A deductive analysis of causal reasoning levels. *International Journal of Studies in Education and Science*, *7*(1), 12-24.

Shavlik, M., Köksal, Ö., French, B. F., Haden, C. A., Legare, C. H., & Booth, A. E. (2022). Contributions of causal reasoning to early scientific literacy. *Journal of Experimental Child Psychology*, *224*, 105509.

Smith, G. R. (2026). A meta-framework for organizing transversal knowledge about systems. *Systems Research and Behavioral Science, 43*(2), 399–410

Sugiyono. (2021). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Alfabeta.

Sukmawati, S. (2023). Development of quality instruments and data collection techniques. *Jurnal Pendidikan Dan Pengajaran Guru Sekolah Dasar (JPPGuseda)*, *6*(1), 119-124.

Sulaiman, A., & Fauzi, A. (2024). Penalaran dan objektivitas moral: Filsafat etika ayatullah muhammad taqi mishbah yazdi. *Academic Journal of Islamic Principles and Philosophy*, *5*(2), 253–282.

Walidin, A. P., Zai, T. S. W., Harahap, F. A., & Perdana, A. (2025). Perkembangan projek rancangan sistem penyelesaian ekuasi dengan model deep learning berbasis GNN. *JATI (Jurnal Mahasiswa Teknik Informatika)*, *9*(4), 6175–6179.

Wasiyem, Kalsum, U., Syahri, P., Abdi, W. T., Darussalim, & Iskandar, T. (2023). *Isu-isu kontemporer*. PT. Sonpedia Publishing Indonesia.

Weng, C., Chen, C., & Ai, X. (2023). A pedagogical study on promoting students' deep learning through design-based learning. *International Journal of Technology and Design Education*, *33*(4), 1653-1674.

Winch, P., & Campbell, M. (2020). *Ethics and action*. Routledge.

Xu, H. (2026). Zero-waste prototyping: Lifecycle assessment of materials and energy in an ai-driven visual communication course. *Advances in Humanities and Modern Education Research*, *1*(4), 1-12.

Yew, T. M., Dawood, F. K., Jen, L. S., & Hoay, K. C. (2018). Stimulating deep learning using active learning techniques. *MOJES: Malaysian Online Journal of Educational Sciences*, *4*(3), 49-57.

York, E., & Conley, S. N. (2020). Creative anticipatory ethical reasoning with scenario analysis and design fiction. *Science and Engineering Ethics*, *26*(6), 2985-3016.