Towards Designing AI-Enhanced Lesson Structure in Grade 9 Science

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ABSTRACT

This study explores the need for designing an artificial intelligence (AI)-embedded lesson structure in Grade 9 science education, with a focus on integrating sustainability concepts in response to the demands of Education 4.0. Grounded in the context of the Industrial Revolution 4.0, the research investigates learners', and science teachers' readiness, perceptions, and needs regarding AI and sustainability integration in science instruction. Using a descriptive mixed-methods research design, data were collected through a researcher-developed needs assessment survey administered to 48 Grade 9 learners and 7 science teachers in a public secondary school. Quantitative data were analyzed using descriptive statistics, while qualitative responses were examined through thematic analysis. Findings reveal that learners demonstrate high familiarity with AI tools and show strong interest in using AI for solving scientific and community-related problems. However, their understanding of the connection between science concepts and sustainability remains limited. Teachers exhibit willingness to integrate AI into instruction but face significant barriers, including lack of access to devices, unstable internet connectivity, and insufficient pedagogical support. Triangulation of data indicates that while awareness and motivation among stakeholders are evident, institutional capacity and instructional design support remain key challenges. The study concludes that effective integration of AI in science education requires not only technological access but also structured lesson designs that explicitly connect AI tools, scientific concepts, and sustainability issues. It highlights the importance of addressing infrastructure gaps and enhancing teacher competencies to support meaningful AI integration. The findings provide a basis for developing an AI-embedded lesson framework that promotes critical thinking, problem-solving, and real-world application of science learning aligned with sustainable development goals

Keywords: Artificial Intelligence in Education; Science Education; Sustainability; AI-Embedded Lessons

INTRODUCTION

The Industrial Revolution 4.0 (IR 4.0) brought significant changes in different areas of society and human life. In response to the new technological landscape, model of education for the future (Education 4.0) has been provided in which future learning is more customized, personalized, smarter, flexible, and interactive with the use of artificial intelligence tools, virtual reality (VR), and Augmented Reality (AR) (Mulyani et al., 2021; Shahroom & Hussin, 2018). AI has been developed to perform tasks that conventionally require human intelligence, including perception, reasoning, learning, and interaction (Ergen, 2019). Transformation brought by AI can also be seen in various dimensions in education system such as instructional practices, assessment strategies, and administrative processes (Almasri, 2024). The "Science for All" movement advocating the importance of science for all students not only those who pursue careers in science (Almasri et al., 2022). The necessity of improving science educational approaches that could meet the demands of the 21st century has also been highlighted in the "Call to Action" for science education (Holme, 2021). Incorporating AI in science education can extend students learning experience in science while meeting demands of the 21st century and solving societal complex problems.

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With the advancement of AI in science education, various options are being explored in bracing the challenges of IR 4.0 in which one of them is proposing the Sustainability standards (Ramirez, 2018) in recognition of the need of innovative curricula grounded in real-world issues (Tirol, 2020). UNESCO (2025) stated that artificial intelligence has the capability in addressing some of the urgent challenges in today's education that can advance the progress towards SDG 4 (Quality of Education) through innovative teaching and learning. UNESCO (2019a, p.5) emphasizes the consideration of introducing new models in delivering instruction that can be enabled with the use of AI.

The Department of Education (DepEd) and lawmakers have acknowledged the need for educational reform, focusing on equipping future workers with the skills for the 4IR (Garcia, 2022). As the world rapidly changes, this also poses significant challenges for Philippine education. As reported by Ayo (2024), essential features in the new industrial revolution and the use of technologies for future skills need to be improved in the Philippine academe.

Currently, the Philippine education system faces several challenges in incorporating AI and sustainability in science education (Almazan, 2023). Present gaps such as over-relying on AI tools can restrict the students' development of critical thinking, problem solving and decision-making skills (Chen et al., 2023). Despite the increasing popularity of AI in education, it remains a challenge for teachers how to make students collaborate with AI in an effective way as there is a lack of studies in bringing new knowledge to design learning with AI as a collaborative tool to classrooms. Thus, this study sought to conduct needs analysis among grade nine (9) learners and science teachers toward designing AI-embedded lesson structure for the identified least mastered topic in grade nine (9) science.

METHODOLOGY

Research Design

This study utilized a mixed-method descriptive design to assess the learners and science teachers' understanding about sustainability and AI in science education; including their awareness and acceptance of AI in science education; and least mastered topic in grade nine (9) science. Descriptive research is appropriate for describing specific conditions, practices, and perceptions within a defined population (Siedlecki, 2019). Descriptive design combines qualitative and quantitative approaches to gather data which allows for an in-depth understanding of the research participants in the study. To support and strengthen the quantitative result, open-ended questions were also included in the survey questionnaire.

Participants and Setting

The participants in this study were compromised of 48 grade nine (9) learners (evenly distributed between the higher and lower sections) three (3) admins, and four (4) science teachers. The researcher selects the grade level as the learner-participants in this study because at this age, according to the formal operational stage by Piaget, this is where the students develop the ability to think abstractly such as using their logical reasoning (Scott & Cogburn, 2023) in evaluating AI output and create simple projects using the AI tool such as ChatGPT. The science teachers were selected with at least five (5) years of science teaching experience. The study was conducted in a large public school in Iligan City that has a diverse population of learners coming from different socio-economic backgrounds.

Research Instruments

A researcher-made needs assessment survey questionnaire was used to gather data from both learners and science teachers regarding their familiarity, understanding, and needs related to sustainability and artificial intelligence in science education. The instrument consisted of parallel sets of questionnaires for learners and teachers where each set was divided into three (3) parts. Part I aimed at eliciting the respondents' background information, access to digital resources, prior exposure to AI tools, and personal insights on the use of AI and sustainability in science learning and teaching through a closed-ended and open-ended questions. Part II used a four-point Likert scale (4 – Strongly Agree, 3 – Agree, 2 – Disagree, 1 – Strongly Disagree) to measure respondents' level of familiarity, perceived competence, access to resources and expressed needs related to AI integration and sustainability concepts in science education. Part III focused on asking the respondents to rank the topics in fourth quarter based on the level of difficulty (for learners) or level of mastery (for science teachers).

Before it was being administered to the participants, the instrument underwent face validation. The instrument was structured to gather a comprehensive data for needs analysis with the combination of descriptive quantitative measures and qualitative insights to inform the design of AI-embedded science lesson.

Data Gathering Procedure

Prior administering the researcher-made survey needs assessment questionnaire, the researcher secured first the approval from the school principal and collect consent and assent form from the respondents. This is to ensure that the participation of the respondents in this study is voluntary. During the data gathering process, the respondents was assisted by the researcher in any clarifications they needed in answering the survey. The researcher gave the respondents adequate time to finish answering the survey questionnaire where mostly of them finished answering the survey in 20 minutes. The data collected was then organized and analyzed using appropriate statistical and qualitative data analysis.

Data Analysis

Descriptive statistics such as mean, standard deviation, percentage and frequency was used to analyze the collected data. Frequency and percentage were used to describe the results from checklist items of part I of the survey from the learner-respondents. While quantitative datasets from the Likert-scale items were analyzed using mean and standard deviation. Mean rank was employed in analyzing the result in part III of the survey since there was an inconsistency of agreement between rankings of the most difficult topic in grade 9 science fourth quarter.

Open-ended responses from the survey were analyzed using Braun and Clarke's (2006) thematic analysis to identify recurring patterns. Thematic analysis is theoretically flexible for identifying, describing, and interpreting patterns (themes) within a data set (Braun & Clarke, 2006). This study will follow a six-step thematic analysis process: (1) familiarisation of data; (2) generating initial codes; (3) searching for themes; (4) reviewing themes; (5) defining and naming themes; and (6) writing reports.

RESULTS AND DISCUSSION

The findings were organized into demographic profile, thematic results, discussion supported by literature, and triangulation of data across respondent groups. Quantitative datasets and qualitative open-ended responses from science teachers and grade 9 learners allow method triangulation by comparing scaled responses with narrative accounts.

Participants

The researcher-made instrument was administered to seven (7) science teachers, and forty-eight (48) grade 9 learners from the selected school participant.

Science Teachers

The study involved seven (7) science teachers with teaching experience ranging from 7 to 20 years. Their areas of expertise included Physics, Biology, and Chemistry.

Grade 9 Learners

Grade 9 students aged 14-18 years old. Students came from diverse socio-economic backgrounds with parents working in professional, skilled, and informal sectors.

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Learners' Quantitative Results

Table 1: Learners' access to devices, study use, and AI familiarity

Indicator	Result
With smartphone access	46 (95.8%)
With computer/laptop access	21 (43.8%)
With tablet access	3 (6.3%)
Mostly use gadget for studies	42 (87.5%)
Familiar with AI	46 (95.8%)
Not familiar with AI	2 (4.2%)

The learner dataset suggests that access to technology is already widespread at the student level, especially through smartphones, while access to computers and tablets is much lower. It also shows that most learners report using their gadgets for studying and indicate a very high familiarity with AI. This pattern is important because it suggests that readiness for AI-supported science learning exists at the level of basic access and awareness, even if that readiness may still be uneven in terms of device quality and connectivity. This finding is consistent with research showing that early AI uptake in education commonly begins with accessible digital tools rather than highly specialized systems. Zawacki-Richter et al. (2019) found that AI use in education is often concentrated in narrower and still-developing forms of adoption rather than deep pedagogical transformation.

Table 2: Learners' views on AI

Item	**Yes**	**No**
AI can help develop solutions to complex problems in science	46	2
AI can help develop solutions to community problems	36	12
AI can support solutions to sustainability-related science and community problems	36	12

Learners showed very strong endorsement of AI for science problem solving and strong endorsement of both AI and STEM for community and sustainability-related problems. This suggests that learners do not merely view AI as abstract school concepts; rather, they connect them to real-world issues, particularly those affecting the community. Their responses align closely with the open-ended learner data, where students repeatedly mentioned climate change, flooding, waste management, cyberbullying, and garbage disposal as problems that AI could address.

The finding is supported by problem-centered learning literature. *How People Learn* (National Research Council, 2000) emphasizes that meaningful learning becomes stronger when learners connect concepts to authentic problems and applications.

Table 3: Learners' self-rated needs and readiness on AI and sustainability in Science Class

Indicator	**Mean**	**Description**
Familiar with basic sustainability concepts	3.00	Agree
Understand how sustainability connects to science topics	2.44	Disagree
Have used AI tools for learning science topics	3.27	Strongly Agree
Feel comfortable using digital tools during science class	2.77	Agree
Need more help understanding AI-embedded science topics	3.17	Agree
Need support applying science concepts to real-life situations	3.19	Agree
Have access to a device for science learning	3.08	Agree
Have stable internet connection in school or at home	2.86	Agree
Want to improve AI skills for learning science	3.02	Agree
Want more science activities integrating sustainability with AI	3.06	Agree

Legend: 1.00 - 1.74 – Strongly Disagree 1.75 - 2.49 – Disagree 2.50 - 3.24 – Agree 3.25 – 4.00 – Strongly Agree

Table 3 shows the contrast between AI use and conceptual integration. Learners strongly agreed that they have used AI tools for learning science, but they disagreed that they understand well how sustainability connects to science topics. This suggests that learners are already using AI in practice, but the curriculum connection between science content, sustainability, and application remains underdeveloped. This also shows that learners agree they need more help with AI-embedded science topics and with applying science to real-life situations. Students may become proficient in accessing information but still struggle to connect scientific concepts to sustainability challenges (Digital Educational council, 2024). While most students regularly use AI, many believed it reduced students' creative thinking, problem-solving, and independent learning that will eventually diminished their conceptual processing when AI is only used for obtaining answers rather than constructing knowledge (Adams, 2025). Which means that acquiring those abilities do not only lies with using AI as a tool alone (UNESCO, 2023).

Teachers' Quantitative Results

Table 4: Science teachers' self-rated needs and readiness

Indicator	Mean	Interpretation
Familiar with basic sustainability concepts	2.75	Agree
Know how to embed sustainability into science topics	2.75	Agree
Have used AI tools for teaching science topics	2.75	Agree
Feel comfortable using digital tools during science instruction	3.25	Strongly Agree
Need additional teaching resources for sustainability in science lessons	3.50	Strongly Agree
Need support in designing AI-embedded science activities	3.75	Strongly Agree
Have access to devices suitable for AI-enabled teaching	1.50	Strongly Disagree
Have stable internet connection for teaching science lessons	1.50	Strongly Disagree
Want to improve skills in using AI tools for teaching science	3.50	Strongly Agree
Need instructional materials integrating sustainability in science topics	3.50	Strongly Agree

Legend: 1.00 - 1.74 – Strongly Disagree 1.75 - 2.49 – Disagree 2.50 - 3.24 – Agree 3.25 – 4.00 – Strongly Agree

The teacher ratings show a clear pattern: science teachers are personally open to AI and digital tools, but they report serious structural constraints. They strongly agree that they need more resources, more support in designing AI-enabled activities, and more instructional materials. At the same time, they strongly disagree that they have sufficient device access and stable internet for AI-enabled teaching. In other words, the main barrier does not appear to be teacher resistance; it is the combination of resource scarcity and pedagogical support needs.

This strongly matches the open-ended teacher responses. Teachers reported using AI mostly for personal preparation, relying on downloaded online materials, and struggling with unstable internet and inaccessible or paid AI tools. They also explicitly stated difficulty in integrating AI and sustainability effectively into science lessons.

The results also reflect a common pattern in AI-in-education literature: teachers may be willing to adopt digital innovations, yet implementation remains shallow when infrastructure and design support are weak (Zawacki-Richter et al., 2019).

Thematic Results

Table 5: Science teachers' open-ended responses

Responses	Code	Theme
ST1: "Using AI mostly for my own consumption… activities"	AI-limited use	Emerging but limited AI integration
ST2: "AI-powered teacher support… unstable internet"	Infrastructure barrier	Infrastructure and access constraints
"AI sites are not accessible and not free" (ST3)	Access barrier	Infrastructure and access constraints

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"Difficulty integrating AI and sustainability effectively into lessons" (ST3, ST4)	Pedagogical difficulty	Pedagogical uncertainty
"Reliance on online/downloaded resources" (S1T1, ST2, ST3, ST4)	Resource limitation	Limited instructional resources

The teacher narratives confirm that AI use is happening, but mostly at a basic or preparatory level rather than as deep instructional redesign. Their responses consistently point to unstable internet, lack of access to tools, and uncertainty about how to integrate AI and sustainability meaningfully into science teaching.

That combination of willingness plus uncertainty fits TPACK closely: teachers may already possess some comfort with digital tools, but still need support in aligning technology with content and pedagogy (Mishra & Koehler, 2006). It also echoes the survey results, where teachers strongly wanted more AI skills, more materials, and more support while rating device and internet access very poorly.

Table 6: Learners' open-ended responses

Responses	Code	Theme
Learners' responses frequently define AI as a tool/helper	AI tool view	Basic understanding of AI
Learners' responses define STEM as science, math, technology, and problem solving	STEM-basic view	Basic STEM understanding
Learners cite climate change, flooding, waste, cyberbullying, drainage, poverty	Community issue awareness	Awareness of social and environmental issues
Learners say AI can help solve real-life problems	Problem-solving orientation	AI as solution tools
Some learners provide no answer or vague answers	Uneven understanding	Variability in learner understanding

The learner narratives complement the survey results very well. The surveys showed high AI familiarity and strong agreement that AI can help solve problems; the open-ended responses show what that looks like conceptually. Most learners understand AI functionally, as a helper, tool, or chat-based aid. They also identify many community problems, especially environmental issues such as flooding, pollution, and waste management, but some remain vague or give no answer. Based on the Technology Acceptance Model (TAM) that explains the technology adoption through perceived usefulness (PU) and perceived ease of use (PEOU) which strongly influence user's intentions to use AI (ElSayary et al., 2026)

This means that learner readiness is best described as broad but shallow: students are aware, interested, and optimistic, but not yet consistently sophisticated in their reasoning. That interpretation fits both AI-literacy discussions and sustainability education literature, which emphasize that learners need guided opportunities to connect concepts, systems, and real-world problems more explicitly (Lu et al., 2018).

Triangulation of Quantitative and Qualitative Data

Table 7: Triangulated interpretation across learners and teachers

Aspect	Quantitative evidence	Qualitative evidence	Triangulated interpretation
Learner AI readiness	Very high AI familiarity; strong AI use in science learning; desire to improve skills	Learners describe AI mainly as a helper/tool	Learners are ready to use AI, but mostly at a functional level
Learner sustainability understanding	Mean for basic sustainability familiarity = Agree; mean for sustainability-science connection = Disagree	Learners identify many real-world issues	Learners recognize issues but need help linking sustainability explicitly to science concepts

Teacher AI readiness	Teachers agree they use AI and strongly want more support/materials	Teachers report personal/preparatory AI use and integration difficulty	Teachers are willing but under-supported
Teacher infrastructure	Teachers strongly disagree about device and internet access	Teachers cite unstable internet and inaccessible tools	Infrastructure is a major classroom-level barrier

Learners already have access and interest, especially through smartphones, and they are strongly disposed to see AI as useful for solving science and community problems. Teachers are open to these innovations but lack infrastructure, devices, connectivity, and design support. Together, these results suggest that the school is not facing a problem of low interest; it is facing a problem of implementation capacity. Moreover, AI-TPACK has also been recognized as technology-related knowledge domains (AI-TK, AI-TPK, and AI-TCK) that can significantly improve science teachers' competencies in integrating AI effectively in the classroom (Ning et al., 2024). Referring to TAM Model, teachers' and students' intentions to use AI is most likely driven by a belief that AI can improve their performance and a belief that AI is easy to use (ElSayary et al., 2026). Taken together, teachers with stronger TPACK are more likely to adopt and use AI tools in teaching (Oved & Alt, 2025).

This pattern matches the broader literature. AI in education does not become pedagogically meaningful by access alone; it requires teacher knowledge, curriculum integration, and institutional leadership. It also suggests that sustainability can serve as a strong organizing context for science and AI integration because all three groups already connect science learning to community issues in some way (UNESCO, 2023).

Proposed AI-Embedded Lesson Structure

Recent studies found out that the expansion of TPACK to AI-TPACK helps explain how science teachers can align AI tools with science content rather than using it merely as an integral part in the teaching process (Antonio, 2025; Ning et al., 2024). Inspired by the educational landscape brought by fourth industrial revolution (I.R 4), AI tool such as ChatGPT have been included and will be embedded in the lesson structure that will serve as pedagogical resource.

This lesson structure also aims to emphasize the importance of AI literacy which refers to students' ability to understand, evaluate AI's responses, and ethically use AI. Gu and Ericson (2025) identified three majors dimensions of AI literacy: functional, critical, and sociocultural that highlights the relevance of assisting learners to use AI responsibly and critically. Similarly, Alhuraybi et al. (2025) found that AI literacy does not only include conceptual knowledge but also predicts the learning outcomes and instructional quality. Moreover, UNESCO-sponsored research stated that AI literacy helps educators bridge gaps in pedagogical application and ethical decision-making when utilizing AI tools in education (Gunder & Ford, 2025).

Utilizing AI alone does not only enhance AI literacy but also promote sustainable development goal 4 (Quality of Education) by providing access to AI-supported learning instruction/materials. As mentioned by Alvero (2025), research in Philippine Education shows that AI integration guided by TPACK contributes to achieving SDG 4 through more inclusive and innovative learning environments. This justifies the inclusion of sustainability within science lessons, aligning it with global educational priorities.

Celik et al. (2026) indicated in their study that prompt engineering can offer a comprehensive overview of what the teachers need in order to design an effective AI-enhanced learning experience. Basically, this lesson structure would emphasize how AI could scaffold learning inside the classroom through the prompts they used. In prompt engineering, detailed instructions are needed in order to generate relevant output. Choosing the most appropriate phrases, words, and symbols that guide the AI tool can help the user to interact with it more meaningfully. In this case, introducing prompt engineering could help the students in using ChatGPT interactively, following a format guiding ChatGPT to generate the desired information the student asked. When engaging with AI, students learn to structure problems or lessons so an AI tool can assist, especially in problem-solving. These are the segments in the lesson structure:

I. Investigating - A contextualized problem related to the topic will be given to the students. The teacher will facilitate the students investigating solutions using AI through prompt engineering. A human-to-human

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interaction will then take place after receiving and accepting one solution from AI. (e.g., think, pair, and share activity)

II. Improving the required knowledge – Students will dwell on individual AI-enabled learning activities. In this segment, the students are being scaffolded personally by AI in improving their knowledge about the topic at their own pace. AI acts as a cognitive partner in the learning process and not just merely delivering content to the students.

III. Assessing the input – The students will critically assess the input and determine if the inputs generated by AI are accurate. The students will be given time to evaluate the AI inputs rather than just relying on them, using the "EDIT" strategy. This will also provide real-time feedback to the students if the AI inputs are able to deliver the desired information. The students will have time to revise their prompt to achieve the desired outcome. The teacher will have a short discussion during this segment.

IV. Testing the knowledge – The students will be given an activity to test the knowledge they acquired from the teacher's discussion and the AI inputs. During this segment, the students are not allowed to use their mobile phones or gadgets.

V. Reflecting and Refracting – At the end of the activities, the students will reflect on their learning experiences by answering the reflection part given in the worksheet. In refracting, just like how light bends when it passes through different medium, students will transform and extend their learning in new ways. Students will apply the science concepts in new context or problems.

Figure 1: Implementation Guidelines following the 7E Lesson Plan

Day	7E Phase	Lesson Structure	Learning Activities	AI Integration	Expected Output
Day 1	-	-	Short orientation on using AI in education and establishing rules and guidelines for using AI. Introducing prompting and the "EDIT" strategy in assessing AI outputs. (20 mins)	-	Students practice their prompting and assess an AI's outputs based on the "EDIT" strategy.
Day 2	-	-	**Pre-test**	-	-
Day 3	Engage / Elicit	INVESTIGATE	The teacher presents a contextualized problem about a small-heat powered device. Students discuss possible solutions.	Students use ChatGPT through prompt engineering to investigate possible solutions on how to improve the design so that more of the heat energy is converted into useful work.	Students generate possible solutions and share insights with their seatmates.
Day 4	Explore	IMPROVE	The teacher introduces the concept of heat transfer through simple demonstrations and real-life examples. Students explore the methods of heat transfer through guided activities and discussion.	Students use AI as a learning partner to ask questions and clarify concepts about the three methods of heat transfer.	Students create a concept map describing the three methods of heat transfer.
Day 5	Explain		The teacher explains heat engines and energy transformation, highlighting that not all heat energy is converted into useful work. Students analyze and verify the explanations obtained from AI.	Students apply the **EDIT strategy (Evaluate, Determine, Identify, Test)** to assess the accuracy of AI-generated responses and revise their prompts if necessary.	Students submit an evaluation of AI responses and improved prompts.
Day 6	Elaborate	TEST	Students work in groups to apply their knowledge in making thermal-powered fan.	AI is not used during this stage to encourage independent application of knowledge and collaborative problem-solving.	Group outputs such as calculations, designs of the thermal-powered fan.
Day 7	Evaluate / Extend	REFLECT AND REFRACT	Students present their group outputs and reflect on their learning. Students will accomplish the reflection part in the lesson structure student's guide.	AI is not used in reflection activity to ensure authentic assessment of students' learning.	Group presentations, and reflection responses.
Day 8	-		Post-test	-	Achievement test results.

CONCLUSIONS AND RECOMMENDATIONS

Taken together, the data shows promising result but not yet fully prepared for AI-enabled, sustainability-oriented science instruction. Students are digitally exposed and interested. Teachers are willing but need stronger material and pedagogical support. However, the teachers' needs assessment results may limit the breadth of perspective due to the small sample size which affects the generalizability of the findings to other context. The strongest direction emerging from the data is the need to design science learning experiences that explicitly connect AI tools, science concepts, and sustainability issues, while simultaneously addressing infrastructure and addressing learners' needs. Future research should explore on larger groups of science teachers to improve the robustness and generalizability of the findings when it comes to the needs assessment. The proposed lesson structure should be implemented and evaluate using quasi-experimental or design-based approaches to assess its effectiveness in enhancing students' conceptual understanding, critical thinking, sustainability, and responsible use of AI.

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