

Research Article

The influence of teacher competencies on integrating SDGs into curriculum design: The role of pedagogical innovation

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This study examined the relationships among teacher competencies, pedagogical innovation, and the integration of Sustainable Development Goals (SDGs) into curriculum design using a descriptive correlational Research design. A total of 250 teachers from public and private basic and secondary schools implementing SDG-aligned curricula were selected through multistage sampling. Data were collected using a validated questionnaire measuring teacher competencies, innovative pedagogical practices, and SDG integration. Reliability and validity were confirmed through expert review, pilot testing, exploratory and confirmatory factor analyses, with strong model fit indices. Structural Equation Modeling revealed that teacher competencies significantly predicted both SDG integration and pedagogical innovation. Pedagogical innovation also positively influenced SDG integration. Mediation analysis showed that pedagogical innovation partially mediated the relationship between teacher competencies and SDG integration. These findings highlight the essential role of teacher expertise and innovation in advancing sustainability education and provide evidence to guide professional development and curriculum reform initiatives.

Keywords: Curriculum design; Pedagogical innovation; SDGs; Teacher competencies

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1. Introduction

The United Nations Sustainable Development Goals [SDGs], adopted in 2015 as part of the 2030 Agenda for Sustainable Development, represent a global commitment to addressing critical social, economic, and environmental challenges (Lovren & Willats, 2019). Among the seventeen goals, Goal 4: Quality Education emphasizes the need to “ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.” This goal positions education as the foundation for achieving sustainable development because it equips individuals with the knowledge, attitudes, and skills necessary to foster responsible citizenship and environmental stewardship. The pursuit of Goal 4 extends beyond access to schooling; it calls for reimagining teaching and learning through curriculum design that encourages innovation, equity, and critical thinking. As such, curriculum design serves as a crucial platform for embedding SDG principles

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into educational systems by integrating sustainability concepts across disciplines and promoting active, learner-centered pedagogies.

Teachers play a pivotal role in this global transformation, acting as mediators who translate international sustainability frameworks into practical classroom realities. Their competencies, pedagogical creativity, and reflective practices determine how effectively SDG values are contextualized within local curricula (David, 2025). Through curriculum planning and instructional design, teachers integrate sustainability-related themes, utilize project-based and experiential learning, and foster students' problem-solving and civic engagement skills. Global frameworks such as UNESCO's Education for Sustainable Development [ESD] Framework, the Global Action Programme on Education for Sustainable Development [GAP], and national education strategies influenced by the 2030 Agenda reinforce the teacher's position as a catalyst for implementing sustainability education (OECD, 2021; UNESCO, 2017). These frameworks advocate for curriculum reorientation and teacher professional development to ensure that education systems make meaningful contributions to the achievement of SDG 4 and the broader vision of a sustainable future.

The meaningful integration of the Sustainable Development Goals into educational curricula depends substantially on teachers' capacity to interpret complex sustainability issues and translate them into meaningful, subject-specific, interdisciplinary, and action-oriented learning experiences. Such capacity extends beyond familiarity with the SDGs themselves and involves sustainability-related content and pedagogical knowledge, systems and critical thinking, appropriate values and dispositions, and the ability to connect global sustainability concerns with disciplinary, local, and learner-specific contexts (Brandt et al., 2022; Fischer et al., 2022). Recent work further conceptualizes effective sustainability teaching as a multidimensional professional competence that combines sustainability literacy with pedagogical content knowledge and the capacity to integrate skills across complex sustainability issues (Bayram & Aslan, 2025).

However, the development of these competencies remains uneven within teacher education. Preservice teachers may enter professional preparation with limited knowledge of how environmental and sustainability concerns can be incorporated into their disciplinary teaching, while targeted educational experiences can substantially reshape both their sustainability understanding and their perceptions of their responsibilities as future educators (Kuzu & Çubukçu, 2026). This suggests that sustainability should not be treated as additional curriculum content to be transmitted to learners, but as a pedagogical orientation requiring teachers to connect disciplinary knowledge with real-world problems, multiple perspectives, and opportunities for responsible action. Transformative ESD environments therefore emphasize interdisciplinary and challenge-based learning, participation, systemic and creative thinking, collaboration with external actors, and engagement with authentic community problems rather than reliance primarily on content transmission (Rekalde-Rodríguez, 2026).

Teacher preparation for the SDGs consequently requires professional learning environments in which these competencies can be developed through authentic practice. Real-world and collaborative learning experiences can foster systems thinking by exposing learners to complex sustainability problems and enabling them to exchange and reconsider diverse perspectives (Demssie et al., 2023). Similarly, experiences in which preservice teachers investigate phenomena in natural environments and transform their observations into digital pedagogical products can simultaneously develop environmental awareness, pedagogical knowledge, creativity, and technological self-efficacy (Uluçınar & Sezer, 2026). Sustainable teacher preparation in digitally mediated environments is also strengthened when technological engagement is accompanied by structured practice, modelling, feedback, reflection, and supportive conditions rather than exposure to technology alone (Mohafa et al., 2026).

Accordingly, preparing teachers to advance the SDGs requires a coherent and multidimensional approach to professional competence. Sustainability knowledge needs to be integrated with pedagogical expertise, systems and critical thinking, interdisciplinary collaboration, technological

competence, reflection, and opportunities for authentic and action-oriented learning. Technology can contribute to this process, but its successful pedagogical integration depends on the interaction between teachers' competence and supportive school- and system-level conditions rather than on individual teacher effort alone (Antwi, 2026). Such preparation can enable teachers to move beyond presenting sustainability as a discrete body of knowledge and instead design learning environments in which students investigate complex problems, connect disciplinary and local perspectives, collaboratively develop possible responses, and build competencies for responsible and informed action.

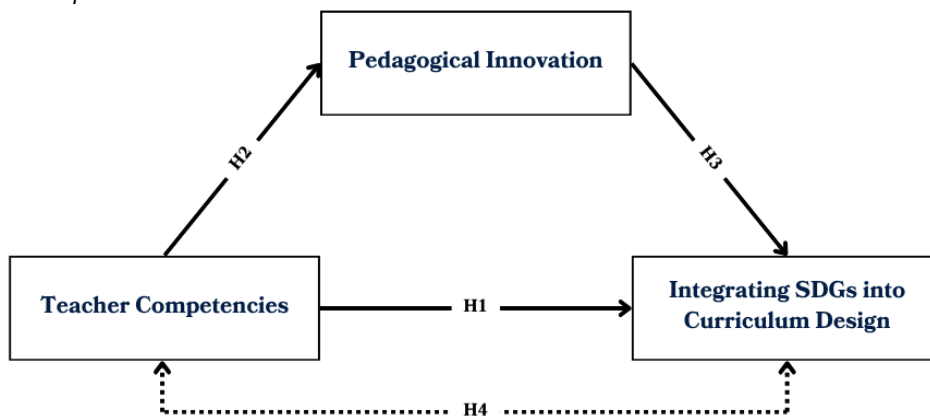
Although teacher competencies and pedagogical innovation have each received considerable attention, comparatively limited research has examined how teachers' professional capacities are translated into innovative pedagogical practices and how this interaction shapes the meaningful integration of the Sustainable Development Goals into curriculum design. Existing sustainability research has documented teachers' sustainability competencies, the influence of teacher education and curricula on these competencies, and the need for more integrated and transformative approaches to Education for Sustainable Development (Baena-Morales & González-Villora, 2023; Hassan & Ahmad, 2025). More recent work has begun to bridge these domains by linking sustainability literacy and pedagogical competencies with integrated skills training and by demonstrating how interdisciplinary, challenge-based, and collaborative pedagogies can create transformative environments for sustainability education (Bayram & Aslan, 2025; Rekalde-Rodríguez, 2026). Nevertheless, direct empirical attention to the mechanism through which teacher competencies enable or constrain pedagogical innovation in SDG-oriented curriculum design remains comparatively limited. This gap is particularly noteworthy because research beyond the sustainability field increasingly shows that professional readiness, technological and pedagogical competence, and self-efficacy are closely connected with teachers' capacity to design and implement innovative learning experiences (Mohafa et al., 2026; Tusyanah et al., 2026; Uluçınar & Sezer, 2026). Evidence from innovative pedagogical interventions further suggests that learner-centred approaches such as project-based and flipped learning can translate pedagogical design into meaningful engagement and skill development (Okanya et al., 2025). Examining teacher competence and pedagogical innovation as interconnected rather than separate constructs may therefore provide a stronger basis for understanding how SDG commitments are transformed from curricular intentions into concrete teaching and learning practices. Empirical investigations that connect teachers' skills, attitudes, and pedagogical creativity with curriculum transformation for sustainability are still limited, particularly within the educational contexts of Ghana and the wider Sub-Saharan Africa region. This gap underscores the need for a contextually grounded study that explores how teachers' competencies and pedagogical innovation jointly drive the inclusion of sustainability principles into curriculum planning and classroom practice, providing evidence to guide policy and teacher professional development for sustainable education reform. This study aims to investigate the influence of teacher competencies on integrating SDGs into curriculum design. This study will examine whether pedagogical innovation will mediate the nexus between teacher competencies on integrating SDGs into curriculum design. Specifically, the hypotheses of this study were to: (1) assess the effect of teacher competencies on integrating SDGs into curriculum design; (2) find out the effect teacher competencies on pedagogical innovation; (3) assess the effect of pedagogical innovation on integrating SDGs into curriculum design and (4) ascertain the mediating role of pedagogical innovation on the nexus between teacher competencies and integrating SDGs into the curriculum.

2. Literature Review

2.1. Teacher Competencies and the Integration of SDGs into Curriculum Design

The integration of Sustainable Development Goals into curriculum design is strongly influenced by the competencies that teachers possess, especially within the context of Education for

Figure 1
Conceptual Framework



Note. Source: Authors' Framework, 2025

Sustainable Development [ESD]. Teachers who have well-developed competencies, such as pedagogical content knowledge, curriculum planning skills, assessment literacy, and an understanding of real-world contexts, are more capable of meaningfully embedding sustainability concepts into their teaching. Research shows that such teachers can effectively align learning objectives, classroom activities, and assessment methods with SDG targets, making the curriculum more relevant and impactful for students (Cottafava et al., 2019; Lei et al., 2024). In practice, this means that competent teachers can move beyond simply adding SDG-related topics to the syllabus; instead, they redesign the curriculum in a way that integrates sustainability into the core of teaching and learning. Additionally, scholars emphasize that integrating SDGs successfully requires teachers to foster higher-order thinking skills such as critical thinking, systems thinking, and problem-solving, which are essential competencies in sustainability education (Lorenzo-Rial et al., 2026; Suhendro et al., 2021). Therefore, teacher competence plays a central role in transforming traditional curricula into ones that genuinely reflect sustainability principles.

Furthermore, several studies highlight that teacher competence is a key predictor of how well SDGs are integrated into curriculum design and classroom practice. Teachers who lack adequate training or professional development often struggle to incorporate SDGs effectively, resulting in fragmented or superficial implementation across subjects (Syahidan et al., 2024; Triyanto, 2025). On the other hand, competent teachers are more likely to adopt interdisciplinary approaches and innovative teaching strategies that bring sustainability issues to life in the classroom. This ensures that SDG concepts are not taught in isolation but are connected across different subject areas, enhancing students' overall understanding. Broader research also suggests that the success of SDG integration does not depend solely on policy frameworks or curriculum guidelines, but largely on teachers' ability to interpret and implement them in practical ways (Holst et al., 2024). As a result, investing in teacher professional development and competency-based training is essential for strengthening the integration of SDGs into curriculum design. Such efforts will ultimately help education systems contribute more effectively to achieving the global sustainability agenda. Based on these discussions, we proposed that;

H₁: Teacher competencies significantly influence the integration of SDGs into curriculum design.

2.2. Teacher Competencies and Pedagogical Innovation

Teacher competencies play a crucial role in promoting pedagogical innovation, especially in modern classrooms where teaching is expected to be interactive, technology-driven, and learner-centered. Scholars argue that when teachers possess strong competencies in areas such as pedagogy, technology integration, creativity, and collaboration, they are more capable of designing innovative instructional strategies that actively engage students (Budirahayu & Saud, 2023). The Technological Pedagogical Content Knowledge [TPACK] framework explains that

effective teaching innovation occurs when teachers can combine what they teach (content), how they teach (pedagogy), and the tools they use (technology) (Jiménez Sierra et al., 2023). In this regard, teachers who are competent in using digital tools, creating interactive learning environments, and applying diverse teaching methods are more likely to move away from traditional lecture-based approaches and adopt methods such as problem-based learning and collaborative learning. This suggests that teacher competencies are not only important for effective teaching but are also key drivers of innovation in the classroom.

However, the extent to which teacher competencies are translated into pedagogical innovation often depends on enabling conditions, particularly sustained professional development, supportive leadership and school climate, and teachers' beliefs and agency (Badal, 2025; Hidayat & Patras, 2024; Yakavets et al., 2023). Even when teachers possess relevant knowledge and skills, contextual constraints such as inadequate resources or technical facilities and limited institutional support can restrict the implementation of innovative practices, highlighting the importance of continuous professional development, collaborative professional learning, and administrative support for sustained change (Aydemir Altaş & Babacan, 2025; Tadesse & Derza, 2020). Teachers' beliefs about teaching and learning also shape how they respond to pedagogical change, with greater alignment between existing beliefs and student-centered approaches facilitating the adoption of new roles and practices (Keiler, 2018; Yakavets et al., 2023). In addition, adaptability, problem-solving, openness to learning, and continuous professional growth are closely associated with innovative teaching, suggesting that these capacities can support teachers in experimenting with and refining new pedagogical strategies (Aydemir Altaş & Babacan, 2025). Despite this, many studies highlight a gap between what teachers know and what they actually practice, often due to limited resources, resistance to change, and lack of institutional support. In all, the literature suggests that while teacher competencies are essential for pedagogical innovation, their impact is strengthened when combined with supportive conditions and continuous professional learning. Based on these discussions, we proposed that;

H₂: Teacher competencies have a significant influence on pedagogical innovation.

2.3. Pedagogical Innovation and the Integration of the SDGs into Curriculum Design

Pedagogical innovation plays an important role in helping educators effectively integrate the Sustainable Development Goals into curriculum design, especially within the context of Education for Sustainable Development. Many scholars have highlighted that innovative teaching approaches, such as project-based learning, inquiry-based learning, and interdisciplinary methods, support the alignment of curriculum goals with essential sustainability competencies like critical thinking, global citizenship, and problem-solving (Martinez, 2022). Rather than simply adding SDG-related topics into existing syllabi, these approaches encourage a shift toward competency-based and transformative learning, where students actively engage with real-world sustainability issues. In higher education, for instance, pedagogical innovation has been shown to improve how SDGs are mapped and embedded across courses, ensuring that learning outcomes are consistently aligned with sustainability principles (Alm et al., 2021; Novaes, 2024). This transition from traditional lecture-based teaching to more student-centered learning environments allows learners to better understand the complexity and interconnected nature of global challenges.

In addition, pedagogical innovation can strengthen the quality and relevance of SDG integration by enabling more flexible, participatory, inclusive, and context-responsive learning designs (Martins et al., 2025; Rekalde-Rodríguez, 2026). Innovative approaches that combine digital tools with experiential, challenge-based, and community-connected learning can help learners relate conceptual knowledge to authentic sustainability issues while promoting engagement, environmental awareness, and meaningful participation (Rekalde-Rodríguez, 2026; Uluçınar & Sezer, 2026). Such approaches can also support sustainability-related capacities, particularly systems thinking, collaboration, reflective reasoning, and engagement with complex and interconnected problems (Bozkurt, 2026; Rekalde-Rodríguez, 2026). However, their successful

implementation is shaped by teacher preparedness and competence, access to appropriate resources and infrastructure, and supportive institutional and policy conditions (Antwi, 2026; Martins et al., 2025; Parry & Kumi, 2026). The literature therefore suggests that pedagogical innovation can play an important role in integrating the SDGs into curriculum design, although its effectiveness depends on sustained teacher development, enabling institutional conditions, and pedagogical designs that are responsive to local contexts (Antwi, 2026; Martins et al., 2025; Mohafa et al., 2026). Based on these arguments, we further propose that:

H₃: Pedagogical innovation has a significant influence on the integration of the SDGs into curriculum design.

From Hypotheses 1, 2, and 3, it was realized that teacher competencies significantly influence the integration of SDGs into curriculum design. Further, teacher competencies have a significant influence on pedagogical innovation. Moreover, pedagogical innovation has a significant influence on the integration of the SDGs into curriculum design. Based on these, it was proposed that;

H₄: Pedagogical innovation mediates the nexus between teacher competencies and integration of SDGs into the curriculum.

2. Methodology

2.1. Research Design

The study employed a descriptive correlational research design, which is appropriate for exploring the relationships among teacher competencies, pedagogical innovation, and the integration of Sustainable Development Goals into curriculum design. This design enabled the researcher to gather quantitative data reflecting the extent to which teachers' professional knowledge, instructional skills, and innovative pedagogical practices influence their ability to embed SDG principles into teaching and learning processes. By using this design, the study did not manipulate any variables; instead, it sought to describe existing conditions and determine the nature and strength of relationships among the variables under investigation. The correlational approach was beneficial for identifying patterns of association that could reveal whether teachers with higher levels of pedagogical competence and innovation were more likely to integrate sustainability concepts into their curriculum planning and classroom delivery.

2.2. Population, Sample Size, and Sampling Techniques

The target population for this study comprises all teachers involved in curriculum design and classroom implementation within public and private basic and secondary schools that have incorporated elements of the Sustainable Development Goals into their teaching and learning frameworks. Teachers are central agents in achieving educational transformation since they are responsible for translating curriculum objectives into meaningful classroom practices that align with the broader goals of sustainability and global citizenship. The population, therefore, includes classroom teachers, headteachers, and curriculum coordinators who have undergone professional training or development related to pedagogical innovation or sustainability education. Focusing on this group provides a comprehensive basis for examining how teacher competencies, encompassing pedagogical, technological, and professional skills, influence the integration of SDG concepts into curriculum design and instructional practice.

The sample size was determined based on both statistical and contextual considerations to ensure representativeness and accuracy in the findings. In quantitative research, an adequate sample size is essential for ensuring the reliability and validity of data analysis (Cohen et al., 2018). Following the guidelines proposed by Krejcie and Morgan (1970), a minimum of 200 participants was deemed appropriate for a target population exceeding 500 teachers. However, to enhance precision and account for possible non-responses, a sample of 250 teachers was selected. This sample size was suitable for advanced statistical analyses such as multiple regression or structural equation modeling, which require relatively large samples to detect significant relationships

among variables (Hair et al., 2017). Moreover, the sample design accounted for diversity in teaching experience, educational level (basic or secondary), and institutional type (public or private), ensuring that the findings reflect a broad spectrum of teacher perspectives.

A multistage sampling technique was employed to select respondents systematically. In the first stage, districts were purposively selected based on the presence of schools implementing SDG-aligned curricula or Education for Sustainable Development programs. This purposive approach ensured the inclusion of relevant institutions actively involved in curriculum reforms (Creswell, 2014). In the second stage, schools were stratified by type and level to ensure balanced representation. Finally, teachers within each selected school were chosen using simple random sampling, providing every eligible teacher an equal opportunity to participate and reducing potential sampling bias. This combination of purposive, stratified, and random techniques enhanced the validity and generalizability of the findings by ensuring that the data represented diverse educational contexts and teaching environments.

Attention was also given to ensuring gender balance and equitable representation of teachers from urban and rural areas, as these factors often influence access to pedagogical resources and exposure to innovative teaching methods. This systematic and inclusive approach to sampling allowed for a nuanced understanding of how teacher competencies and pedagogical innovation collectively shape the integration of SDGs into curriculum design. Consequently, the study's findings are expected to provide empirically grounded insights that can inform teacher education policies, curriculum development, and sustainability-driven educational reforms.

2.3. Questionnaire and Measure

The study employed a structured questionnaire as the primary data collection instrument to measure the key constructs, teacher competencies, pedagogical innovation, and SDG integration in curriculum design. The questionnaire was carefully designed based on a review of relevant empirical and theoretical literature to ensure comprehensive coverage of all dimensions associated with the study variables. The items related to teacher competencies were adapted from established frameworks that assess Subject-Matter Expertise and Instructional Skills (Tondeur et al., 2019). The pedagogical innovation scale was developed to capture Curriculum Adaptation for SDGs and Technology-Enhanced Innovation (Buendia et al., 2025). The SDG integration section included items that measured the extent to which teachers embed sustainability principles, values, and interdisciplinary content into their curriculum planning and classroom activities (UNESCO, 2020). Each item was rated on a five-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree"), enabling quantitative assessment of teachers' perceptions and practices.

2.4. Assessment of Validity and Reliability

Before the main data collection, the questionnaire underwent content and face validity checks to confirm its appropriateness and clarity. Content validity was established through expert review, involving three specialists in curriculum design, sustainable education, and teacher professional development. These experts reviewed the questionnaire for relevance, wording, and alignment with the study's objectives, resulting in minor revisions that enhanced item clarity and coherence. Face validity was further confirmed through a pilot study involving a small group of teachers who were not part of the final sample. Their feedback helped refine ambiguous statements, reduce redundancy, and ensure the instrument was contextually understandable and culturally suitable for the Ghanaian educational environment.

To ensure the construct validity of the measurement model, the data from the pilot test were subjected to exploratory factor analysis [EFA] to identify underlying factor structures and verify item loadings. The Kaiser-Meyer-Olkin [KMO] test and Bartlett's test of sphericity confirmed the sampling adequacy and suitability of the data for factor analysis. Items with low factor loadings (below 0.50) or cross-loadings were removed to improve construct purity. In the main study, confirmatory factor analysis [CFA] was later conducted to verify the dimensionality and convergent validity of the constructs, ensuring that all observed variables adequately represented

their respective latent constructs.

The reliability of the instrument was examined using both internal consistency and composite reliability measures. Cronbach's alpha coefficients were computed for each subscale to assess the internal consistency of the items, with all coefficients exceeding the recommended threshold of .70 (Edo et al., 2024; Hair et al., 2014), indicating strong reliability. Additionally, composite reliability [CR] values and average variance extracted [AVE] were calculated during the CFA process to further evaluate how consistently and accurately each construct was measured. CR values above 0.70 and AVE values above 0.50 confirmed that the items reliably measured their respective constructs. Discriminant validity was also tested by comparing the square root of AVE values with the inter-construct correlations, ensuring that each construct was empirically distinct from the others. Table 1 presents the results for confirmatory factor analysis and the model fit indices.

Table 1

Confirmatory Factor Analysis (CFA) and Model Fit Indices

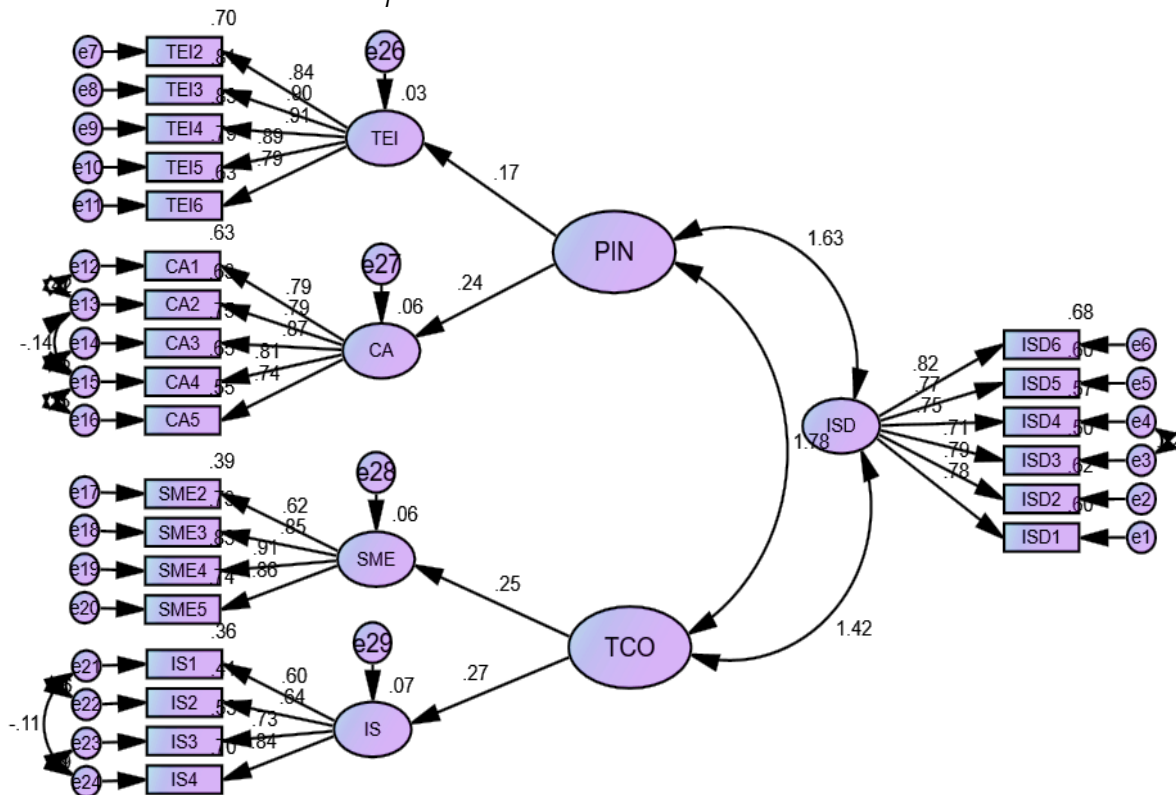
Model Fit Indices: CMIN = 470.913; DF = 239; CMIN/DF = 1.970; TLI = .948; CFI = .955; GFI = .896; NFI = .914; RMR = .058; RMSEA = .055; PClose = .148	Std. Estimate
ISD: CA = .900; CR = .898; AVE = .678	
ISD1: I incorporate SDG-related themes into my lesson plans.	.775
ISD2: I align learning objectives with relevant SDG goals.	.788
ISD3: I use SDG frameworks to structure course content.	.710
ISD4: I design assessment tasks that reflect SDG competencies.	.752
ISD5: I ensure students understand the global relevance of SDGs.	.773
ISD6: I update curriculum materials to include recent SDG developments.	.822
PIN: CA = .834; CR = .977; AVE = .876	
TEI: CA = .935; CR = .936; AVE = .746	
TEI2: I integrate online resources to teach SDG-related topics.	.835
TEI3: I employ technology for collaborative learning activities.	.898
TEI4: I use multimedia to illustrate complex concepts effectively.	.910
TEI5: I design lessons that combine technology with active learning.	.890
TEI6: I encourage students to use digital platforms for problem-solving tasks.	.791
CA: CA = .908; CR = .901; AVE = .646	
CA1: I modify existing curriculum content to reflect SDG objectives.	.791
CA2: I integrate local sustainability issues into the curriculum.	.793
CA3: I adjust lesson plans to include SDG-aligned projects.	.867
CA4: I ensure learning materials address relevant SDG topics.	.806
CA5: I restructured course content to enhance students' SDG understanding.	.740
TCO: CA = .754; CR = .879; AVE = .687	
SME: CA = .869; CR = .875; AVE = .642	
SME2: I stay updated with recent developments in my field.	.623
SME3: I can explain complex concepts clearly to students.	.855
SME4: I can connect subject content to real-world sustainability issues.	.912
SME5: I can integrate interdisciplinary perspectives into teaching.	.860
IS: CA = .842; CR = .825; AVE = .544	
IS1: I can manage classroom activities efficiently.	.602
IS2: I use diverse instructional strategies to enhance learning.	.637
IS3: I provide clear instructions for all learning tasks.	.725
IS4: I monitor and evaluate students' understanding regularly.	.837

Figure 2 illustrates the Confirmatory Factor Analysis. From Figure 2, PIN and TCO are the independent variables, and ISD is the dependent variable. Moreover, PIN also serves as the mediating variable. Also, PIN had two sub-variables: TEI and CA, while TCO had two sub-variables: SME and IS. TEI had five measurement items: TEI 2, TEI 3, TEI 4, TEI 5, and TEI 6, while CA also had five measurement items: CA1, CA2, CA3, CA4, and CA5. Furthermore, SME had four

measurement items: SME2, SME3, SME4, and SME5, while IS also had four measurement items: IS1, IS2, IS3, and IS4. In addition, ISD had six measurement items: ISD1, ISD2, ISD3, ISD4, ISD5, and ISD6. Finally, Figure 2 revealed a strong correlation result between OIN, TCO, and ISD.

Figure 2

Structural Validation via Conceptual Framework



Note. Source: Authors' Creation, 2025.

To assess discriminant validity, the study compared the square roots of the AVE values with the correlations among the constructs. Discriminant validity is confirmed when the lowest square root of the AVE is greater than the highest construct correlation. Table 2 presents the discriminant validity result. The value which are bolded and italicized are the square-root values for AVE.

Table 2

Assessment of Discriminant Validity

Variables	CR	AVE	PIN	ISD	TCO
PIN	.977	.542	.736		
ISD	.898	.746	.627	.864	
TCO	.879	.677	.417	.687	.823

In this study, the smallest square root of the AVE was .736, which was higher than the strongest correlation recorded (.687), as shown in Table 2. This indicates that the constructs were clearly distinct from one another, confirming that discriminant validity was achieved.

3. Results

The different relationships in the model were examined using a covariance-based Structural Equation Modeling approach, carried out with Amos (ver. 23). After completing the analysis, the outcomes were organized and displayed in Table 3 and illustrated graphically in Figure 3. Table 3 is divided into five sections, that is, direct effect and indirect effect sections showing the effect of the independent and the mediating variable on the dependent variable. Standardized Estimates result in determining whether the results are positive or negative. Standardized Error (S.E.)

together with the direct effect result determines whether the Standardized Estimates result will be statistically significant or not by considering the z-score value of at least 1.96 for a 95% confidence interval.

Table 3

Parameter Estimation of the Model Paths

<i>Direct Effect</i>	<i>Std. Estimate</i>	<i>S.E.</i>	<i>C.R.</i>	<i>p-value</i>
TCO → PIN	1.779	1.010	1.761	.034
PIN → ISD	.413	.056	7.375	<.001
TCO → ISD	.682	.158	4.316	<.001
<i>Indirect Effect</i>	<i>Std. Estimate</i>	<i>Lower B.C.</i>	<i>Upper B.C.</i>	<i>p-value</i>
TCO → PIN → ISD	.578	.104	.353	<.001

H₁: Teacher competencies significantly influence the integration of SDGs into curriculum design.

Hypothesis one sought to assess whether teacher competencies significantly influence the integration of SDGs into curriculum design. From Table 3, the result revealed that teacher competencies had a significantly positive influence on the integration of SDGs into curriculum design, with a *p*-value less than 5% ($\beta = 0.682$; C.R. = 4.316). The result demonstrated that teacher competencies had a significantly positive influence of 68.2% on the integration of SDGs into curriculum design. Based on this finding, H1 is accepted.

H₂: Teacher competencies significantly influence pedagogical innovation.

Hypothesis two sought to assess whether teacher competencies significantly influence pedagogical innovation. From Table 3, the result revealed that teacher competencies had a significantly positive influence on pedagogical innovation, with a *p*-value less than 5% ($\beta = 1.779$; C.R. = 1.761). Based on this finding, H2 is accepted.

H₃: Pedagogical innovation significantly influences the integration of SDGs into curriculum design.

Hypothesis one sought to determine whether pedagogical innovation significantly influences the integration of SDGs into curriculum design. From Table 3, the result revealed that pedagogical innovation had a significantly positive influence on the integration of SDGs into curriculum design, with a *p*-value less than 5% ($\beta = 0.143$; C.R. = 7.375). The result demonstrated that pedagogical innovation had a significantly positive influence of 14.4% significantly positive influence on the integration of SDGs into curriculum design. Based on this finding, H3 is accepted.

H₄: Pedagogical innovation mediates the nexus between teacher competencies and integration of SDGs into the curriculum.

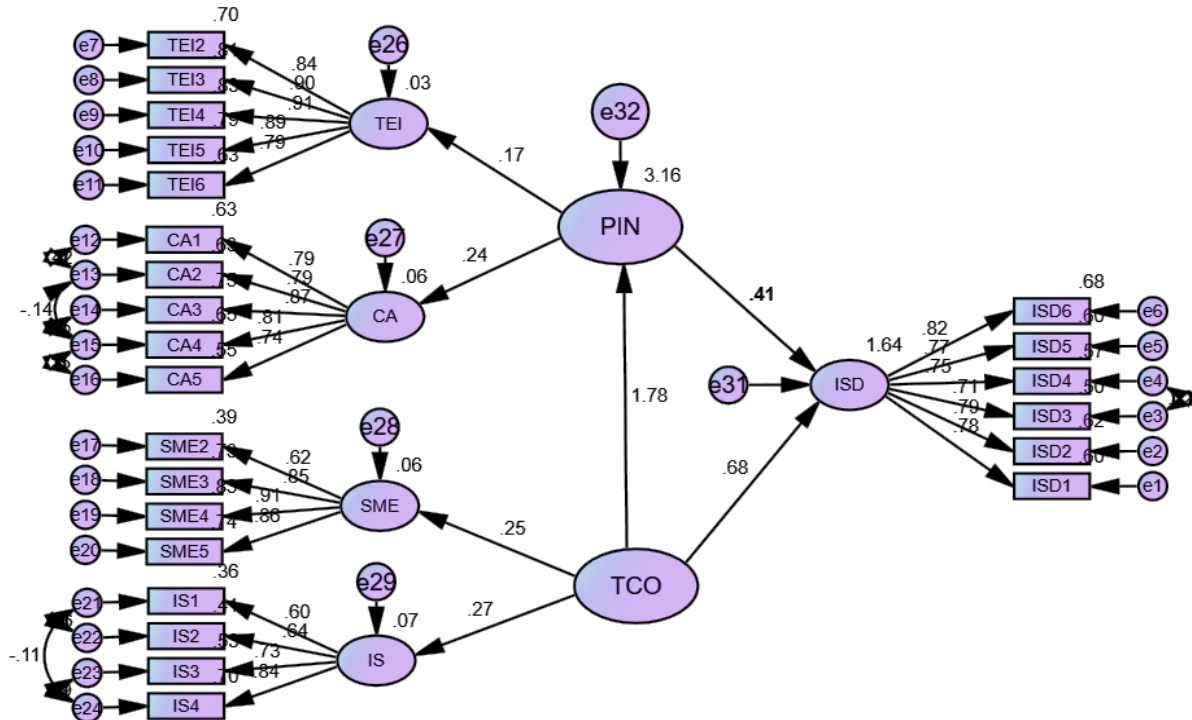
The fourth hypothesis (H4) suggested that PIN serves as a mediating factor between TCO and ISD. The results presented in Table 3 show that TCO significantly and positively predicts PIN, and PIN in turn has a significant positive influence on ISD. Although PIN plays a mediating role, TCO still maintains a direct effect on ISD, indicating that the mediation is only partial. To confirm whether this indirect pathway was statistically meaningful, a bootstrapping procedure with 5,000 resamples was carried out. As shown in Table 4, the indirect effect value of 0.578 was found to be significant because the confidence interval (lower = 0.104, upper = 0.353) did not include zero. Based on these results, H4 was supported.

Figure 3 illustrates the path estimates. From Figure 3, PIN and TCO are the independent variables, and ISD is the dependent variable. Moreover, PIN also serves as the mediating variable. Also, PIN had two sub-variables: TEI and CA, while TCO also had two sub-variables: SME and IS. TEI had five measurement items: TEI 2, TEI 3, TEI 4, TEI 5, and TEI 6, while CA had five measurement items: CA1, CA2, CA3, CA4, and CA5. Furthermore, SME had four measurement

items: SME2, SME3, SME4, and SME5, while IS had four measurement items: IS1, IS2, IS3, and IS4. In addition, ISD had six measurement items: ISD1, ISD2, ISD3, ISD4, ISD5, and ISD6. Finally, Figure 3 PIN had a positive effect on ISD, TCO had a positive effect on PIN and ISD, while PIN positively mediates the nexus between TCO and ISD.

Figure 3

Paths Estimates Illustration



Note. Source: Authors' Creation, 2025.

4. Discussion

4.1. The Influence of Teacher Competencies on the Integration of SDGs into Curriculum Design

The findings revealed that teacher competencies have a strong and meaningful influence on how effectively Sustainable Development Goals are integrated into curriculum design. When teachers possess strong pedagogical knowledge, subject expertise, and reflective capacities, they are better positioned to integrate global competencies, sustainability perspectives, and transformative learning approaches into the curriculum. This result aligns with existing literature highlighting the central role of teachers in promoting sustainability education. Scholars such as Williams-McBean emphasize that teachers equipped with 21st-century competencies, including systems thinking, anticipatory skills, and critical thinking, are more likely to integrate SDG principles within instructional programs. Similarly, Corney and Reid (2007) argue that teacher expertise determines the depth and authenticity of sustainability content embedded in the curriculum. Without adequate teacher competence, curriculum integration often remains superficial or fragmented. The present study reinforces these views by showing empirically that teachers with higher competency levels are better at aligning learning experiences with SDG-related outcomes. The findings further imply that capacity-building initiatives, continuous professional development, and SDG-oriented training programs are crucial for improving curriculum quality. When teachers gain exposure to sustainability frameworks, global citizenship ideals, and innovative teaching strategies, they develop the confidence and creativity needed to adapt curriculum content to real-world challenges.

4.2. The Influence of Teacher Competencies on Pedagogical Innovation

The results demonstrated that teacher competencies significantly predict the level of pedagogical innovation exhibited in teaching and learning processes. The findings suggest that teachers with stronger professional knowledge, problem-solving abilities, classroom management skills, and technological literacy are better positioned to adopt and adapt innovative instructional practices. This interpretation is supported by evidence showing that technopedagogical competence is positively associated with teachers' acceptance of emerging technologies, while technology self-efficacy and readiness are closely related to innovative lesson design (Çakır & Güner, 2026; Tusyanah et al., 2026). Such innovation may involve student-centered approaches, inquiry-oriented learning, digital tools, project-based learning, and other strategies intended to strengthen learner engagement and understanding. Evidence from innovative pedagogical interventions further indicates that learner-centered approaches such as project-based and flipped learning can enhance student engagement and practical learning outcomes when implemented appropriately (Okanya et al., 2025). Rather than implying that competent teachers are naturally inclined to innovate, the present findings suggest that stronger competencies may provide teachers with greater confidence and readiness to experiment with alternative pedagogical approaches. This interpretation is consistent with evidence linking teacher self-efficacy and supportive school conditions with innovativeness (Hidayat & Patras, 2024). Similarly, insufficient technological competence can constrain teachers' willingness and ability to integrate new technologies, while school leadership and broader institutional conditions can further shape whether such competencies are translated into classroom practice (Antwi, 2027). Thus, teacher competence appears to function within a wider professional and institutional environment rather than independently of it. The findings also reinforce the importance of sustained professional development. Recent research indicates that teachers require practical, hands-on digital training, mentoring, reflective evaluation, and supportive institutional conditions to translate newly acquired knowledge into pedagogical change (Parry & Kumi, 2026; Tambak & Sukenti, 2026). Moreover, short-term exposure to emerging technologies may improve readiness without necessarily producing equivalent development in integrated technological-pedagogical competence, suggesting a need for longer-term, practice-oriented teacher development (Gürbüz et al., 2026; Mohafa et al., 2026). Structured engagement with emerging technologies during teaching practice can further support pedagogical decision-making, classroom interaction, adaptation to learner needs, and reflective awareness (Danışman, 2026). Overall, the present findings reinforce the need for continued investment in teacher development aimed at strengthening technological proficiency, pedagogical reasoning, creativity, and reflective practice as foundations for sustained pedagogical innovation.

4.3. The Influence of Pedagogical Innovation on the Integration of SDGs into Curriculum Design

The finding revealed that pedagogical innovation contributes significantly to the integration of SDGs into curriculum design. The results indicated that innovative teaching approaches enhance the extent to which SDG themes are incorporated into curriculum structures. This finding is supported by the literature, which consistently emphasizes the importance of innovative pedagogy in fostering SDG-oriented learning. Davidson et al. (2021) highlight those transformative pedagogies, such as problem-based learning, experiential education, and collaborative inquiry, are essential for enabling students to understand and respond to sustainability challenges. Similarly, Schuler et al. (2018) argue that pedagogical innovation promotes critical thinking, systems thinking, and ethical reasoning, all of which form the foundation of education for sustainable development. Thus, without innovative teaching methods, the integration of SDGs into curriculum content may become rigid, theoretical, and disconnected from real-life contexts. Educators who adopt innovative pedagogies provide environments where learners actively explore sustainability concepts rather than passively receiving information. Therefore, pedagogical innovation acts as a

catalyst that strengthens the curriculum's alignment with the SDGs and enhances the relevance and impact of sustainability education.

4.4. The Mediating Role of Pedagogical Innovation in the Relationship Between Teacher Competencies and SDG Integration

The fourth hypothesis examined whether pedagogical innovation plays a mediating role in the relationship between teacher competencies and the integration of SDGs into curriculum design. The results revealed that while teacher competencies directly influence SDG integration, a significant portion of this influence also operates indirectly through pedagogical innovation. The bootstrapping analysis confirmed that the mediation effect was statistically significant because the confidence interval did not include zero. However, teacher competencies continued to exert a direct effect on SDG integration, meaning the mediation was partial rather than full. This suggests that competencies enable teachers not only to innovate but also to incorporate SDGs directly into the curriculum, even without innovation. These findings are in line with previous research showing that pedagogical innovation often serves as an intermediary mechanism through which teacher skills shape teaching outcomes. Peterson and Lundquist (2021) note that competencies alone do not produce transformative learning unless they translate into innovative classroom practices. Similarly, Jurow et al. (2019) explain that innovation mediates the connection between professional skills and educational impact by converting teacher expertise into practical learning experiences. This literature supports the empirical evidence that pedagogical innovation acts as a pathway linking teacher competencies to the successful implementation of SDG-focused curriculum design. The results suggest that simply improving teacher competencies may not yield the highest possible gains in SDG integration unless equal focus is placed on supporting innovative teaching practices. Professional development programs, therefore, should not only build competence but also encourage experimentation, creativity, and reflective practice. By doing so, educational systems can strengthen both the direct and indirect pathways through which teachers contribute to sustainability education.

5. Implications

The findings provide strong evidence that improving teachers' competencies directly enhances both pedagogical innovation and the successful integration of the Sustainable Development Goals into curriculum design. Practically, this means that educational institutions, ministries of education, and school leaders must prioritize continuous professional development that targets specific competencies such as instructional design skills, assessment literacy, curriculum interpretation, and digital pedagogy. Since the results reveal that competent teachers contribute up to 68.2% of the variance in SDG integration, investing in teacher capacity-building becomes a strategic pathway for achieving SDG-driven educational reforms. Additionally, the partial mediating role of pedagogical innovation suggests that providing teachers with opportunities to experiment, collaborate, and adopt creative instructional methods will strengthen their ability to embed sustainability concepts into classroom activities. Schools may therefore need to create supportive environments, such as innovation hubs, peer-learning circles, and curriculum design workshops, to translate policy intentions into meaningful classroom practice.

From an educational standpoint, the study underscores the crucial role teachers play in shaping learners' exposure to sustainability themes and global citizenship competencies. The significant relationship between pedagogical innovation and SDG integration implies that students benefit more when teachers adopt learner-centred, inquiry-based, and problem-solving strategies that bring SDG concepts to life. This finding calls for curriculum planners and teacher educators to embed more SDG-aligned content and innovative teaching strategies into pre-service training, in-service programs, and school-level curriculum reviews. It also suggests that integrating the SDGs should not be seen as an "add-on" to the curriculum but rather a process that requires redesigned instructional practices and assessment tasks that encourage critical thinking and real-world application. Furthermore, since teacher competencies significantly shape innovation in teaching,

universities and colleges of education should strengthen their pedagogical coursework to prepare teachers who are not only knowledgeable but also confident and creative in advancing sustainability education.

The study advances theoretical understanding by reinforcing the argument that teacher competencies serve as a foundational driver of instructional transformation and curriculum innovation. The confirmation of partial mediation by pedagogical innovation enriches existing models that explain how teacher-related factors influence curriculum outcomes. Specifically, the results suggest that competency frameworks alone are not sufficient; rather, competencies activate their full potential when teachers engage in innovative pedagogical practices. This aligns with contemporary educational theories such as constructivism and transformative learning, which posit that meaningful curriculum integration occurs when teachers translate their knowledge and skills into dynamic teaching approaches. By demonstrating that teacher competencies exert both direct and indirect effects on SDG curriculum integration, the study contributes a more nuanced explanation of how teacher behaviours shape the implementation of global educational agendas. This theoretical refinement may guide future researchers in developing more comprehensive models that link teacher attributes, instructional processes, and curriculum outcomes.

6. Conclusion

The study was considered four researcher hypotheses, which were H₁: "Teacher competencies significantly influence the integration of SDGs into curriculum design," H₂: "Teacher competencies have a significant influence on pedagogical innovation," H₃: "Pedagogical innovation has a significant influence on the integration of the SDGs into curriculum design," and H₄: "Pedagogical innovation mediates the nexus between teacher competencies and integration of SDGs into the curriculum." The study concluded that teacher competencies had a significant influence on the integration of SDGs into curriculum design. In addition, the study concluded that teacher competencies had a significant influence on pedagogical innovation. Furthermore, the study concluded that pedagogical innovation had a significant influence on the integration of the SDGs into curriculum design. Finally, pedagogical innovation positively and significantly mediates the nexus between teacher competencies and the integration of SDGs into the curriculum. Taken together, these results highlight a dynamic interplay in which teacher competence directly and indirectly strengthens SDG-aligned curriculum practices, while pedagogical innovation serves as a strategic mechanism that amplifies this influence.

7. Limitations of the Study

Despite the methodological rigor applied in this study, several limitations should be acknowledged to provide a balanced understanding of the findings. First, the study relied heavily on self-reported data obtained through structured questionnaires, which may have been influenced by social desirability bias, teachers' personal perceptions, or their desire to present themselves as competent in SDG integration and pedagogical innovation. Second, the use of a descriptive correlational design restricts the ability to establish causal relationships among teacher competencies, pedagogical innovation, and SDG integration; therefore, interpretations of influence should be taken as associations rather than direct causal effects. Additionally, the sample, although statistically adequate, was limited to teachers from schools already implementing SDG-related initiatives, which may have excluded institutions with weak or no exposure to sustainability education, thereby narrowing the scope and generalizability of the results. Finally, the study did not incorporate qualitative methods such as interviews or observations, which could have provided richer insights into how teachers translate their competencies into practice.

8. Suggestions for Further Studies

Future research should build on the current study by incorporating mixed-methods approaches that combine quantitative data with qualitative insights from classroom observations, interviews,

or document analysis. Further studies could also examine additional contextual factors, such as school leadership, availability of teaching resources, teacher professional development opportunities, and institutional culture, that may moderate or strengthen the link between teacher competencies and SDG integration. Longitudinal studies would be particularly valuable for tracking how teachers' competencies and innovative practices evolve, especially as national policies or global sustainability initiatives continue to shift. Expanding the scope to include schools that have not yet adopted SDG-aligned curricula would also provide comparative insights into the challenges and barriers preventing integration. Additionally, Future researchers could examine how teachers' competencies and their use of innovative pedagogical practices affect students' learning outcomes, their attitudes toward sustainability, and their levels of classroom engagement.

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