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Integrating Sustainable Development Goals into educational information systems: toward a theoretical model for sustainable school management

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ABSTRACT

This research addresses the critical challenge of implementing Sustainable Development Goal (SDG) 4, "Quality education," in Indonesian secondary schools. While national policies exist, schools lack a systematic digital tool to plan, monitor, and evaluate sustainability-based activities against concrete SDG indicators. To bridge this gap, this study employs a six-cycle design science research (DSR) methodology to develop a theoretical model for a sustainable education information system. The model is designed to integrate SDG principles into school management, enabling systematic data handling, adaptive curriculum functions, and real-time monitoring. A web-based prototype was developed using a React.js frontend and Node.js backend and evaluated through a mixed-methods approach. Data from interviews with 15 administrators and surveys of 97 teachers (yielding a usability satisfaction score of 4.34/5) validated the model's effectiveness in making educational administration more efficient, transparent, and quality-oriented. The resulting artifact serves as a foundational technical and managerial reference for schools, education offices, and policymakers to leverage information technology in fostering a sustainable, participatory learning culture aligned with the SDGs.

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1. INTRODUCTION

Education plays a central role in sustainable human development. The United Nations (UN), through the Sustainable Development Goals (SDGs), has established Goal 4 (SDG 4), which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. In Indonesia, 118 out of 164 relevant SDG targets have been integrated into the National Medium-Term Development Plan (RPJMN) 2020–2024, including targets under SDG 4; however, significant challenges remain, as reflected in the 2024 Global Education Ranking by *worldtop20.org*, which places Indonesia at 67th out of 209 countries [1]. This step reflects a strong commitment to advancing the education sector as part of the national development agenda [2]. At the secondary school level, education is not solely focused on academic aspects but is also required to shape students' character and awareness of global issues such as climate change, environmental sustainability, gender equality, and social participation. However, the implementation of SDG principles in schools still faces various challenges. Information technology facilities offer numerous options

and support for the learning process, ranging from simple to sophisticated, such as the use of computers and the internet. Many schools lack a systematic digital mechanism for planning, monitoring, and evaluating sustainability-based educational activities [3]. This results in a lack of integration between school activities and the achievement of concrete SDG indicators.

In this modern era, technology has become a key element in accelerating and expanding access to education, thereby improving the quality of the learning process. Advances in information technology have had a positive impact on the world of education. Information technology facilities offer numerous options and support for the learning process, ranging from simple to sophisticated, such as the use of computers and the internet [4]. Along with the development of information technology, educational information systems have become a potential solution for supporting effective and efficient education management. These systems can be used to document school activities, measure student engagement in sustainability programs, and even compile reports on the achievement of relevant SDG indicator [5]. Therefore, the development of educational information systems specifically designed to support SDG principles is an urgent need. Therefore, this study aims to design a model for developing a relevant and applicable sustainable education [6] information system at the secondary school level. It is hoped that this model can serve as a reference for schools, education offices, and policymakers in integrating and implementing the SDGs through an information technology-based approach.

Based on the background, the research questions are as follows:

a. What are the needs of schools to support SDGs-based sustainable education?
b. How can we integrate a relevant and applicable sustainable education information system model for secondary schools?

Given the challenges of integrating SDG-based sustainable education, particularly the lack of a sustainable education information system that can integrate SDG dimensions [7], be implemented in schools, and ultimately improve school efficiency and accountability management, the approach used is to design a conceptual model [8], build a system artifact or prototype, and evaluate its effectiveness through case studies or expert validation.

Previous research serves to analyze and enrich the research discussion, as well as differentiate it from the research to be conducted. This study includes two international journals and three national journals related to research topics. These journals include:

a. The study entitled “The influence of using smart technologies for sustainable development in higher education institutions” was conducted by Shishakly *et al.* [9]. This study discusses the important role of students as influential catalysts for advancing sustainable development in higher education. Specifically, this study investigates the extent of students' familiarity with sustainable development initiatives in higher education institutions in the United Arab Emirates (UAE). To achieve this goal, this study introduces the technology integration framework for educational sustainable development (TIFESD), which serves as an evaluative tool to assess students' awareness of technology-driven elements woven into the broader context of Education for Sustainable Development (ESD).
b. Research entitled “Teacher quality and educational technology: a tool for achieving SDGs in secondary schools” researched by Okoro *et al.* [10] discuss teacher quality and education, teacher quality for SDGs, teacher quality and educational technology, and steps to achieve SDGs. This study concludes that, with the application of educational technology, students can independently progress in mastering teaching materials, choose the pace of work, repeat unclear materials, so that after the test is carried out, they can immediately get results and track their progress.
c. Research entitled “Integration of educational technology to support SDG 4 in developing countries: a scoping review” was researched by Andriyanto and Asrori [11] discussing the urgency of technology integration in the field of education in elementary school while also identifying associated opportunities and challenges. The results of this study concluded that elementary schools can create sustainable learning environments that positively impact students and communities as a whole.
d. Research entitled “Technology plays an important role in continuing education especially in elementary schools” researched by Ully and Nugraheni [12], this research explores the role of technology in students' readiness in instilling sustainable development values in students at school.
e. Research entitled “Application of wordwall technology in learning in elementary schools to realize the fourth goal of the SDGs program” was researched by Maulida and Trimurtini [13]. This research explains that achieving educational quality can be implemented through the application of Wordwall-based technology in the learning process.

2. METHOD

2.1. Research approach and type

This research uses design science research (DSR) as the primary methodology to develop a model for a sustainable education information system in secondary schools based on the SDGs [14]. DSR was chosen because of its focus on creating innovative solutions to practical problems while simultaneously providing theoretical contributions to the field of information systems and sustainable education. Rationale for choosing DSR:

a. Solution-oriented: DSR not only analyzes problems but also designs and tests artifacts (models, systems, or frameworks) as solutions.
b. Iterative and adaptive: Enables continuous improvement through the design-development-evaluation cycle.
c. Relevant to the SDGs: Suitable for integrating sustainability principles into education systems.

2.2. Data source and type

a. Data primer

Primary data was obtained directly from research participants through:

- Interviews with the principal, teachers, and administrative staff
- Observations of the school information system usage process
- Questionnaires distributed to system users (teachers and students).

b. Data secondary

Secondary data was obtained from:

- Education and SDGs policy documents
- Internal school reports and documentation
- Literature and previous research results related to education information systems and sustainable development.

2.3. Data collection techniques

Several data collection techniques were used in this study:

- Semi-structured interviews to explore the needs and challenges of school stakeholders regarding the information system
- Participatory observation to examine the implementation of the existing information system and the potential integration of SDG principles
- Questionnaires to obtain quantitative data regarding user perceptions of the developed system
- Documentation studies to understand the policy context and existing school conditions.

2.4. Data analysis technique

a. Qualitative data

Data from interviews and observations were analyzed using thematic analysis techniques to identify patterns of needs, perceptions, and expectations regarding sustainable information systems.

b. Quantitative data

Questionnaire data were analyzed using descriptive statistics to examine user trends and perceptions of the developed model. Instrument validity and reliability tests were also conducted to ensure data accuracy.

c. Model validation

The developed model will be validated through: i) expert judgment from the fields of education and information technology and ii) limited trials to determine the extent to which the model can be implemented in practice and provide benefits.

2.5. System development

The system was developed to support adaptive and sustainable educational management by using the model–view–controller (MVC) architecture as shown in Figure 1 to ensure modularity and maintainability. PHP with the CodeIgniter 4 framework was employed for application development, while MySQL was used for managing academic, assessment, and curriculum data. An adaptive curriculum mechanism was implemented using a rule-based algorithm that analyzes student performance and learning outcomes to generate individual learning profiles. Based on mastery levels, the system dynamically recommends remedial, standard, or enrichment learning paths, enabling data-driven and personalized instructional decision-making [15].

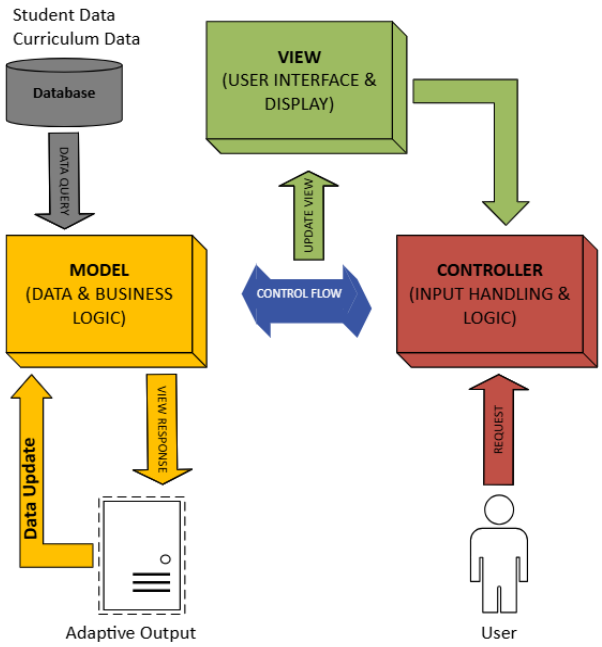

Figure 1. MVC architecture

3. MAIN RESULTS

This research resulted in a sustainable education information system model specifically designed to support secondary schools in achieving the SDGs, particularly Goal 4 (quality education), as illustrated in Figure 2. This model was developed in response to the need for a system capable of integrating various critical components in education management. Through this information system, schools can manage academic data more systematically, optimize the learning process, and provide relevant information to teachers, students, and school management. This model makes educational administration processes more efficient, transparent, and oriented towards continuously improving the quality of education.

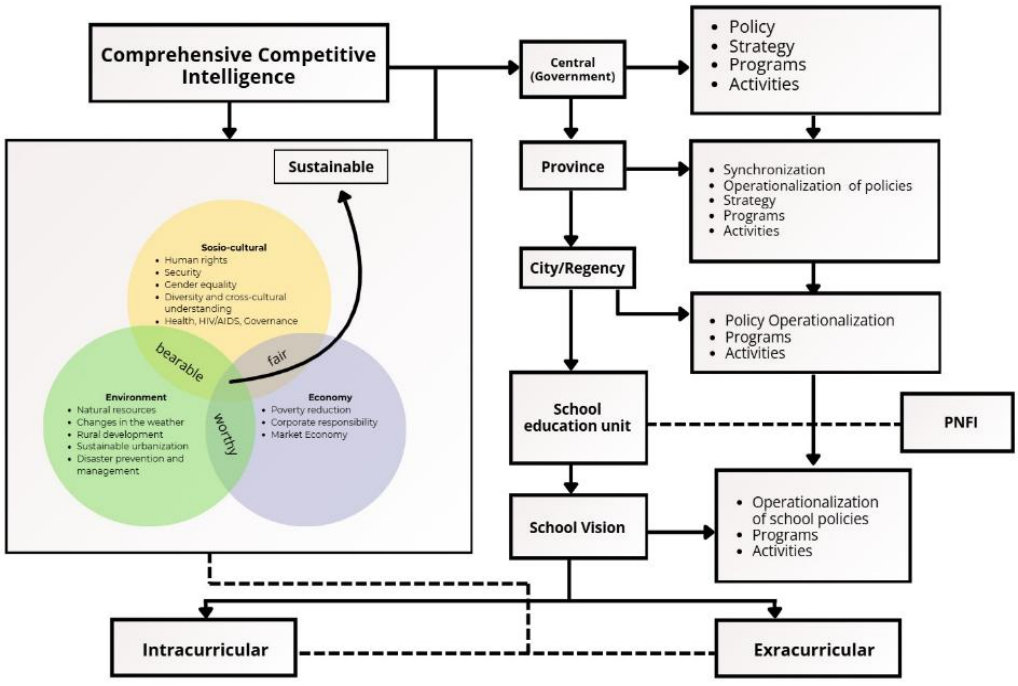

Figure 2. SDG for educational information systems

Furthermore, this system incorporates adaptive curriculum management functions, real-time monitoring of student achievement, and the active involvement of all school stakeholders through a web-based or mobile platform. This integration enables teachers to dynamically design and evaluate curricula, students to monitor their learning progress, and management and parents to obtain accurate information regarding educational achievements. By utilizing digital technology [16], this model not only functions as an administrative tool, but also as a collaborative medium that encourages the creation of a sustainable, participatory learning culture that is in line with the principles of sustainable development as proclaimed by the SDGs.

To empirically validate the developed sustainable education information system model, a perception survey was distributed to 12th-grade students (N=~100). The survey employed a Likert scale (1-5) to measure the gap between user expectations ("I expect") and their actual experience ("I feel") after using the system prototype. The results demonstrate strong positive reception and confirm the system's alignment with SDG principles, particularly SDG 4 (quality education) and SDG 12 (responsible consumption and production). From the respondent we received 97 data with several variations of class, with this data we can describe as in Figure 3.

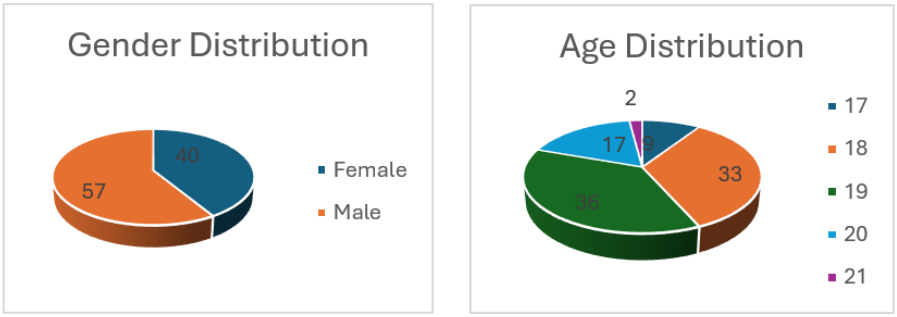

Figure 3. Respondent data from school

In Figure 4 is a feature or user interface in the SDG-based education information system with a dashboard for students' average achievement scores. These points are used to summarize the evaluation results, highlight the system's contribution to SDGs, and identify opportunities for further improvement to ensure long-term effectiveness and sustainability.

a. High overall usability and positive user experience

The system was rated highly on core usability metrics. Students reported that the system was easy to use, responsive, and accessible via web and mobile platforms. While expectations were very high (often averaging 4.5-5.0), the actual experience scores were consistently positive (generally averaging between 4.0 and 4.7), indicating that the system successfully met, and in many cases, exceeded user demands for a functional and reliable digital tool [17].

b. Strong support for SDG 4: quality education

The survey results provide direct evidence that the system contributes to achieving quality education:

- Enhanced learning management: Students confirmed that the system effectively helped them view class schedules and assignments and monitor their grades and learning outcomes. This functionality directly supports personalized learning and academic transparency.
- Increased learning motivation: A key finding was that a significant majority of students agreed that the system made them more motivated to learn. This perception is a crucial indicator that the model is not just an administrative tool but an active enabler of SDG 4's quality and engagement objectives.

c. Positive impact on SDG 12: responsible consumption

The system's role in promoting sustainability was also validated:

- Reduction of resource use: Students strongly agreed that the system encouraged more economical use of paper and other resources, as shown in Figure 5. This confirms that the digitalization of administrative and academic processes directly supports the goal of sustainable resource management within the school environment.

d. Identification of areas for refinement

The expectation-experience gap, while generally small, highlighted specific areas for iterative improvement, which aligns with the DSR methodology:

- User interface (UI) refinement: The score for the "attractive and easy-to-understand display" saw a slight

dip from expectation to experience, suggesting that visual design and layout can be further polished.

- Awareness of sustainability culture: Scores related to fostering care for the school environment and involvement in sustainability activities, while positive, were slightly lower than for core academic functions. This indicates an opportunity to enhance features that more explicitly promote and track these behavioral and participatory aspects.

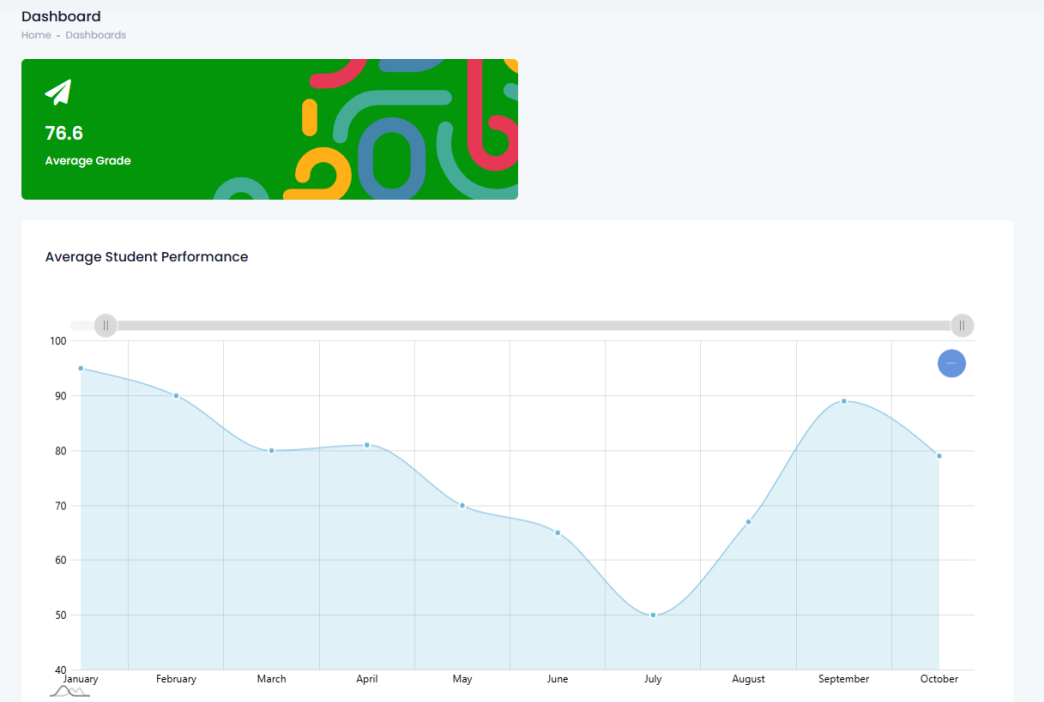

Figure 4. Average student grade

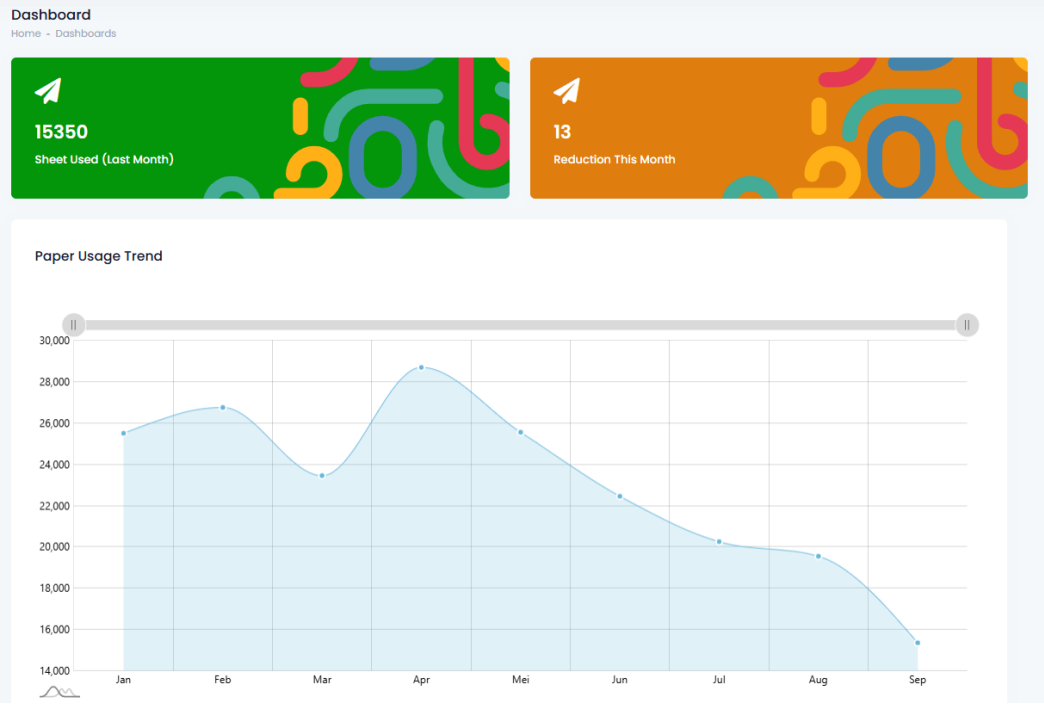

Figure 5. Reduce paper results

In Table 1, the results indicate that all dimensions show negative gaps, confirming that the system has not yet fully met user expectations, a pattern consistent with previous findings on service quality gaps in digital learning environments [18]. The three largest negative gaps were data security (-0.49), quick information updates (-0.45), and availability of help and guidance (-0.45) which represent the system's most critical shortcomings. Three indicators that show relatively small gaps are paper reduction/SDG 12 (-0.11), environmental awareness (-0.15), and monitoring of values and learning outcomes (-0.22) this indicates strong system performance.

Data security aspects indicate that users still feel concerned about the protection of personal and academic data. Recent research confirms that perceived security directly influences trust and acceptance of digital systems, particularly in educational settings [19], [20]. Gaps in the quick information updates indicate that the system is not providing information quickly and consistently. Studies in the past five years have emphasized that responsive systems that provide real-time data can improve decision-making effectiveness and user engagement [21]. In terms of user support and guidance, limited technical support indicates system usability issues. Recent literature suggests that accessible guidance, digital help centers, and responsive technical support are crucial for improving user experience and reducing cognitive load [22], [23].

Recent studies have shown that campus digitization effectively supports paper reduction and sustainable practice [24], increases environmental awareness through the use of technology [25], and supports more accurate and efficient monitoring of grades and learning outcomes [26]. This confirms that the system's performance in these areas meets user expectations.

The student perception survey serves as a robust validation tool for the proposed theoretical model. It confirms that the system is well-received, functional, and effective in meeting its primary objectives. More importantly, it provides tangible evidence that the system successfully operationalizes the principles of SDG 4 and SDG 12 from the student's perspective, fostering a more organized, motivating, and sustainable learning environment. The feedback also provides a clear roadmap for the next cycle of development, focusing on UI/UX enhancement and features that deepen student engagement with broader sustainability goals [27].

Empirical validation through a student perception survey (N=~100) further substantiates the model's effectiveness. The survey revealed strong positive reception, with students reporting that the system was user-friendly, accessible, and effectively supported their learning management (*e.g.*, tracking schedules, assignments, and grades). Crucially, students affirmed that the system increased their learning motivation (directly supporting SDG 4) and promoted the economical use of resources like paper (aligning with SDG 12). While the overall feedback was highly positive, minor gaps between expectation and experience provide valuable, actionable insights for the next iterative cycle of system refinement, particularly concerning interface design and features that foster environmental stewardship.

Table 1. Summary of expectation and perception scores

No.	Aspect	Mean		Gap scores
		Expectation	Perception	
1	Attractive and easy-to-understand interface	4.59	4.21	-0.38
2	Smooth access via web/mobile	4.67	4.35	-0.32
3	Fast system response	4.71	4.31	-0.40
4	Data security	4.75	4.26	-0.49
5	Viewing schedules and tasks	4.69	4.42	-0.27
6	Monitoring grades and learning outcomes	4.65	4.43	-0.22
7	Relevant information for student needs	4.67	4.37	-0.30
8	Quick information updates	4.72	4.27	-0.45
9	Boosts learning motivation (SDG 4)	4.55	4.29	-0.26
10	Reduces paper use (SDG 12)	4.45	4.33	-0.11
11	Increases environmental awareness	4.56	4.41	-0.15
12	Encourages involvement in school activities	4.53	4.32	-0.21
13	Ease of use for students	4.71	4.46	-0.25
14	Availability of help/guidance	4.64	4.19	-0.45
15	Comfortable use at school and home	4.72	4.42	-0.30
16	Real benefits for learning	4.65	4.34	-0.31
Average		4.64	4.34	-0.30

4. CONCLUSION

The implementation of the SDGs, particularly SDG 4 on quality education, in secondary schools requires moving from policy adoption to practical, integrated action. This research concludes that a purpose-built Sustainable Education Information System is a vital enabler for this transition. The developed model

demonstrates that by digitizing and aligning school management processes—such as curriculum design, student progress tracking, and stakeholder reporting—with SDG indicators, schools can overcome the current lack of systematic integration.

The key to successful SDG implementation lies in the system's ability to transform the school into a collaborative ecosystem. It empowers teachers to dynamically align curricula with sustainability principles, allows students to engage with and track their own learning journey, and provides management and parents with transparent data on educational outcomes. Therefore, the strategic integration of information technology is not merely an administrative upgrade but a fundamental tool for creating a sustainable learning culture. This approach ensures that the pursuit of quality education is efficient, accountable, and directly contributes to the measurable achievement of the SDGs.

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AUTHOR CONTRIBUTIONS STATEMEN

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Veri Arinal	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓	✓
Miswanto		✓	✓	✓			✓	✓		✓	✓	✓		
Kiki Setiawan		✓				✓		✓	✓	✓	✓	✓		
Agus Tanti Rahayu	✓		✓	✓			✓			✓	✓		✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

DATA AVAILABILITY

- All the data that we used for this research came from our internal survey of customers' experience using the application that we provided to the Perguruan Cikini and other schools.
- The data that support the findings of this study are available from the corresponding author, initials: VA, upon reasonable request.

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