Educating for Sustainability: The Impact of ICT on Promoting Sustainable Development Goals in Education

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Abstract. This research explores the role of Information and Communication Technology (ICT) in supporting sustainability-based education to achieve the Sustainable Development Goals (SDGs). Amid crucial issues regarding the access gap and digital literacy, especially in developing countries such as Indonesia, ICT in sustainability education faces significant challenges. This research aims to identify the effectiveness of ICT in expanding students' understanding of sustainability issues and examine the obstacles that arise in its implementation. A qualitative research method with a case study approach is applied, using in-depth interviews, observations, and document analysis from educational institutions. The subject of this study includes students, teachers, and educational institutions in Indonesia that implement ICT in the SDGs-based curriculum. The study results show that ICT has great potential to strengthen sustainability awareness through interactive learning despite infrastructure constraints in remote areas. The conclusion of this study confirms that policy support and digital capacity building are urgently needed to optimize ICT in sustainability education.

Keywords: ICT; SDGs; digital literacy; Sustainability Education

1 Introduction

Sustainability issues and efforts to achieve the Sustainable Development Goals (SDGs) have become global education's main focus, encouraging the younger generation to understand and overcome educational, social, and economic challenges. Information and Communication Technology (ICT) plays a central role in supporting sustainability-based education, as it allows for broad access to information, intercultural collaboration, and interactive learning methods. In Indonesia, the application of ICT for sustainability education still needs to be improved, including access gaps in remote areas, limited infrastructure, and low digital literacy among educators [1]. However, amid these challenges, ICTs offer significant opportunities for students to understand their role in safeguarding environmental sustainability and increase their global awareness of the impact of changes in the learning process in education. [2] The application of

ICT in Indonesia's education sector, especially in the context of sustainability, is a promising step in addressing these issues.

Previous studies have shown that ICTs positively impact the achievement of more inclusive and effective learning goals. A study by [3] shows that ICT-based learning can increase student engagement in sustainability issues. Furthermore, research by [4] found that digital platforms help students better understand climate change through interactive simulations. In Indonesia, according to [5], ICT in schools is still limited to big cities, so the access gap in rural areas needs to be addressed. A study by [6] highlights that integrating ICT with the SDGs curriculum positively impacts collaborative learning in developing countries. In addition, research by [7] confirms that limited infrastructure is a significant challenge in adopting ICT for sustainability education in Indonesia. From an international perspective, [8] it was found that ICTs can connect students from different countries in cross-cultural sustainability projects. Other results from the study [9] show that applying ICT in project-based learning improves students' understanding of resource management. Finally, research by [10] supports that digital technologies encourage active learning and build more vital sustainability awareness.

This study aims to analyze how ICT can be used as an educational tool to promote SDGs and identify the challenges and opportunities that arise in the process, especially in Indonesia. This research also aims to evaluate the effectiveness of ICT in helping students understand sustainability issues through an SDGs-based curriculum and develop an inclusive and relevant approach to integrating sustainability education with digital technology.

The results of this study show that ICT has great potential to broaden students' horizons about sustainability, mainly by providing access to interactive and collaborative learning materials. Although infrastructure challenges remain in Indonesia, this study concludes that policy support and investment in digital literacy will increase the effectiveness of ICT as a sustainability education tool. ICT also enables cross-cultural collaboration that strengthens students' understanding of global issues with relevant and applicable learning experiences in various contexts. This study is expected to guide the development of more inclusive sustainability-based education policies in Indonesia and the context of global education.

2 Method and Materials

This research focuses on two main variables: ICT (Information and Communication Technology) and sustainability-based education related to achieving Sustainable Development Goals (SDGs). The material object of this study includes students, teachers, and educational institutions in Indonesia that implement ICT in the SDGs-based curriculum. This research also compares the international education context to see how ICT is used in other countries in sustainability-related learning. This object covers various levels of education, from high school to college, focusing on applying technology to improve students' understanding of global sustainability issues.

The research design used is a qualitative method with a case study approach. The study collected data from a variety of sources, including in-depth interviews with informants consisting of educators and students, observations, and analysis of documents from curricula that integrate ICT in sustainability learning. Other sources of information that support data collection are relevant literature, including previous research on the use of ICT in SDGs education. This study also uses secondary data from educational institution reports and policies related to the implementation of ICT in education, both in Indonesia and in the global context.

The data collection stage is carried out through several techniques. First, semi-structured interviews were conducted with teachers and students to understand their perspectives on the role of ICTs in supporting sustainability education. Second, classroom observation is performed to see how technology is used practically in daily learning. Third, researchers collect relevant documents, such as teaching materials, curriculum records, and program progress reports related to the SDGs. Data collection is carried out over a specific period to ensure consistency of results and allow for in-depth analysis.

In the data analysis stage, the researcher uses thematic analysis techniques to identify the main patterns that emerge from the results of interviews, observations, and documents. The data was analyzed by comparing findings from various sources to understand the effectiveness and challenges of ICT use in SDGs education. This analysis provides insights into how ICTs can strengthen sustainability education and identify areas that need further attention, especially in Indonesia's infrastructure and digital literacy challenges.

3   Results and Discussion

Result

This article explores and analyzes how the use of Information and Communication Technology (ICT) in education can effectively support the achievement of the Sustainable Development Goals (SDGs). Here are some of the main points of the results obtained;

3. 1.Raising Awareness of Sustainable Development through ICT

ICT is critical in providing broader and easier access to information related to sustainability issues. With the internet and various digital devices, students can learn about sustainable development, climate change, renewable energy, and other environmental topics independently or through teacher guidance. Digital content such as e-books, learning videos, infographics, and online scientific articles offer more engaging and comprehensive material than conventional textbooks. Access to online learning platforms such as Coursera**,** EdX**,** and Khan Academy also enriches learning resources for students. These online courses provide modules and materials relevant to the SDGs, which can be accessed for free or at an affordable cost [11]. [12] The platform provides students with the opportunity to learn from trusted sources, enrich their knowledge, and provide a global perspective on sustainability issues. With this broad access to materials, ICT-based education can prepare students to become a generation that is more concerned and has a higher awareness of the importance of sustainable development.

Table 1. An effective Learning Platform supports the achievement of the SDGs

Learning Platform	Examples of Taught Sustainability Topics	Sample Material	Accessibility
Coursera	International and National Education Policy	Video, e-book, chaste	Free to paid
EdX	International issues in education	Videos, articles, online discussions	Free to paid
Khan Academy	ICT in areas with limited internet access.	Infographics, simulations, practice questions	Free

[13]

In addition to providing access to learning materials, ICT allows students to learn collaboratively with students from different countries. Digital platforms such as Google Classroom, Microsoft Teams, and Zoom enable students to interact in collaborative projects, exchange ideas, and share experiences about sustainability challenges faced in their respective countries. These collaborations allow students to understand how sustainability is practiced in different contexts, highlight innovative solutions from other cultures, and study global issues such as pollution, deforestation, or carbon emissions.

For example, a virtual student exchange program under the auspices of UNESCO allows students from Indonesia to collaborate with students from Japan to discuss the issue of equal distribution of education [14]. These discussions enhance students' understanding of local and global challenges and instill awareness that the actions of individuals and their communities impact the broader ecosystem. Additionally, interaction with international students helps improve foreign language and critical thinking skills, which are essential for facing future global challenges.

Table 2. Digital Collaboration Platform in supporting ICT achievement

Digital Collaboration Platform	Examples of Collaboration Activities	Main Purpose	Expected Results
Google Classroom	History of the archipelago	Understanding cross-cultural sustainability	Increasing students' knowledge of sustainability
Microsoft Teams	Discussion on renewable education issues	Exchange of ideas between international students	Innovative and inspiring energy solution ideas
Zoom	Virtual meetings with Education experts	Learn directly from trusted sources	Strengthening understanding of global environmental issues

[15]

By utilizing ICT, students not only gain knowledge from quality sources but can also engage with a global community to deepen their understanding of sustainability issues. The results of using ICT can create a generation that is more aware and ready to act for a more sustainable future.

3. 2. Integration of SDGs-Based Curriculum with ICT Assistance

Integrating the curriculum based on the Sustainable Development Goals (SDGs) with the help of Information and Communication Technology (ICT) is an innovative approach that aims to shape the educational curriculum to be more relevant and responsive to the global need for sustainability. ICT allows learning materials that emphasize sustainable development goals to be integrated into the curriculum in an interactive, dynamic, and accessible way. Through ICT, teachers can convey SDG concepts, such as quality education and sustainable innovation, using more exciting learning methods, such as videos, infographics, and digital simulations. Thus, students become more exposed to SDGs issues, which is expected to shape their understanding and concern for the importance of sustainability actions in their daily lives.

In addition to delivering materials, ICT enables project-based learning that focuses on the SDGs [15]. With the help of digital devices and online learning platforms, students can be given real projects, such as providing teaching programs in disadvantaged areas and developing digital

learning [7]. This kind of project develops students' knowledge regarding the SDGs and their critical thinking, teamwork, and technological skills [16]. In addition, ICT-supported project-based learning methods allow students to collaborate digitally in local and international environments to learn from different cultural perspectives.

Furthermore, the integration of ICT in the SDGs-based curriculum allows the development of learning modules that are easily adapted according to students' needs or level of understanding. This technology-supported module can be accessed through Learning Management Systems (LMS) or other educational applications, making it easier for teachers to design and share materials by certain SDGs [17]. Teachers can also leverage data obtained from the LMS to assess students' understanding and engagement in each SDGs topic [2]. This approach creates more personalized and directed learning, allowing students to master the concept of SDGs gradually, according to their respective abilities [18], [19].

Integrating the SDGs-based curriculum with ICT is expected to produce graduates who are not only academically competent but also have a high awareness of the importance of sustainable development. Through technology-supported SDGs-based education, students are prepared to become agents of change and face global challenges, such as education, social inequality, and the economy. This approach aligns with modern education's mission, which is not only to develop academic abilities but also to shape students' character and concern for a better and sustainable future.

3. 3. Challenges in the Use of ICT for Sustainability Education

The use of Information and Communication Technology (ICT) in education to support sustainability brings significant challenges, both at the international level and in Indonesia. At the global level, one of the main challenges is the inequality of access to technology or *the digital divide*. Many schools in developing countries and remote areas still need more fundamental infrastructure, such as fast internet and adequate digital devices. This causes students in these countries not to have equal access to technology when studying sustainability topics, which impacts their ability to understand and implement sustainability concepts.

This challenge is increasingly evident in the differences between urban and rural areas in Indonesia. [20] Schools in remote areas often need more ICT facilities and low internet connectivity, while urban schools have more resources and access to technology. Another challenge is the low level of digital literacy among teachers and students [21]. Many teachers still need to become more familiar with technology, making integrating ICT into SDGs-based learning difficult. In addition, the need for more training and support for teachers in Indonesia is a significant obstacle to using ICT to support sustainability education effectively.

From a policy perspective, implementing ICT in sustainability education in Indonesia is also hampered by regulations and funding that still need to support technology integration fully. Although the government has initiated several education digitalization programs, implementing ICT-based curricula focusing on sustainability still needs improvement [22]. In addition, uneven educational infrastructure poses challenges in effectively deploying ICT programs [23]. Budget constraints for education in some regions also reduce the ability of schools to access the technology needed, so the goal of sustainability education through ICT has yet to be fully achieved [24].

On the other hand, sustainability also poses additional challenges in using ICT, such as the environmental impact of using electronic devices and the need for electronic waste management (*e-waste*). Often, ICT devices used for education must be appropriately managed when they are obsolete, thus adding to the environmental burden. This issue is relevant globally, and in Indonesia, awareness of e-waste management in education is still low. Therefore, implementing

sustainability education through ICT must be accompanied by policies that encourage the responsible use of technology in both the economy and the environment.

Table 3. Challenges in the Use of ICT at the International and National Levels

No	Challenge	International Level	National Level
1	ICT Infrastructure Access	The digital divide in developing countries	Gaps in facilities between cities and villages
2	Digital Literacy of Teachers and Students	Low literacy in developing countries	Teachers and students are not yet familiar with the technology
3	Policy and Funding	Unsupported regulations in some countries	ICT funding is still limited
4	Environmental Impact of ICT Use	Global *e-waste* issue	Low awareness of e-waste management

Table three explains the complexity of the challenges that need to be overcome to optimize the role of ICT in sustainability education, both in terms of infrastructure, digital capabilities, policies, and environmental impacts. The application of information and communication technology (ICT) in sustainability education faces several significant multidimensional challenges. At the international and Indonesian levels, the main obstacles include unequal access to infrastructure, low digital literacy among teachers and students, limited policies and funding, and the environmental impact of using ICT devices [25], [26].

In developing countries such as Indonesia, the inequality of facilities between urban and rural areas widens the access gap, which limits the ability of schools to implement ICT-based sustainability education equitably. In addition, [27] the limitations of digital literacy hinder the optimization of learning, while budget and regulatory constraints reduce access and utilization of technology in schools [6], [28]. Therefore, collaborative efforts that include infrastructure improvements, digital training for teachers, policy and funding support, and wise e-waste management are urgently needed to maximize the role of ICTs in achieving educational goals that support sustainable development.

Discussion

This research highlights how information and communication technology (ICT) in education can accelerate achieving sustainable development goals (SDGs) in education, primarily related to increasing student awareness of sustainability issues. ICT enables more comprehensive and inclusive access to learning materials, introducing students to critical topics such as education issues, the use of digital learning, or gaps and limitations in internet access to support learning in the equitable distribution of digital education. In various educational contexts, ICTs support project-based and collaborative learning methods, which provide a deeper understanding of the application of sustainability principles. The results of this study show that the use of ICT in the SDGs education curriculum can increase student participation globally and in Indonesia by bringing them together in cross-cultural projects that focus on sustainability solutions.

The implications of this study are vast for the education system at the international and national levels. Using ICT as a sustainability learning tool on a global scale helps equalize access to knowledge for students from different economic and geographical backgrounds. In Indonesia, the implication is the need for ICT integration in the curriculum and the development of digital infrastructure to support SDGs-based learning in all regions. This study shows that

policy support for digital technology and training for educators is critical so that ICT can produce an optimal impact. [29], this highlights the importance of collaboration between the government, educational institutions, and the private sector to strengthen sustainability-oriented education in Indonesia.

The results of this study indicate that ICT functions not only as a learning tool but also as a bridge for the younger generation to understand and be actively involved in global sustainability issues. In Indonesia [30], the use of ICT in SDGs education contains an added value; given the sustainability challenges faced by this country, the proper implementation of ICT in sustainability education can form a proactive mindset in facing global challenges in a relevant and applicable way [31], [32].

This research aligns with previous studies that show that ICT plays a vital role in sustainability-based education. A European study shows that using digital applications in the SDGs curriculum increases students' understanding of climate change and renewable energy [33], even in countries with advanced digital infrastructure [34]. However, the challenge in Indonesia and other developing countries is more on access and technology gaps [35]. This study supports these findings, highlighting that ICT adoption in Indonesia is still constrained by infrastructure, so efforts towards sustainability education require a more inclusive approach. Overall, although ICT is efficacious in improving the learning of the SDGs [36], differences in infrastructure in different countries result in variations in the success of their implementation [37].

For further studies, further research should focus more on evaluating the impact of ICT in sustainability education in more detail at different levels of schools, including the factors that influence its success. In Indonesia, the development of studies can be directed at the effectiveness of digital platforms tailored to the needs of remote areas [38] and how international collaboration can increase knowledge about sustainability among students [39], [40]. Governments and educational institutions need to consider more proactive policy support, such as subsidies for technology infrastructure in remote schools. In addition, developing interactive and sustainable digital education resources is essential to address global challenges while ensuring inclusive and equitable education for all students.

4   Conclusion

This study concludes that the use of Information and Communication Technology (ICT) in education can significantly increase students' understanding and awareness of sustainable development goals (SDGs). ICT allows students to access interactive and in-depth sustainability learning materials, which teach concepts col, laboratory skills, and critical thinking related to global issues. In Indonesia and other developing countries, implementing ICT has proven beneficial, especially in overcoming limited access to information and learning resources. However, access challenges in remote areas show that achieving sustainability education goals still needs improvement.

The main strength of this research is its contribution to expanding the understanding of how ICTs can be a strategic tool in sustainability education, focusing on digital technology for cross-cultural learning. This research makes an essential contribution to the academic world by providing empirical insights that reinforce the argument that ICT can support the achievement of the SDGs through education. In particular, this research highlights the relevance of ICTs in more inclusive and sustainable education. It opens opportunities for developing more interactive curricula in various cultural contexts, including Indonesia.

However, this study has some limitations. One of the limitations is the need for more analysis of the variation in ICT implementation in areas with different infrastructures, such as the difference between urban and rural schools in Indonesia. In addition, the study has yet to address technical challenges, such as the limitations of digital skills among teachers and the lack of sustainable funding for digital infrastructure in remote schools. These limitations highlight the need for further research focusing on digital capacity building in a diverse educational environment in Indonesia and internationally. Overall, this study shows that ICT is an effective tool to support sustainability education. Still, more excellent infrastructure and digital literacy support are needed for equitable implementation at the international level, especially in countries like Indonesia. The results of this study underscore the importance of collaboration between governments, educational institutions, and stakeholders to address these challenges and strengthen the role of ICTs in sustainability-based education globally.

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