PEDAGOGIA: JURNAL ILMIAH PENDIDIKAN *Volume 16, Nomor 02, Desember 2024, Hal. 131 -139*
https://journal.unpak.ac.id/index.php/pedagogia *e-ISSN: 2460-2175*

EDUCATIONAL TOOLS FOR SUSTAINABLE GROWTH IN SCIENCE EDUCATION: LITERATURE REVIEW

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Riwayat Artikel *: diterima: 00 00000 0000; direvisi: 00 00000 0000; disetujui: 00 00000 0000*

Abstract.

The idea of learning apps for Education for Sustainable Development (ESD) has recently made major strides. However, many people are unsure of what learning applications for ESD are, why they are necessary, and how to utilize them. The literature review on ESD-based science learning applications is so wide that many researchers need more time and a longer process to locate the relevant data sources. This study aims to give a summary or literature review of the significance of ESD-based learning apps for students in schools. The researcher's summary article highlights the fundamental difficulties that must be addressed regarding ESD, the importance of ESD and its application in education, notably in science education, as well as ways for efficiently applying ESD learning applications. ESD-based learning applications constitute a novel technique in the educational field. ESD consists of three major areas: economic, social, and environmental. Integrating ESD into science education is critical to accomplishing the SDGs. Several significant factors in the implementation of ESD learning applications in science in Indonesia include the government (PATK IPA), professional bodies such as the Indonesian Science Educators Association, Science Subject Conferences, and community involvement. The method in this study is qualitative research, specifically content analysis. This study includes a literature review of several periodicals, publications, and textbooks.

Keywords: ESD based-learning application; teaching for lasting development; goals for sustainable growth

APLIKASI PENDIDIKAN UNTUK PERTUMBUHAN BERKELANJUTAN DALAM PENDIDIKAN SAINS: TINJAUAN PUSTAKA

Abstrak. Konsep aplikasi pembelajaran untuk Pembangunan Berkelanjutan (ESD) baru-baru ini telah mengalami kemajuan yang signifikan. Namun, banyak individu yang tidak jelas tentang apa itu aplikasi pembelajaran untuk ESD, mengapa hal itu penting, dan bagaimana cara penggunaannya. Literatur review yag khusus membahas tentang konsep aplikasi pembelajaran IPA yang berbasis ESD sangat luas cangkupannya sehingga membuat banyak peneliti membutuhkan waktu dan proses lebih lama untuk mencari sumber data yang diperlukan. Tujuan dari penelitian ini adalah untuk memberikan rangkuman atau literatur overview dari pentingnya konsep aplikasi pembelajaran yang berbasis ESD untuk siswa di sekolah. Artikel yang peneliti rangkum ini membahas isu-isu utama yang perlu diperhatikan terkait ESD, pentingnya ESD, dan penerapannya dalam pendidikan, khususnya dalam pendidikan sains, serta strategi untuk melaksanakan aplikasi pembelajaran ESD secara efektif. Aplikasi pembelajaran berbasis ESD mewakili pendekatan baru dalam sektor pendidikan. ESD mencakup tiga bidang utama: ekonomi, sosial, dan lingkungan. Mengintegrasikan ESD dalam pendidikan sains sangat penting untuk mencapai Tujuan Pembangunan Berkelanjutan. (SDGs). Beberapa faktor kunci dalam menerapkan aplikasi pembelajaran untuk ESD dalam sains di Indonesia termasuk pemerintah (PATK IPA), Asosiasi Profesional seperti Asosiasi Pendidik Ilmu Pengetahuan Alam Indonesia, Konferensi Mata Pelajaran Sains, dan keterlibatan masyarakat. Metode dalam penelitian ini menggunakan analisis kualitatif yaitu menganalisis konten. Pada penelitian ini mengacu pada tinjauan pustaka dari berbagai jurnal, artikel, dan buku teks.

Kata Kunci: aplikasi pembelajaran berbasis ESD; perkembangan pengajaran berkelanjutan; pertumbuhan berkelanjutan

I. INTRODUCTION

The United Nations UN World Environment and Development WECD Commission provided its first report on sustainable growth. The United Nations General Assembly decided in 1987 that sustainable growth should be a guideline for organizing human development to fulfill long-term living requirements (Henderson & Loreau, 2023). In 1992, the United Nations held an environmental and development conference in Rio de Janeiro, Brazil. The meeting determined that education must emphasize sustainable growth. A few years later, on December 2002, the United Nations General Assembly approved a resolution declaring the decade from 2005 to 2014 as the United Nations Decade of Education for Sustainable Development.

The assembly appointed UNESCO to promote the resolution worldwide and offer suggestions for including it in education policies, plans, and actions (UNESCO, 2003). The resolution on education for sustainable development aims to incorporate sustainable development into all levels, paths, and forms of education. To apply sustainability across all educational levels and fulfill various policy needs, special focus should be given to present and future training and education that will serve as agents of change (Holst, 2023; Sposab & Rieckmann, 2024). The effectiveness of including ESD in school curriculums and practices greatly relies on how

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skilled and committed teachers are to sustainability (Barth, 2014; Frisk & Larson, 2011).

The United Nations General Assembly in Rio de Janeiro approved the Sustainable Development Goals (SDGs) on December 2015, as a part of the 2030 agenda. The Global Program of Action (GAP) seeks to build on the successes of the United Nations Decade by enabling people to take part in sustainable development (UNESCO, 2014). The 2030 Agenda has 17 goals for sustainable development (SDGs). It describes the 17 Sustainable Development Goals (SDGs) as transformative, inclusive, and universal. They seek to foster prosperity, peace, justice, and a viable planet for everyone.

Education for Sustainable Development (ESD) strives to achieve the SDGs. According to Kioupi and Voulvoulis (2019), it has the potential to change society and create a more sustainable nation. Education is the most powerful tool for nurturing and applying sustainable development values. Education is essential for promoting sustainable development and enabling individuals to tackle environmental and developmental issues (Uralovich *et al*., 2023; Pudryk *et al., 2023*). ESD is an all-encompassing idea that looks at the idea of development from social, economic, and environmental angles. Developing human resources is crucial for societal longevity and economic progress (Han *et al., 2024*). Information plays a significant role in reaching these goals in the twenty-first century. This is shown by the experiences of leading economic systems that have invested heavily in education while building an effective, competitive, and sustainable national economy.

The area of human growth is seeing a change towards innovation based on theory in research and practice. People's development is shaped by their culture and relationships, which are vital in deciding their quality of life (Ravshvnovna, 2023). Today's world is about to change the technology landscape. Intelligent technologies are taking the place of traditional IT, leading to chances for more sustainable human connections. Numerous organizations have endorsed global agreements and promised to include sustainability ideas in their teaching programs and research efforts (Bartels & Parker, 2023; Bataeineh & Aga, 2023). Even with good aims and political shifts at various levels, there has been little advancement in merging education for sustainable development into a cohesive curriculum (Purnomo *et al.*, 2023; Ahmad *et al.*, 2023).

This study looks into the literature on science learning applications as a successful model for remote education aimed at sustainable development. It emphasizes advanced technology solutions and self-management methods for online learning settings. The model was created using niche construction theory, guiding frameworks for applying SDGs in education, guidelines for distance learning, and ISO standards. Consequently, many elements can be consolidated while also categorizing them into seven levels of professional development for the model's real-world use. The model's importance will lie in its suggested adaptability of use, which will ensure that the developed tools remain relevant for a long time.

Educating future generations on sustainable development (ESD) can have a substantial impact on global sustainability (Uralovich *et al*., 2023). Teachers have an essential role in educating future generations, hence the Faculty of Mathematics and Science Education at Universitas Pendidikan Indonesia answers to this demand by offering ESD courses. The implicit and explicit approaches are chosen as implementation strategies. The implicit method incorporates ESD ideas into two faculty-wide mandatory courses aimed at developing literacy in mathematics, science, technology, and engineering, scientific process skills, and engineering design capabilities. The two courses are offered in the first and second semesters, respectively. The courses' basic model is scientific processes (performing scientific inquiries), followed by engineering processes (fixing real-world problems through the development of technology). Students perform scientific research in the first stage, followed by the development of creative and new technological solutions in the second. These preservice sceince teacher are prepared for teaching in junior high shool, so that this paper aims to analyze the characteristics of science learning methods for ESD, their importance, and ways to integrate ESD into science education

II. RESEARCH METHOD

The research method used is a literature review as qualitative research (Lim, 2024). Information and data regarding ESD and SDGs were collected from literature reviews, which included journals, publications, and textbooks as much as obtained. After selection by analyze the content of ESD, then there are 17 articles which will be analyzed for this research.

The analysis utilized the information and data obtained from various sources. The present study also covers ESD's definition, importance, and application in science teaching. This study explores the characteristics of science learning methods for ESD, their importance, and ways to integrate ESD into science education. This research used BioD application made by the researcher. This application focuses on improving students' critical thinking and sustainability awareness of biodiversity topics for junior high school students. The focus is the content of the article or topic under this study, as shown in Table 1.

TABLE 1. Data Analysis Example

Parameter	Description
Definition of ESD	Aim to find out what is included in articles or books regarding ESD
The importance of learning applications for ESD	To understand why it is essential to teach learning tools for ESD
How to implement learning applications for ESD	To explore different methods for using ESD in science education applications

III. RESULTS AND DISCUSSION

In this study, the researchers have summarized and analyzed articles and scientific journals related to the use of ESD-based science learning applications. The researchers

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used the BioD learning application as an educational tool to obtain data linked to complete this article, as well as how to integrate it into science lessons, what can be done to support the implementation of effective science learning can be seen in Table 2.

TABLE 2. Data articles/journals/books in this research

No	Publication Year	Author	Title	Article/Journal/Book
1	2014	UNESCO	Roadmap for Implementing the Global Action Programme on ESD	UNESCO
2	2015	Nyasimi & Peake	Examination of Goals for the Sustainable Development Objectives: The Scientific Examination of Goals for the Sustainable Development Objectives: The Scientific Viewpoint	International Council of Science and International Social Science Council
3	2015	Eilks, I	Science Education and Education for Sustainable Development – Justifications, Models, Practices and Perspectives	Eurasia Journal of Mathematics, Science & Technology Education,
4	2015	Azeiteiro, U. M., Bacelar-Nicolau, P., Caetano, F. J., & Caeiro, S.	Education for sustainable development through e-learning in higher education: experiences from Portugal	Journal of Cleaner Production (ELSEVIER)
5	2018	UNESCO	Issues and Trends in Education for Sustainable Development	UNESCO Publishing
6	2018	Rieckmann, M.	Learning to transform the world: Key competencies in Education for Sustainable Development	Issues and trends in education for sustainable development
7	2020	UNESCO	Guide for the successful sharing of the Asia Pacific ESD teacher skill framework	Report Asia-Pacific ESD Teacher Competencies
8	2020	Zhang, T., Shaikh, Z. A., Yumashev, A. V., & Chłąd, M. (2020).	Applied model of E-learning in the framework of education for sustainable development	Journal Sustainability, MDPI
9	2023	Eliyawati, Widodo, A., Kaniawati, I., & Fujii, H.	The Development and Validation of an Instrument for Assessing Science Teacher Competency to Teach ESD.	Journal Sustainability, MDPI
10	2024	Abulibdeh, A., Zaidan, E., & Abulibdeh, R.	Finding a way through the intersection of artificial intelligence and learning for sustainable growth in the time of Industry 4.0: Problems, possibilities, and moral aspects	Journal of Cleaner Production (ELSEVIER)
11	2024	Istiqomah, N., Yunikawati, N. A., Puspasari, E. Y., Jabar, M. A., Sidi, F., & Fitrianti, W.	Preparing Practical Learning Through the Development of Education for Sustainable Development, ESD EDU Simulator	Springer Nature Switzerland
12	2024	Puspita, G. N., Widodo, A., Sriyati, S., & Samsudin, A.	The Integration ESD and Ethnoscience to Merdeka Curriculum: Study on Junior High School.	IJIS Edu: Indonesian Journal of Integrated Science Education.
13	2024	Funa, A. A., Roleda, L. S., & Prudente, M. S.	Integrated Science, Technology, Engineering, and Mathematics—Problem-Based Learning—Education for Sustainable Development (I-STEM-PBL-ESD) Framework	Springer Nature Singapore
14	2024	Impedovo, M., & Cederqvist, A. M.	Socio-(im) material-making activities in Minecraft: retracing digital literacy applied to ESD.	Research in Science & Technological Education.
15	2024	Zhang, J., Shen, X., & Liu, H.	Current Situation and Training of Chinese Elementary School Science Teachers in the Context of Education for Sustainable Development	. Science Education for Sustainable Development in Asia.
16	2023	Ahel, O., & Schirmer, M.	Education for sustainable development through research-based learning in an online environment.	International Journal of Sustainability in Higher Education (Emerald)
17	2024	Lee, S. K., & Fujii, H.	Lee, S. K., & Fujii, H. (2024). Conclusion: Toward Advancing Science Education for Sustainable Development in Asia.	Springer Nature Singapore.

Based on data from summaries of researched articles, books, or journals, the researcher will explain the skills that must be gained through training. What abilities are required to implement ESD, and how can teacher training assist

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students develop these skills (Bürgener & Barth, 2018). In Indonesia, there is a scarcity of research on the integration of ESD into science instruction in schools. Several Indonesian colleges are currently exploring this and planning to include it as a course.

A. The Importance of Education for Sustainable Development (ESD)

The condition of the planet currently is concerning. Natural disasters such as floods, landslides, and hurricanes occur frequently. Additionally, global warming leads to an increase in the earth's temperature. Consequently, everyone needs to be involved in fixing current problems, particularly those linked to education. Education is considered a practical answer to ongoing issues. The potential of education to transform the world cannot be realized until the education system promotes sustainable development. We are expected to achieve the Sustainable Development Goals (SDGs) through education. Table 3 illustrates the connection between education and the 17 SDGs.

TABLE 3. The Correlation between Education and SDGs

SDGs	The Correlation with Education
Goal 1 (No Poverty)	Education is very important to lift people out of poverty.
Goal 2 (Zero Hunger)	Education plays a key role in helping people move towards more sustainable farming methods and in understanding nutrition.
Goal 3 (Good health and well-being)	Education can make an important difference in a wide range of health issues, including premature death, reproductive health, disease spread, healthy lifestyles, and well-being.
Goal 4 (Education)	Education in this goal is a core of this discussion. The education for all and education for sustainability could be inserted in curricula.
Goal 5 (Gender Equality)	Education for women and girls is highly important to achieve basic literacy, improve participatory skills and abilities, and increase life opportunities
Goal 6 (Clean water and Sanitation)	Education and training improve skills and capacity to use natural
Goal 7 (Affordable and Clean Water)	Education programs, particularly non-formal and informal, can promote better energy conservation and absorption of renewable energy sources.
Goal 8 (Decent Work and Economic Growth)	There is a direct correlation among areas such as economic vitality, entrepreneurship, job market skills, and education level.
Goal 9 (Industry, Innovation, Infrastructure)	Education is necessary to develop the skills needed to build more resilient infrastructure and more sustainable industrialization.
Goal 10 (Rduced Inequalities)	Where it is equally accessible, education makes a difference proof to social and economic inequalities.
Goal 11 (Sustainable Cities and Communities)	Education can give people the skills to participate in shaping and sustaining more sustainable cities, and to achieve resilience in disaster situations.
Goal 12 (Responsible, Consumptions, and Production)	Education can make an important difference to production patterns (for example with regard to circular economies) and consumer understanding of goods produced more sustainably and waste prevention.
Goal 13 (Climate Action)	Education is the key to mass understanding of climate change impacts, adaptation and mitigation, particularly at the local level.
Goal 14 (Life Below Water)	Education is important in developing awareness about the marine environment and building proactive consensus on its wise and sustainable use.
Goal 15 (Life on Land)	Education and training enhance skills and capacities to support sustainable livelihoods and to conserve natural resources and biodiversity, especially in threatened environments.
Goal 16 (Peace, Justice, and Strong Institutions)	Social learning is essential to facilitate and ensure a participatory, inclusive and equitable society, and social coherence.
Goals 17 (Partnerships for the Goals)	Lifelong learning builds the capacity to understand and promote sustainable development policies and practices.

B. Education for Sustainable Development Skills

As the 20th century draws to a close, it is important for everyone to strive to build a sustainable community. A sustainable community needs each person to learn how to comprehend the complicated world they inhabit, as well as how to handle unpredictability, risk, and the swift pace of social (global) changes. They should also be able to work together, communicate, and respond positively to global shifts (Wals, 2016). Achieving this requires skill. The competency approach emphasizes discovering effective practical methods and applying suitable education. There are eight main ESD skills which are systems thinking, anticipatory thinking, normative thinking, strategic thinking, collaboration, critical thinking, self-awareness, and integrated problem-solving. These abilities are essential for ongoing success. Each ability has its own characteristics and significance. These competencies rely on one another. This is why integrated problem-solving abilities are so crucial. Additionally, fundamental skills like communication are vital for lasting development success. These essential sustainability skills must be developed together with basic skills (Wiek et al., 2011). Taimur and Sattar (2020) note three aspects of essential ESD skills: cognitive (knowledge and reasoning skills), socio-emotional (social skills), and behavioral (action skills). The following table organizes the eight ESD skills into three categories.

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TABLE 4. ESD Competencies in Three Domains

	Cognitive Domain	Socio-Emotional Domain	Behavioral Domain
ESD Key Competencies	Systematic Thinking Anticipate Normative Critical Thinking	Collaboration Self-awarness	Strategic Integrated problem solving

Growing skills in thinking, social-emotional understanding, and behaviour in that sequence is the best approach. The thinking area forms the basic support for the other two areas. Information, reasoning abilities, and social abilities act as the base for feelings and behaviors.

C. Learning Application for ESD

While ESD research exists in technology education, it is not a commonly researched issue. This is connected to the reasons why many countries' curricula include technology education. By the end of the 1980s, education, combined with market reforms, had taken a prominent role in educational policy. Education was considered as a means of responding to technological change and increasing economic competitiveness (Legi & Giban, 2023; Al-Emran & Griffy-Brown, 2023). The strong relationship between education and the economy sparked disputes over technology education in numerous reports conducted by educational authorities around the world. The idea was that technology education should be relevant to the nation's economic demands and prepare students for jobs and society. Technology education was viewed as a means of building information, skills, attitudes, and values that would enable students to optimize their flexibility and adaptation to their future employment, as well as other parts of life (Pavlova, 2023). This economic compulsion connected with the concept of 'development' was mirrored in teachers' perceptions of values in technology education. According to research on the values of UK teachers, practical technology teachers prioritize technical, artistic, and economic values over environmental, social, cultural, moral, and political values.

Some teachers did not consider some values relevant to technology education, resulting in a focus on technical values. However, Gao (2022) found that the historical development of goals that govern program development in the United States has shifted from solely technical to social elements of technology. The results 93.3% of research participants (leaders in the technology education field in the United States) prioritized the goal of understanding the social, ethical, and environmental effects of technology use. Although this aim mainly addresses the cognitive aspect of TE learning, it represents substantial changes in the technology education profession's perspective. The historical growth of ESD concepts is represented in ESD research in technology education. Researchers (Mokski *et al*., 2023; Wang *et al*., 2023; Almuhur, 2023) have emphasized the importance of technology education in tackling ESD. Studies of technology education discourse (Pavlova 2023) show that when the concept of sustainability is discussed in technology education, it is primarily focused on the ecological design of products (eco-design), with a strong emphasis on limiting those products' environmental impacts (Lin *et al.,* 2023), or on environmental sustainability (Al-Sharafi *et al.*, 2023). The approach to sustainability in technology education has primarily focused on environmental factors.

One of the specific ethical domains in which feasible to practice ethics is that of sustainability. Sustainability is a value concerned with dealing with the natural environment and resources in such a way that future generations are not denied the chances that we have. Sustainability involves the intentional and responsible use of materials and energy. Sustainability can be done in classrooms without artificiality since schools should prioritize saving materials and energy. (Howell, 2021).

This highlighted the importance of promoting environmental principles through technology education. Although this is a significant step, it offers a restricted perspective of ESD. Teachers' tools for measuring environmental effects (such as life cycle analysis) are rarely utilized to investigate the underlying causes of environmental problems, which, as shown here, are frequently social in origin. Even when social issues are discussed in the context of technology education, they are frequently interpreted narrowly. Mokski *et al*., (2023), for example, emphasizes justice and equity in his research on the social aspects of sustainability. This study does not address issues of cultural diversity or intercultural understanding.

A similar situation emerges when the economic implications of ESD are considered. One-sided studies frequently focus on negative economic concerns and only consider wealthy countries. These often include the consequences of short-term economic thinking, the widening income disparity, spending and consumerism, unintended revenge costs of technology, and 'perverse' economic subsidies (Mokski *et al*., 2023). Economic concerns such as poverty reduction, corporate responsibility, pricing mechanisms, and alternative economic models are not considered. A recent study by Ferguson (2021) in the UK found that teachers' perceptions of sustainability have shifted, including social factors. More than half of the teachers in the survey expressed an interest in and commitment to sustainable design before receiving in-service training on the subject. According to the study, "nine out of twenty instructors in the sample indicated notable changes in their understanding of, and confidence in, incorporating the social dimension of SD in their D&T instruction"(Ferguson, 2021). Wu *et al*., (2021) advocates for "advancing a culture of socially just ecotechnological innovation" through technology education.

Despite increasing academic involvement and emphasis on social dimensions, ESD research remains fragmented and limited in scope. The findings of these studies do not provide a clear answer to the question of how

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technology education teaching and learning can be contextualized so that it contributes to improving human life quality within the earth's carrying capacity while also preserving the earth's vitality and diversity.

D. Teacher's ESD Skill Framework in Asia-Pacific

The ESD skill framework for educators in Asia-Pacific, which covers Indonesia, includes three areas. The three sections are: supporting learning; linking, working together, and participating; and ongoing learning and crafting. Figure 1 shows a summary of the ESD skill frameworks for teachers in the Asia-Pacific region.

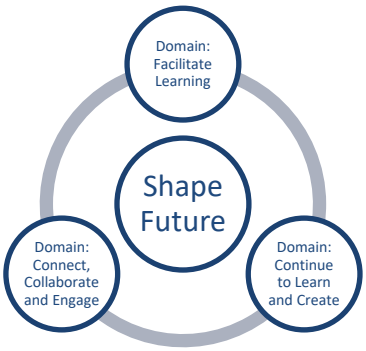

Figure 1. Teacher's ESD Competency Framework in Asia Pacific (UNESCO, 2020)

Helping students learn means providing and creating opportunities for them to develop skills in sustainability. This section includes four parts: teaching methods, tools, subject matter, and cultural understanding. Teaching methods relate to instructing students about ESD, tools refer to the materials used for teaching, subject matter pertains to the learning goals, addressing sustainability challenges, and engaging students in real-life situations. The area of continue to learn and create relates to the professional's skill in regularly reflecting, innovating, and adapting their understanding in ESD practice. This area has three parts: reflecting on what is learned in ESD through thoughtful self-evaluation, recognizing socio-cultural aspects in connecting ESD, the ability to spot and create plans for ongoing enhancement of ESD integration, and the capacity to track and assess progress in ESD integration for long-term education. Creative abilities involve fostering sustainable thinking through professional growth, encouraging cross-disciplinary and sector-wide participation, maximizing ESD efforts with precise plans and strategies, and coming up with inventive solutions to reach sustainability goals. Change means encouraging ESD, adopting a sustainable way of living, and nurturing a mindset geared towards lifelong learning. These three components form a continuous loop, indicating that the process needs to be perpetual and should not be interrupted at any stage. The Connecting, Collaborating, and Engaging Domain focuses on fostering partnerships and teamwork with others to enhance ESD policies and practices both within and outside the community, involving local and national governments. In this clear area, all stakeholders, starting with individuals, educational institutions, and communities, are expected to connect and work together.

E. ESD Implementation in Science Instructions

ESD can be applied through several models and educational methods. Introducing ESD in teaching can be achieved via project-based techniques, like the SLIM project, which involves thinking about three main parts: stakeholders, grasping various contexts, legacy conditions, and ways for collective learning and action. ESD is included in the curriculum by providing training on the SDGs with the Educational Robotics (ER) program. This study indicated that training students to focus on sustainability within school subjects and create ER projects based on SDGs can motivate teacher training colleges to add them to their programs (Schina *et al.*, 2020). ESD methods in education have been practiced in Indonesia for many years. As illustrated in figure 2.

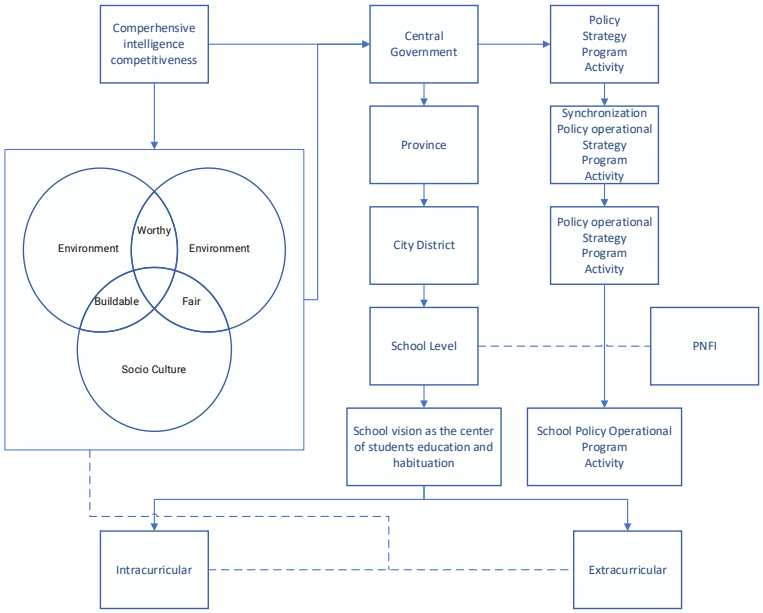

Figure 2. National Strategy Model for ESD Implementation

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Good teaching in science depends on choosing the right method to meet learning goals. The strategy should be planned according to the learning results we want to achieve. In essence, the way science is taught should ethically encourage students to tackle real-life issues, both alone and in teams, with a sense of responsibility and dedication to improving environmental conditions (Permanasari, 2016; Nurramadhani *et al.*, 2024b). Employing ESD in science classes can help students solve problems in their environment, create solutions, and communicate them well. Thus, ESD serves as an excellent resource for science education. ESD can enhance student performance. Research indicates that applying ESD can lead to better academic and personal progress for students (Ningsih & Juandi, 2019; Bürgener & Barth, 2018; Schina *et al.*, 2020). Therefore, ESD-focused science teaching can enhance students' understanding and assist them in overcoming challenges in their environment. Two approaches can facilitate the integration of ESD in science teaching: problem-based learning (PBL) and project-based learning (PjBL). PBL enables students to use their knowledge of sustainability issues like environmental harm, climate change, and more as a way to solve problems. In this sense, applying the PBL approach can motivate students to gain the knowledge necessary to address the issue. This knowledge can take various forms, including information and data, which they will use to tackle issues thoughtfully, methodically, and logically. ESD-oriented science teaching through the PjBL model can equip students with problem-solving abilities. The PjBL model focuses on outcomes in solving issues. Implementing the PjBL approach can lead to tangible ideas or inventions that help improve life quality, economy, social aspects, and environment (Nurramadhani *et al.*, 2024a; Permanasari *et al.*, 2021).

IV. CONCLUSION

Numerous specialists and organizations have introduced a notion of ESD, which is basically education that equips communities (including learners) to participate in solving sustainability issues. ESD needs to be included in the school curriculum. Communities are vital in addressing various economic, social, and environmental problems. ESD is a means for 17 SDGs. ESD can be incorporated into science education through a project-based approach. Learning tools that support ESD are one of the elements that can continue to be improved in the educational setting. The fundamental application of ESD-based science education can now act as the basis for more advanced research. The study still has several shortcomings, such as insufficient reference sources from varied indexed journals, suggesting that future researchers will likely carry out more detailed studies on ESD.

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