



Implementation of ESD (Education for Sustainable Development) in Climate Change Learning: A Literature Review

Susanti Indah Perwitasari^{1*}, Eko Hariyono², Endang Susantini³
^{1,2,3} State University of Surabaya, Surabaya, Indonesia



DOI: <https://doi.org/10.46245/ijorer.v4i4.317>

Sections Info

Article history:

Submitted: January 25, 2023

Final Revised: March 4, 2023

Accepted: March 6, 2023

Published: July 7, 2023

Keywords:

Climate Change;

Education;

ESD;

Learning;

Sustainable Development.



ABSTRACT

Objective: Education for Sustainable Development (ESD) is an educational agenda that focuses on the quality of learning outcomes and the emphasis on learning content and its contribution to future environmental sustainability, one of which is tackling climate change. Education for Sustainable Development (ESD) can be integrated into curriculum and learning. This study aims to describe and conduct a literature review of the implementation of ESD in climate change learning. **Methods:** This research is a literature study by screening 370 Scopus-indexed papers in the 2017-2022 time frame into 20 papers for analysis. The analysis results show that journal publications on implementing ESD in climate change learning still need to be made available despite increased research trends. The implementation that has been carried out can be through formal / school and non-formal education with learning innovations and developing curricula and policies. There is a tendency for developing learning innovations is the most widely practiced form of implementation in climate change learning. Implementing ESD in climate change learning is vital in improving the understanding, skills, and awareness of climate change. **Novelty:** The study reveals an urgent need to develop the right innovations, methods, and designs to implement ESD in climate change learning, especially government policies. These findings invite researchers, practitioners, governments, and communities to be involved in developing innovations, methods, designs, and policies within a sustainable framework by implementing ESD in climate change learning.

INTRODUCTION

The decade's first year was disconcerting in human history. The "new normal" period after the COVID-19 pandemic, followed by the disruption of the war in Ukraine, has caused a food and energy crisis. It also impacts environmental risks, such as failure to mitigate and adapt to climate change (McLennan & Zurich, 2023). Based on NOAA (National Oceanic and Atmospheric Administration) analysis, the January 2023 global surface temperature is 1.57°F (0.87°C) above the 20th-century average of 53.6°F (12.0°C). It is ranked the seventh warmest in 174 years and January 47th in a row, and the 527th consecutive month with above-average temperatures in the 20th century (NOAA, 2023).

Climate change is an urgent global crisis dramatically changing Earth's life. Climate change results in significant environmental damage, and if no reduction in emissions will destroy the livelihoods of future generations (Powell, 2019). Natural processes cause climate change, but anthropogenic activity has accelerated, seriously threatening global biodiversity and the sustainability of natural resources for future generations (Mahmoud & Gan, 2018; Naeem et al., 2020). Sustainability itself is defined as meeting current needs without compromising the ability of future generations to meet their own needs (United Nations, 2022; Moretti et al., 2023). ESD (Education for Sustainable Development) is the key to solving the problem of unsustainability, one of which is climate change. Society and government are well aware that dependence on economic

growth today is not a sustainable approach. Therefore, integrating sustainable development curricula into educational curricula is necessary (Buckler & Creech, 2014; Lopez-Perez et al., 2017; Nousheen et al., 2019).

Climate change education can be one of the means to provide strategic narratives and tools for mitigating climate change and social norm behavior. Climate Change Education is part of ESD (Molthan-Hill et al., 2019; Tang, 2022). Recent research suggests that climate change education is discussed in ESD (Leal-Filho et al., 2016; Brunstein & King, 2018; Crookes et al., 2018). Tackling climate change has become a critical ESD agenda aimed at using education as a conduit to advance sustainable development. ESD aims to develop competencies, empowering individuals to reflect on their actions, given their current and future social, cultural, economic, and environmental impacts from local and global perspectives (Tejedor et al., 2019; Guillen et al., 2022). In some studies, ESD has improved knowledge and overcome learners' preconceptions, thus positively influencing their beliefs (Tang, 2022). ESD also produced attitudinal changes in learners (Nousheen et al., 2020). This is the same as climate change learning.

Education is essential to promote climate action, help people understand and address the impacts of the climate crisis, and empower them with the knowledge, skills, values, and attitudes necessary to act as agents of change (UNESCO, 2023). This study aims to describe and conduct a study of the implementation of ESD in climate change learning through literature studies (Zuk, 2023). This research is expected to provide an overview of the opportunities and constraints in applying ESD, especially to overcome climate change, so that it can help researchers, practitioners, governments, and the community develop the right ESD design.

RESEARCH METHOD

This literature study aims to describe and analyze the application of ESD in climate change learning. Literature studies are conducted as a basis for knowledge development, create guidelines for policy and practice, provide evidence of impact, and have the capacity to give birth to new ideas and directions (Hallinger & Kovačević, 2019; Snyder, 2019). Literature studies play an essential role in gathering available literature and providing descriptive analyses such as journal publications, their trends, and the potential to create insights into implementation, barriers, future directions, and the development of existing knowledge bases on the topic (Saphira, 2022; Saphira et al., 2023). This literature review evaluates the literature on the implementation of ESD in climate change learning to provide a richer analysis of the literature so that it can serve as an introduction and foundation for future research (Williams, 2018).

The literature study reviewed articles/journals on applying ESD in climate change learning indexed by Scopus. The articles/journals were published within the last five years, between 2017 and 2022. The framework for the literature study procedure for applying ESD in climate change learning adapted from Petyko et al. (2021) includes identification, screening of titles and abstracts, a full review of literature, data extraction, analyzing, and making conclusions likely in Figure 1.

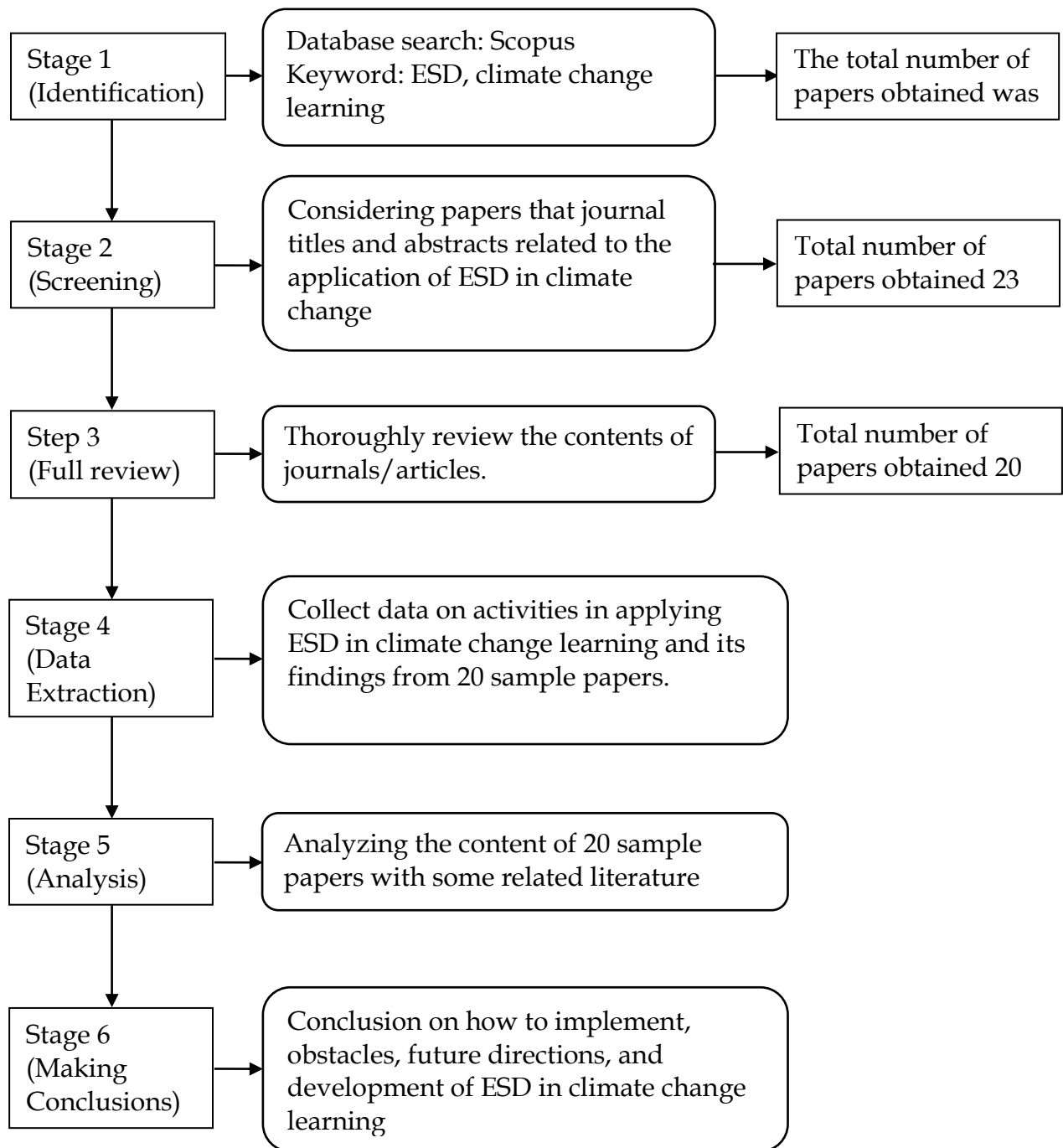


Figure 1. Research flowchart of the application of ESD in climate change learning (Petyko et al., 2021).

RESULTS AND DISCUSSION

Results

Search results show a scarcity of published academic research related to the implementation of ESD in climate change learning. The gaps in the literature signal a need for more attention and knowledge from researchers and practitioners about implementing ESD in climate change learning (Chiba et al., 2021; Lindgren et al., 2021; McKenzie, 2021). Based on the results of identifying journals or articles indexed by Scopus, 370 titles and abstracts of journals/articles were obtained. Of the 370 papers, only 20 journals/articles are the most relevant and related to the application of ESD in climate change learning. These 20 journals/articles are then extracted and analyzed in Table 1.

Table 1. The results of the article analysis of the application of ESD in climate change learning in the range of 2017 – 2022.

Author's Name and Year	Application of ESD in climate change learning	Findings
Emblen-Perry (2022)	Enhance case-based learning in continuing education by using case media and facilitate multidimensional analysis through continuous completion in an active learning environment	<ul style="list-style-type: none"> - Students engage and develop the skills, knowledge, and values necessary for job readiness and become agents of sustainable change - Case-based learning can develop learner self-efficacy, academic confidence, and motivation to participate in learning, which in turn stimulates knowledge, abilities, cognitive skills, and reasoning - Learning can engage students in the increasingly complex, transdisciplinary, and multidimensional concepts of sustainability that will be faced in their future careers
Senevirathne et al. (2022)	Delivering climate change education through Massive Open Online Courses (MOOCs) in higher education	<ul style="list-style-type: none"> - New curricula on climate change and course modules Developed - In the development and implementation of the MOOC curriculum, cross-institutional resources, as well as relevant literature theories, are used.
Brumann et al. (2022)	Conducting learning with an Inquiry-Based Learning approach that is close to science	<ul style="list-style-type: none"> - Assessments must be authentic, students' skills to engage with climate change must be scaffolded, and teaching climate change must be meaningfully enriched by appropriate technology. - Science teachers in schools are an essential factor influencing the success of the learning process and the context of climate change
Gutierrez et al. (2022)	Create an extracurricular STEM club focused on climate change	Students' climate change literacy is increasing
Nieto et al. (2022)	Conducting scenario and reality-based learning for three years	Environmental awareness and attitudes toward climate change and sustainability among nursing students are increasing. Students are well aware of unsustainable practices in the work environment. Most students feel that scenarios help them connect climate change, resources, and health.
Toffaletti et al. (2022)	Learning sequences (TLS) on the greenhouse effect, relying on the educational	<ul style="list-style-type: none"> - Design can support the learning of the greenhouse effect, leading to the formulation of design principles that help foster students' understanding - Students can achieve effective performance in the greenhouse effect

Author's Name and Year	Application of ESD in climate change learning	Findings
Nelson et al. (2022)	Conduct climate education with community-level climate stewardship courses in 6 categories of educational/interpretation services, conservation/restoration, science participation, community resilience and adaptation, environmental and climate justice, and program support to advance community and ecosystem resilience (the ability of a system/community to survive disruption and to anticipate, adapt, and thrive in the face of change).	There is a link between climate change education and individual carbon emission reduction, improving pro-environment behavior.
Tolppanen et al. (2022)	Implement holistic climate change education courses that all students in higher education can take	<ul style="list-style-type: none"> - Some students' understanding and perceptions are changing about climate change - Students are finding new, environmentally friendly ways to cope with their hedonistic pleasures, also potentially having long-term positive effects
Aydogan et al. (2021)	Using the "Climapp" mobile app to promote climate change communication	Mobile apps raise awareness and valuable learning about climate change
Howell (2021)	<ul style="list-style-type: none"> - Conducting effective Education for ESD with pedagogy engages learners in transformative learning that includes reflective and active learning, engaging experiential, collaborative, and learner-centered - Using flipped classroom design and innovative assessment 	<ul style="list-style-type: none"> - Students' perceptions are very positive towards ESD courses and illustrate some of the benefits of flipped classroom design - Active learning exercises in the classroom make classes more engaging and material more accessible to remember than usual, offering valuable opportunities to practice information/learning - Pre-class preparation using quiz-like assessments helps students understand/remember the content and gives them the confidence to contribute in class.
Trott (2021)	Children's program-based experiences by enacting policies to instill transformative climate	<ul style="list-style-type: none"> - Clarify the importance of attitudes and affective in Climate Change Education (CCE) that can be measured in any classroom or context, the psychological

Author's Name and Year	Application of ESD in climate change learning	Findings
	change education (CCE) in schools	and emotional reality of children when playing in the learning process.
Author's Name and Year	Application of ESD in climate change learning	Findings
	-	<ul style="list-style-type: none"> - Children's views on climate change are only sometimes 'doom and gloom,' especially when knowledge is paired with critical reflection, dialogue, and action opportunities. - Gain a broader awareness of climate change and its impacts and more respect for nature and its place in it, and take responsibility for it.
Schrot et al. (2021)	<ul style="list-style-type: none"> - Conducting climate change education with constructivist inquiry-based learning - Conducting research oriented on climate change adaptation projects 	Most of the treatment group's students were able to demonstrate sophisticated knowledge about adaptation to climate-related risks, develop competencies and think critically ahead
Pfirman et al. (2020)	Integrating educational card games into climate education communications and Strategies	<ul style="list-style-type: none"> - Games are just as effective as articles in teaching content about the short-term impacts of climate change and are more effective than articles in long-term retention of new information so that knowledge on topics such as climate change, the food chain, and the Arctic increases. - Students have higher levels of engagement and perception, increasing empathy, personal agency, and conversational spirit about climate change, and know how to help protect Arctic ecosystems.
Zowada et al. (2019)	Phosphate sustainability (ESD) topics implemented into general chemistry courses	This study shows that more sustainability topics should be identified and integrated into chemistry learning to reflect their relevance and relevance of chemistry for the future. Curriculum with related assessments should change to include those topics and encourage students in transdisciplinary and socio-scientific discussions of sustainability topics.
Siegner (2018)	Develop a climate change curriculum by using a school garden as a climate change the educational context or bring a "think globally, act locally" paradigms into the	<ul style="list-style-type: none"> - Climate education can be implemented and evaluated in a more integrated participatory research process - Lessons learned during curriculum trials are more quickly identified, corrected, and scaled through the help of academic

Author's Name and Year	Application of ESD in climate change learning	Findings
	classroom, such as a learning experience that combines elements of action and reflection	program evaluators
Author's Name and Year	Application of ESD in climate change learning	Findings
Schauss & Sandra (2019)	Creating school projects that introduce students to scientific works and, more specifically, to scientific works of climate research	Future career aspirations in the field of climate research are increasing. In addition, the school project reveals positive changes in the understanding of science and shows that the understanding of Natural Sciences can be improved.
Becker (2018)	Political and educational policies are closely linked to climate-relevant local or regional education activities.	Climate Change ESD is still in its infancy for various reasons and has current limitations. Climate science or sustainability science needs to take perspectives from all disciplines in the future.
Coleman et al. (2017)	Combining different disciplines using climate change-focused KKN projects as a tool to teach the concept of sustainability (ESD)	<ul style="list-style-type: none"> - Students gain a better understanding of climate change - Increase a sense of personal and institutional responsibility to tackle climate change - Develop students' skills according to their disciplines
Swim et al. (2017)	Exploring the culture of climate change education in science museums and collective action with coordinated work to assess these educational efforts	Nature-based museums are engaged in efforts consistent with the goals of the AZA (Association of Zoos and Aquariums) to include climate change in their conservation-related educational programs.
Carreira et al. (2017)	Learning with Celsius games for ESD in general and climate change in particular	Games can build students' new perspectives, possible actions, and, most importantly, the choice of new areas for complex issues such as climate change.

Based on data obtained from 20 paper samples, it shows that there is an increase in research trends related to the implementation of ESD in climate change learning in 2017-2022. The number of such studies per year can be seen in Table 2.

Table 2. Number of Studies 2017-2022.

Year	Number of Publications	Percentage
2017	3	15%
2018	2	10%
2019	2	10%
2020	1	5%
2021	4	20%
2022	8	40%
Total	20	100%

The research trends above show that the implementation of ESD in climate change learning is an emerging area of research. There has been a significant increase in recent years. The increase in research trends is due to increased emissions that threaten the global environment. Therefore, a deep and thorough understanding of research trends in ESD implementation in climate change learning can provide a basis for mitigating the negative impacts of climate change on society (Mehmood et al., 2023).

Discussion

Application of ESD in Climate Change Learning

ESD is a unique educational concept and requires new methods for integrative learning. ESD promotes the integration of sustainable development and the SDGs into education and learning and ensures the integration of education and learning into all activities that promote sustainable development (Agbedahin, 2019; Didham & Ofei-Manu, 2020; Ferguson et al., 2021; Hogan & O'Flaherty, 2022) and the SDGs to address global challenges such as climate change, inequality, sustainable communities, and environmental preservation (Rieckmann et al., 2017). School is one means of changing or reproducing attitudes toward climate protection.

Based on the 20 articles analyzed, ESD can be integrated into various elements; 85% of articles apply ESD in formal education/schools, both elementary, middle, high school, and tertiary (articles 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20). In contrast, 15% of articles apply ESD in non-formal education (articles 7, 17, 19). In the process of implementing ESD in schools, it can be done by learning innovation and curriculum development. Meanwhile, ESD is implemented in non-formal education through community development courses, government policies (political and government), and cultural exploration for conservation efforts, likely in Figure 2.

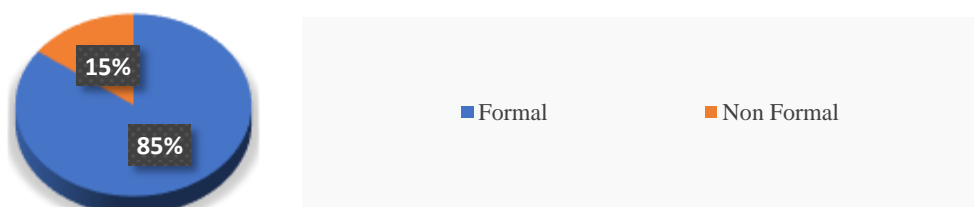


Figure 2. Integration of ESD in climate change learning

ESD has become an important topic—humans' various current environmental challenges (Bie, 2023). ESD is essential to achieving the SDGs, including the goal of taking immediate action to combat climate change and its impacts (Wiratama et al., 2021). The application of ESD in climate change learning contributes to individual success and the collective survival and prosperity of global societies (UNESCO, 2020). The ESD perspective involved is more holistic, in an inclusive approach, all areas, activities, values, stakeholders, structures, etc., of educational institutions and consider input and knowledge from different fields of study to be followed if challenges coming from social responsibility and sustainability are intended to be addressed (Hoover & Harder, 2015; Singer-Brodowski et al., 2019; Veiga-Avila et al., 2017). Climate change education is essential at all levels, from primary school to university. According to Filho

et al. (2023), colleges have great potential to educate students on climate change issues and actively involve them in climate affairs, both as citizens and influencers of future professions. Students believe that climate change education is a means to shape their attitudes and equip them with relevant skills and knowledge to influence others.

The 20 articles analyzed showed that the application of ESD in climate change learning as much as 50% (articles 1, 3, 5, 6, 9, 10, 12, 13, 14, 20) was carried out with learning innovations (case-based learning, inquiry based-learning, scenario based-learning, project-based learning, sequences, flipped classrooms, mobile applications, games); 35% (articles 2, 4, 7, 8, 15, 16, 18) by developing curricula (courses, STEM extracurricular clubs, Community Service Program projects, school gardens) and 15% (articles 11, 17, 19) by developing policies (transformative, political, cultural) in integrating ESD likely in Figure 3.

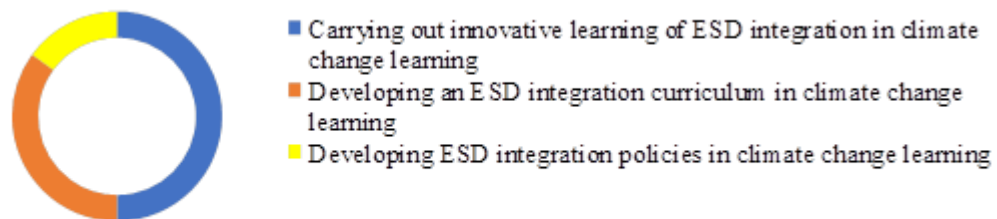


Figure 3. Application of ESD in climate change learning.

Climate change mitigation and adaptation are two strategies countries must implement to anticipate, prevent, and minimize climate change. Mitigation strategies are actions that reduce greenhouse gas emissions and increase carbon sinks, such as improving pro-environmental adaptation behaviors and increasing forest areas as carbon sinks (Van & Steg, 2019; Hussain et al., 2021). Meanwhile, adaptation strategies are actions to reduce the vulnerability to the consequences of climate change, such as adaptation of national policies, instruments, and institutional arrangements to reduce greenhouse gas emissions. The global education policy for ESD identifies issues critical to curriculum theory. The conception of ESD is suggested to be included in curriculum theory to critically explore the curriculum processes involved (Kvamme, 2023). Developing the entire school approach to climate change in education policies and curricula can enable education systems to respond more fully to the climate crisis (McKenzie, 2023).

Educational institutions as transformative organizations can decisively contribute to the development of a more resilient, sustainable, and just world by shaping the consciousness of ethical, responsible, and sustainable future generations, creating public awareness of the consequences and impacts of unsustainable actions, and addressing the current sustainability challenges facing society (Pizzutilo & Venezia, 2021). The outcome of the program will ultimately be that the population deeply appreciates the climate challenges leading to more excellent national action and commitment (Azoulay & Espinosa, 2020). ESD's emphasis on environmental education must be done for sustainable development goals (Fadhilah, 2016) because education can create quality and highly competitive human resources in the future (Anggrayni, 2019). ESD plays an essential role in raising awareness and understanding of climate change and the efforts that everyone can make to address it (Edwards et al., 2020).

Learning Outcomes of ESD Implementation in Climate Change Learning

In the last decade, fruitful research on integrating different competencies for sustainable development has become more precise. Competence for sustainable development starts from a comprehensive and holistic view (Robina et al., 2020). It can be considered as a set of knowledge, skills, values, and attitudes necessary to ensure that students and future leaders are prepared to face complex issues about sustainability (Guillen et al., 2022).

The results of the analysis of 20 articles show that 40% (articles 1, 5, 7, 9, 11, 13, 18, 20) of ESD implementation can foster awareness and caring attitudes towards the environment, especially the problem of climate change; 60% (articles 1, 4, 6, 8, 10, 12, 13, 14, 15, 17, 18, 20) increase knowledge and understanding (cognitive, perceptual, critical reasoning, literacy); 20% (articles 1, 3, 6, 18) improved performance and performance; 15% (articles 1, 10, 16) increase motivation and active participation and 15% % (articles 2, 15, 19) develop new policies and curricula. Based on these results, some articles or journals have two aspects expected from ESD implementation activities, represented in Figure 4.

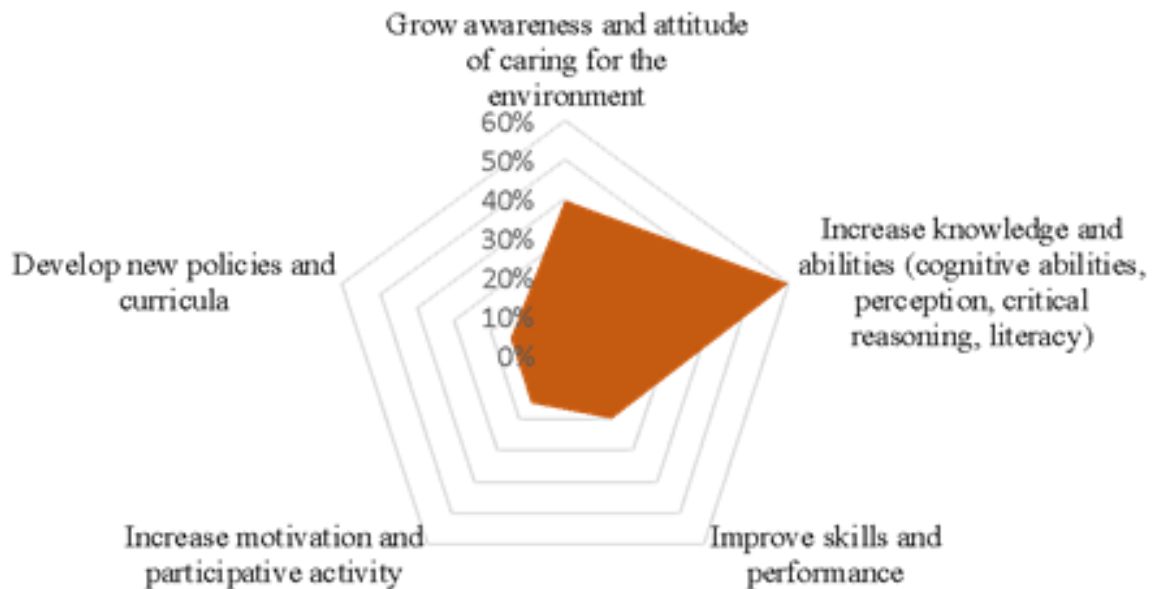


Figure 4. Learning outcomes of ESD implementation in climate change learning.

Competencies for sustainable development are considered one of the most common competencies, so they are integrated with the academic curriculum to develop continuing education. There is a positive relationship between curriculum enrichment and continuing education and the level of sustainability awareness and student behavior about sustainability (Hay & Eagle, 2020). Formal education increases students' knowledge of sustainability and, therefore, will significantly affect the level of sustainability awareness and sustainability practices. Student involvement in sustainable living practices will reveal positive relationships in improving the sustainability of literacy and behavior (Qureshi, 2020). Based on the results of research by Filho et al. (2023), educating students about climate change issues and actively involving them in climate affairs can make them aware of climate change and related

risks. Interventions through environmental education can change students' pro-environment behavior. Environmental education classes not only improve students' environmental knowledge and attitudes, but the use of worksheets in encouraging ensures the effectiveness of environmental education (Kurokawa et al., 2023).

Recommendation of ESD Implementation in Climate Change Learning

Based on the analysis of 20 Scopus-indexed articles that have been carried out opens an overview of opportunities for ESD implementation in climate change learning in Indonesia. The study reveals an urgent need to develop innovations and appropriate methods to implement ESD in climate change learning. According to Filho et al. (2023), it is necessary to revise the teaching curriculum and research programs/projects to include them in the SDGs. In addition, researchers and practitioners have not been proactive in much of the teaching content, policies, and research opportunities related to the SDGs. This supports the recommendations for further actions that need to be taken to help realize the SDGs. Therefore, researchers, practitioners, governments, and the public can have an overview of ESD implementation to design or innovate designs, methods, and policies related to implementing ESD in learning climate change in Indonesia.

CONCLUSION

Fundamental Finding: Search results show scarcity in research related to ESD implementation in climate change learning despite increased research trends. The implementation of ESD in climate change learning that has been carried out can be through formal / school and non-formal education with learning innovations (case-based learning, inquiry based-learning, scenario based-learning, project-based learning, sequences, flipped classrooms, mobile applications, games); by developing curricula (courses, STEM extracurricular clubs, Community Service Program projects, school gardens) and by developing policies (transformative, political, cultural) in integrating ESD. The most widely practiced form of implementation in climate change learning is to develop learning innovations, while developing policies, especially by the government, still needs to be widely developed. The implementation of ESD can foster awareness and an attitude of concern for the environment, especially the issue of climate change; increase knowledge and understanding (cognitive abilities, perception, critical reasoning, literacy); improve performance and performance; Increase motivation and active participation and develop new policies and curricula. **Implication:** This study provides an overview of various activities to implement ESD in climate change learning. This research also provides recommendations on the most appropriate implementation methods to help address climate change so that researchers, practitioners, governments, and communities can design innovative activities, methods, designs, and policies that effectively implement ESD in learning climate change. **Limitation:** This research is limited to a description of the implementation of ESD in climate change learning with a literature review of Scopus-indexed journals. **Future Research:** There needs to be more research to develop the right innovations, methods, designs, and policies in implementing ESD on climate change learning to overcome the global problem of unsustainability.

ACKNOWLEDGEMENTS

Thank you to the Indonesian Endowment Fund for Education/*Lembaga Pengelola Dana Pendidikan* (LPDP) from the Ministry of Finance, Republic of Indonesia, for providing a full scholarship to the first author.

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***Susanti Indah Perwitasari, M.Pd. (Corresponding Author)**

Postgraduate Programme of Science Education
Surabaya State University
Gedung CPD, Jl. Lidah Wetan, Surabaya 60231, Indonesia
Email: susanti.21027@mhs.unesa.ac.id

Dr. Eko Hariyono, M.Pd.

Postgraduate Programme of Science Education
Surabaya State University
Gedung CPD, Jl. Lidah Wetan, Surabaya 60231, Indonesia
Email: ekohariyono@unesa.ac.id

Prof. Dr. Endang Susantini, M.Pd.

Postgraduate Programme of Science Education

Surabaya State University

Gedung CPD, Jl. Lidah Wetan, Surabaya 60231, Indonesia

Email: endangsusantini@unesa.ac.id
