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Assessing Sustainability Literacy in Green Schools through Citizen Science Project on Biodiversity Learning

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Abstract: The research aims to measure students' sustainability literacy after participating in a citizen science project. The subjects of this research were students at one of the state senior high schools (SMAN) in Bandung. The descriptive method with a quantitative approach was used in this research. The research was conducted over four weeks with a total of 12 hours of meetings in two classes with 72 students. Random sampling was used to establish the research sample. Data collection used assessment of students' sustainability literacy questions after they completed citizen science projects. Descriptive analysis was used to conclude the data. The finding shows that most students (93%) received passing grades above the minimum passing criteria (19.5% in sufficient, 55.5% good, and 18% excellent categories). It is shown that CSP-based learning is effective in strengthening the students' sustainability literacy.

Keywords: biodiversity, citizen science project, green school, sustainability literacy

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INTRODUCTION

Sustainability literacy is crucial for students to learn since it is more than simply knowledge; it also demonstrates skills, attitudes, competencies, and sustainability ideals in everyday life (Kokkarinen & Cotgrave, 2013 & Murray & Cotgrave, 2007). The relevance of this literacy in the 21st century is tied to the world population, which continues to grow resulting in a greater consumption of food, energy, water, and other resources. At the same time, resources and biodiversity are limited and not always dependable. These limitations are exacerbated by the issues of climate change, ecosystem degradation, extinction, and resource exhaustion. For this reason, sustainability literacy must be taught in schools, with one focus on biodiversity protection to ensure that the earth's resources remain sustainable and livable (Murzi et al., 2019). Sustainability literacy identifies an understanding of local and global issues related to sustainable development (Storey et al., 2017). The sustainability literacy test was designed to achieve the concept that for a sustainable future, individuals who are aware and literate in sustainability are needed (Décamps et al., 2017). Sustainable literacy is a guide to measuring the achievement of the Sustainable Development Goals (SDGs) through education (Putri et al., 2023).

The Sustainable Development Goals (SDGs) propose 17 global goals to be implemented by UN member countries in formulating their country's agenda and policies for the next 15 years starting in 2015 (Hák et al., 2016). One of the sustainable goals measured through the sustainability literacy test in this study is the fifteenth goal (15), namely the terrestrial ecosystem (life on land). The fifteenth goal of the SDGs is a response to the complexity of tropical forest loss and declining biodiversity. Experts even suggest that the earth is heading towards mass extinction. Limited resources increasingly pose many conservation challenges. One of the goals of the fifteenth SDG is to stop the loss of biodiversity (Queiruga-Dios et al., 2020 & Schneiderhan-Opel & Bogner, 2020). The goal of stopping the loss of

biodiversity is expected to be integrated with other SDG goals (Sayer et al., 2019), one of which is through biodiversity and conservation which are integrated, taught, and practiced in school education (Bopape et al., 2021).

Even though Indonesia is known as a mega biodiversity country, the community's conservation efforts have not been balanced. One of the causes of this issue is a lack of public awareness and information (Hidayat et al., 2018 & Puspasari, A et all, 2019). Indonesia has a biodiversity of Spermatophyta amounting to 11% (38,000) of all types of Spermatophyta in the world, with 18,700 of them being endemic (Rohman et al., 2019 & van Welzen & Slik, 2009). The government has initiated many conservation measures, one of which is to include biodiversity and its conservation discussions in school topics so that the school community is aware of and knowledgeable about conservation in the surrounding environment. This topic contains many complex concepts that have to be mastered well by learners (Fikriyah et al., 2020). In many developed countries, citizen science is usually employed for plant identification in both research and education to promote biodiversity conservation in schools (MacPhail & Colla, 2020 & McKinley et al., 2017).

Citizen science is the practice of involving community members in scientific research activities. Through this practice, the community can share and contribute to data collecting (Haklay et al., 2021 & Robinson et al., 2018). In education, citizen science is typically carried out through project-based learning or a citizen science project. Aside from collecting massive amounts of scientific data, citizen science can be an excellent way to tackle social concerns and contribute to long-term goals by maximizing data sources in the surrounding environment (Fraisl et al., 2020 & Fritz et al., 2019), citizen science activities take the form of collaborative projects, research, and practice (Cohn, 2008 & Roche et al., 2020). Citizen science is also implemented in European and Australian schools using a contextual approach that is in line with reality, such as material on biodiversity (Kelemen-Finan et al., 2018).

Citizen science is also known to actively contribute to achieving the SDGs because it can be applied to various relevant fields such as (1) water and air quality, (2) marine debris, (3) biodiversity, (4) health issues, and (5) gender (Queiruga-Dios et al., 2020). Community involvement in obtaining data and analyzing the effectiveness of policies taken increases community literacy on sustainability. This is in line with research that reports the results of a survey of more than 1,500 students. The results of the study showed that students' concern, involvement, and closeness to the environment increased significantly after participating in data collection and data analysis (Mitchell et al., 2017). Citizen science projects also help students to increase awareness of the value of biodiversity and deepen the concept of biodiversity through their involvement as citizens who act actively and responsibly towards the sustainability of biodiversity (Dörler et al., 2021 & Maurer & Bogner, 2020). Indirectly, this is expected to be able to help conservation efforts after training students in sustainability literacy.

Citizen science projects on the biodiversity of Spermatophyta are still uncommon in schools. These initiatives frequently target the general public/residents in residential settings. For example, some citizen science studies have been conducted on birds, butterflies, ornamental plants, and various other living animals in the vicinity of where inhabitants dwell (Aripin et al., 2022). Meanwhile, citizen science project activities in biodiversity learning recorded in schools aim to improve research skills (Aripin et al., 2022 & Damayanti et al., 2021), creative thinking (Fitriani et al., 2017), critical thinking (Rachmawati et al., 2022), and biodiversity literacy (Aripin et al., 2022). Research on citizen science projects (CSP) to enhance sustainability literacy has not been conducted, although citizen scientific project-based learning on the issue of biodiversity conservation has the potential to promote sustainability literacy (Greving et al., 2022; Newman et al., 2017 & Roche et al., 2020). Therefore, this study aims to increase students' sustainability literacy through citizen science project activities on biodiversity as part of a conservation effort in the school sector.

Conservation and sustainability literacy efforts in schools must be supported by proper learning facilities and materials. Plants as objects/media realia should be diverse and represent all plant families in biodiversity material. The enormous diversity of plants in the surrounding area has the potential to be used as a learning resource (Handayani et al., 2019 & Puspasari, A. et all 2019). CSP encourages students to use genuine ecosystems around them to make the idea of biodiversity more real for them. As a result, this CSP research was conducted in conjunction with a green school or a school with the *adiwiyata* predicate, which promoted plant diversity in the school environment.

The term "green school" or "*adiwiyata*" (for Indonesian schools) refers to an ideal school that provides students with access to varied knowledge as well as standards and ethics that serve as the

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foundation of their life to achieve goals in sustainable development initiatives (Wardani, 2020). The school in this study was also chosen because it promoted a green environment through a variety of sustainable initiatives such as the practice of environmentally friendly conduct, the provision of plants in gardens and around the school, vertical gardens, hydroponics, and greenhouses. Observations revealed about 70 different varieties of spermatophyta in the school environment. The abundance of these plants is a precious resource for CSP. Green schools were also established as a formal educational institution's response to achieving sustainable development goals and encouraging society's transition to sustainability. As a result, students can examine the diversity of Spermatophyta in the context of the school environment and practice conservation behavior from sustainable literacy.

METHOD

This research employed a quasi-experimental approach with a one-group post-test-only design. A total of 72 tenth graders of SMAN X Bandung were established as the research sample. The research data were obtained through test/assessment on sustainability literacy questions. The research instrument in the form of 14 questions was developed from the Sustainability Literacy Test (Sulitest) which consisted of knowledge aspects (four indicators), skills aspects (three indicators), and one indicator of mindset aspects related to sustainability literacy (Décamps et al., 2017). The eight indicators of sustainability literacy are described in Table 1.

Table 1. Indicators of Sustainability Literacy

Indicator 1: Knowledge	
1.a	Sustainable humanity and ecosystems on planet Earth
1.b	Global and local human-constructed systems to answer people's needs
1.c	Transitions towards sustainability
1.d	We each have roles to play in creating and maintaining individual & systemic changes
Indicator 2: Knowledge of Skills	
2.a	Personal skills
2.b	Working with others
2.c	Think & act systemically
Indicator 3: Mindset	
3.	Mindset towards sustainability

The research was conducted over four meetings. The activities included a workshop with biodiversity expert scientists, project implementation for two meetings, and project reporting with expert scientists at the fourth meeting. Every activity always included knowledge, skills, and a sustainable mindset. The research findings, in the form of student scores, were then descriptively analyzed to determine their sustainability literacy. Each indicator (eight themes) was calculated and analyzed using the following formula:

$$\text{Students sustainability literacy: } \frac{\sum \textit{students score}}{\textit{maximum score}} \times 100$$

The resulting scores were then used to determine students' sustainability literacy categories shown in Table 2.

Table 2. Categories of sustainability literacy score

Score	Category
<40%	Very poor
41-55%	Poor
56-70%	Fair
71-85%	Good
86-100%	Excellent

Source: (Fikriyah & Ahied, 2022)

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RESULTS AND DISCUSSION

The citizen science project in learning biodiversity at SMAN 3 Bandung was carried out over meetings. The student's project was an inventory of Spermatophyta in the surrounding environment and school. Aspects of sustainability literacy were inserted into project activities by emphasizing students' understanding, attitudes, and sustainable and environmentally friendly behavior when carrying out the project. The students were constantly exposed to the need for conservation through sustainable behavior that they applied in their daily activities, including in citizen science-based learning projects. Then, at the last meeting, they were assessed on their sustainability literacy via a 14-question sustainability literacy test. The students' scores can be seen in **Figure 1.**

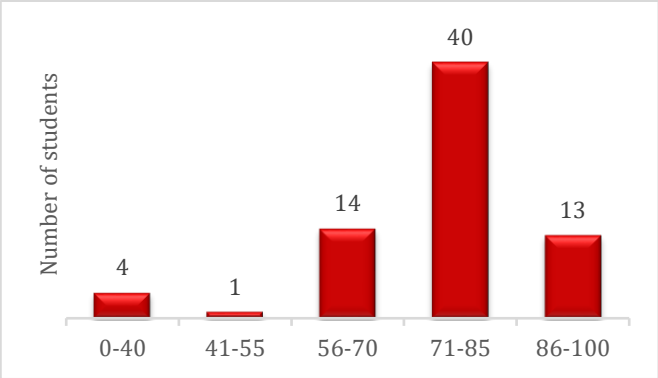

Figure 1. Student's Score on Sustainability Literacy

Figure 1 shows that only four students (5.5%) are in the poor category. Meanwhile, one student (1.5%) is in the poor category, 14 (19.5%) students are in the sufficient category and the remaining students are in the good (55.5%) and excellent (18%) categories. A study Décamps et al.(2017) involved 42,683 college students from 35 countries, whose sustainability literacy scores without learning were 55 points (poor). By comparing the percentage of majority scores of 55 (poor) without learning with 71-85 (good) with learning in this study, we can see that learning about biodiversity through citizen science projects is effective in improving students' sustainability literacy.

This is in line with other studies that indicate a significant relationship between science and society in learning about sustainable topics (Hogan & O'Flaherty, 2021). Then, a total of 22 methods of instruction to promote sustainability derived from diverse studies were examined. It suggested that the most prevalent teaching style was for students to work in groups and actively participate in the learning process (Elster, 2022; Hogan & O'Flaherty, 2021; & Jeronen et al., 2016). Citizen science-based learning fits these criteria indirectly, hence it can be chosen as a learning activity that promotes sustainability.

The implementation of the citizen science project in biodiversity learning at green school allows sustainability education to be developed and trained during the project. In the first meeting, students were introduced to the fact that Indonesia's biodiversity had many threats that could be anticipated with simple sustainable behavior. Then, during the project, students were always encouraged to maintain and appreciate the plants being observed by not picking too many and using only a few parts of the plant. The project at home also invited students to learn about the benefits of plants that were often used by the community. In addition, students also discussed with the community in their environment how to utilize and preserve these plants sustainably.

One of the main factors behind the high achievement of students in the good category is the implementation of a sustainable lifestyle that has long been implemented in this green school. The school has received the Adiwiyata (green school) predicate since 2014 at the city level and became an independent Adiwiyata school in 2018. According to interviews with teachers and students, several programs that support sustainability have been implemented by all school residents, including teachers, staff, students, and even canteen traders. Therefore, students have awareness and knowledge and are even trained to practice a sustainable lifestyle every day.

Other studies have also proven that schools that pay more attention to environmental education will have students who are closer to nature and also more environmentally friendly. Students from green

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schools will have better knowledge, skills, and attitudes toward a sustainable environment than those from green schools. This means that students from green schools show more pro-environmental behavior. For example, students significantly try to reduce plastic waste by choosing reusable plates, and cups, and they refuse to use straws and plastic bags (Djuwita & Benyamin, 2019).

In terms of sustainable and environmentally friendly behavior, students in green schools have significantly higher levels of behavior compared to regular schools. The environmentally friendly behavior of teachers and students in green schools is supported by environment-based activities that are carried out repeatedly. In green schools, students will be accustomed to repeatedly carrying out various environment-oriented activities, such as caring for plants, disposing of garbage in the places provided, processing waste, and various other environment-based activities (Nurwidodo et al., 2020).

In line with Boca & Saraçlı (2019), who revealed that there was no difference in the level of perception of students from various majors regarding the importance of environmental sustainability if they were often involved in environmental activities. Environmental awareness and sustainability can increase if students are involved in sustainability activities. Likewise, 62% of respondents stated that students would be more involved in pro-environmental activities if teachers, staff, and school residents also showed initiative in this regard (Ali & Anufriev, 2020). Figure 2 depicts an analysis of average students' sustainability literacy scores based on three indicators.

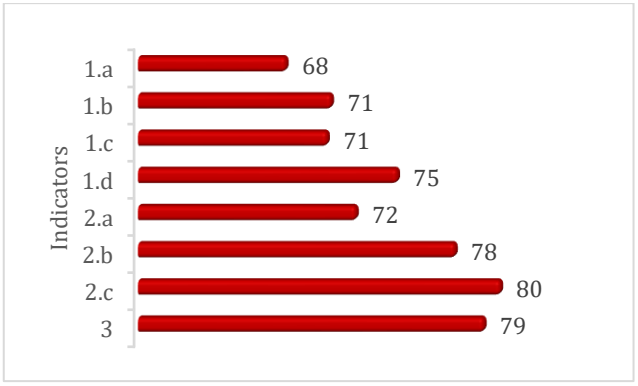

Figure 2. Average students' score on each indicator

Figure 2 shows that the knowledge indicators (1.a-1.d) got an average score of 68-75. Meanwhile, skill indicators got an average score of 72-80, and the average score for mindset indicators score is 79 points. These scores indicate that the student's skill regarding sustainability literacy is the highest compared to other indicators such as skills and mindset. Apart from that, it can be seen that the knowledge indicators got the lowest score. This finding is in line with that of the previous study Heryani et al. (2023) involving students in grade IX who got low scores on knowledge and higher scores on skill and mindset. The low score on knowledge indicators, when compared to the other two indicators, could be attributed to the student's lack of a complete understanding of biological systems and ecosystems on Earth (Heryani et al., 2023). This could also be caused by the students' lack of exposure to sustainability challenges at school and in the real world. Even though the issue raised in this study project is a contextual one, increasing students' awareness of sustainability literacy takes time and consistency.

In addition, it is stated that high knowledge about sustainability does not guarantee high knowledge of skills and an ethical mindset (Décamps et al., 2017). This is proven by the students' higher scores on skills and mindset indicators. These are related to learning activities carried out based on citizen science projects. Mindsets and skills about sustainability are better taught through the phenomena presented in the problem. The abundant plant biodiversity, for example, had received no attention at the school chosen as the research site. Specifically, the school garden contained around 70 different species of spermatophyta. The proximity to real-world challenges that students confront daily should help them comprehend and practice sustainable behavior through citizen science project activities.

There is a positive correlation between awareness and practice among students who have received environmental sustainability education (Punzalan, 2020). It is proven that what students know from school about environmental issues can be transformed into actions that allow them to solve problems with their acquired knowledge. Luan et al. (2020) further state that the scientific epistemic view that students gain from environmental sustainability education predicts decision-making styles and recycling

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intentions. Other studies have also found that student learning outcomes are built on thinking skills and learning experiences. In other words, students learn about sustainability literacy through direct experience and contextual learning (Nugroho, 2021; Perkasa, 2018 & Rasis et al., 2023). The combination of abundant local biodiversity and contextual project learning makes students feel more connected to the concept of sustainability in their surroundings.

The above study suggests that the core components of sustainability literacy, namely knowledge, skills, and mindsets can pay more attention to sustainability practices. When teaching local environmental issues, evidence-based practices (e.g. emphasizing the surrounding nature and culture) can be integrated into learning to encourage a high and sophisticated scientific epistemic view of sustainability. This has been implemented through integrated green school citizen science project learning.

However, knowledge of sustainability through learning alone is not enough. In line with the findings of Yeh et al. (2021), there is no significant difference in environmental sustainability behavior between students who have higher and lower scores in learning outcomes. Of course, this shows that sustainability issues cannot be solved if there is only good environmental science, but also accompanied by sustainable attitudes and behaviors. Attention to various aspects of sustainability education in schools to educate students about environmental sustainability is very necessary. Character formation requires the participation of various groups so that it is internalized in a student. One of them is the participation of the school environment and the surrounding community. Schools and communities must not only convey these values (character), but must also help students understand, internalize, and act based on these values (Kurnia & Suryadharma, 2016).

Furthermore, to enhance the students and the school community's sustainability literacy, the appeal for a sustainable lifestyle can be applied through school curriculum policies (Winter & Cotton, 2012). Citizen science activities are considered ideal, with the idea that sustainability literacy should not make students feel less responsible. This is inspired by modern education programs that tend to force particular individuals or groups to be environmentally responsible (Campbell et al., 2021). This can hinder students' curiosity and imagination to explore the environment and contribute to maintaining its sustainability. However, the citizen science project is considered effective as it engages students, lay people, and expert scientists in scientific activities to share responsibility for the sustainability of life (Kobori et al., 2016; Strasser et al., 2019) (Kobori et al., 2015).

When it comes to drawbacks, lack of time and resources are two potential barriers to establishing citizen science projects in schools (Roche et al., 2020 & Strasser et al., 2018). This is in line with earlier studies that have found that a lack of time leads to ineffective learning activities. Therefore, it is advised that learning with projects to train sustainability literacy use synchronous and asynchronous learning methods, such as online or offline learning (Rasis et al., 2023). Despite the distance, online learning helps boost sustainability literacy; up to 80% of students correctly answered questions about sustainability literacy (Ahmad Mudzakir et al., 2023), so a combination of in-class and out-of-class initiatives can maximize learning.

CONCLUSION

A citizen science project on biodiversity learning trains students' sustainability literacy by 93% (19.5% in sufficient, 55.5% good, and 18% excellent categories). Skill is the highest score of the sustainability literacy indicator at 72-80 points, followed by the mindset indicator at 79, and the knowledge indicator at 68-75 points. This was assisted by the availability of resources such as an abundance of spermatophyta (>70 varieties), project time (in class and on assignments at home), and learning activities that engaged students contextually. Additionally, the involvement of expert scientists in citizen science project activities promoted the students' sense of responsibility for the concept of sustainability literacy, particularly in their immediate surroundings.

There are three limitations found when learning biodiversity and assessing sustainability literacy in a citizen science project. The main limitation felt by some students is the lack of time to study the material in depth. The next limitation is the prohibition on the use and utilization of plants in several open spaces. Although there are eight green open spaces filled with various plants, students are not allowed to use these plants freely in learning for CSP on sustainability literacy. The last limitation is the

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clash between citizen science project activities and class decorating activities by school students so that students have a busy schedule.

Several suggestions can be put forward for further research development. First, the selection of object schools that are not green is expected to be able to produce broader research data for comparison and further development of sustainability literacy studies. The second recommendation is the allocation of more research time, considering that citizen science project activities require more time. This was also responded to by one of the students who stated that the time for delivering sustainability literacy was not enough. Therefore, the recommendation to overcome time constraints is that the implementation of the citizen science project can be carried out as a P5 activity or the *Projek Penguatan Profil Pelajar Pancasila* (Pancasila Student Profile Strengthening Project) which has more time and is flexible.

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