

Citizen science project-based digital encyclopedia of mammals: Improving students' species literacy

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ABSTRACT

This research assessed the improvement of species literacy among students in the content dimension by utilizing a mammal digital encyclopedia based on the Citizen Science Project (CSP). The research method used a pre-experiment with a one-group pretest-posttest design. The research subjects consisted of 30 students. The instrument used was a species literacy test in the content dimension composed of 40 multiple-choice questions. The data were analyzed by conducting a normality test first, followed by a Wilcoxon test because the data were not normally distributed. The results showed a pretest score of 57.75 and a posttest score of 80.42, indicating an improvement in the average score. The N-gain value was 0.545, which fell into the moderate category. The Wilcoxon test results showed a significant difference, suggesting that the intervention conducted significantly improved students' species literacy. The use of the CSP-based mammal digital encyclopedia encouraged active student involvement in the learning process because it provided attractive and easily accessible visualizations, thereby helping students understand the topics about mammals.

INTRODUCTION

Species literacy is a person's ability to identify species found and provide a better understanding of biodiversity. Biodiversity plays a vital role in helping to create ecosystem balance and the survival of various species, including mammals. Understanding species is integral to biology education and requires a diverse approach. Everyone has the potential to develop knowledge about biodiversity in the environment, such as understanding the species and ecosystems around them. Thus, it increases awareness and empowers individuals to contribute to maintaining the balance of nature through real action.

Knowledge of biodiversity provides information on species types (Zukmadini et al. 2024; Gizachew 2022; Kamraju et al. 2024). Thus, species data collection is needed to determine the number of identified mammal species. Knowledge of mammal species is essential in maintaining habitats and food chains, but mammal populations are currently declining, which can lead to changes in habitat structure, so high environmental awareness is needed to encourage changes in individual behavior (Ardiantiono et al. 2024; Wu et al. 2018; Sujana et al. 2018). Therefore, understanding species can not only increase knowledge about nature but also increase awareness of the importance of environmental conservation, including education (Aripin et al. 2022; Hooykaas et al. 2022; Gerl et al. 2021). Species literacy includes species knowledge, the ability to

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KEYWORDS

Citizen science project, Digital encyclopedia, Mammals, Species literacy

identify species, awareness of species diversity, and understanding of species richness (Hooykaas et al. 2019).

Several research results showed that species literacy in society is less than satisfactory (Hooykaas et al. 2019). The community, including students, has limited knowledge about mammal species and biodiversity in general. Limited resources and classroom learning time result in limited knowledge about various mammal species. This condition indicates a learning gap that can affect each individual's understanding. In addition, the learning method affects students' understanding of mammal species. Therefore, students need to learn about mammal species through a digital mammal encyclopedia based on the citizen science project (CSP) designed with the PHP programming language version 8.2.4. MySQL is open source (Aryanti et al. 2024). MySQL database combined with PHP 8.2.4 in developing a digital mammal encyclopedia allows for dynamic and efficient observation data management.

The advantages of using a CSP-based digital mammal encyclopedia include: allowing students to access specific information about mammal species at any time; integrating technology to combine theoretical information with direct data from the field; and providing students the opportunity to engage in ongoing actual research which is then incorporated into the digital encyclopedia. Thus, students contribute to creating a mammal species database that can be used as a basis for enriching the content in the digital mammal encyclopedia. Data uploaded to the digital encyclopedia can be updated regularly to provide the latest information about mammal species.

The mammal diversity database states that of the 6,495 mammal species, 96 species are considered extinct (Burgin et al. 2018). BPS stated that the results of mammal data collection in 2015-2017 have decreased. Several factors cause the decline in species, namely 37% due to exploitation, 13.4% habitat loss, 5.1% the presence of invasive species, 2% due to disease, 31.4% due to habitat degradation, 7.1% due to climate crisis, and 4% due to environmental pollution. Habitat degradation due to human activities is often a significant threat to the survival of mammals, which can lead to habitat loss, exploitation, and expansion of agricultural areas (Periago et al. 2017; Shivanna 2020; Bernardo et al. 2021).

CSP in this study could make a significant contribution to science education, besides targeting students' attitudes and knowledge about science, changing students' behavior towards their surrounding environment (Aripin et al. 2021b; Crall et al. 2013). Citizen science has taken various forms, but the recognition or establishment of citizen science as a formal scientific field of study is a more recent and rapidly growing development (Vance-Chalcraft et al. 2022; Eitzel et al. 2017). Activities in CSP involved public participation and technology that greatly benefit the classroom environment. Based on this background, a study was conducted to determine the increase in students' species literacy in the content dimension through a digital mammal encyclopedia based on CSP because the CSP approach in developing a digital mammal encyclopedia can encourage students to actively participate in searching for information, collecting data and uploading data that provide new contributions to learning. The novelty of this research lied in the integration of digital encyclopedias with CSP as an innovative learning medium because they have not been widely explored in the educational context.

MATERIALS AND METHODS

The research method used in this study was a pre-experiment with one group pretest post-test design using one group of 30

students through pretest, intervention, and post-test. The variables used consist of independent variables in the form of CSP-based digital mammal encyclopedias and dependent variables in the form of student species literacy. The research instrument used was a species literacy instrument on the content dimension consisting of 40 questions through Google form which had previously been validated. The test given was a multiple choice test of 40 content dimension questions composed of several indicators: knowledge of species diversity, activity implementation procedures, knowledge of problems with mammals, and knowledge of mammal handling strategies. Data was analyzed using SPSS. Detailed information regarding how to use SPSS is explained elsewhere (Fiandini et al. 2024; Adeniran et al. 2024; Afifah et al. 2022; Theron et al. 2024). The technical data analysis used a normality test followed by the Wilcoxon signed rank test, a non-parametric statistical test because the data was not normally distributed.

RESULTS AND DISCUSSION

Content dimension species literacy refers to knowledge about mammals presented in various forms of information. Species literacy can help increase public awareness and participation in conservation. The results of the content dimension species literacy data analysis show average pretest and posttest values for each student class (**Figure 1**).

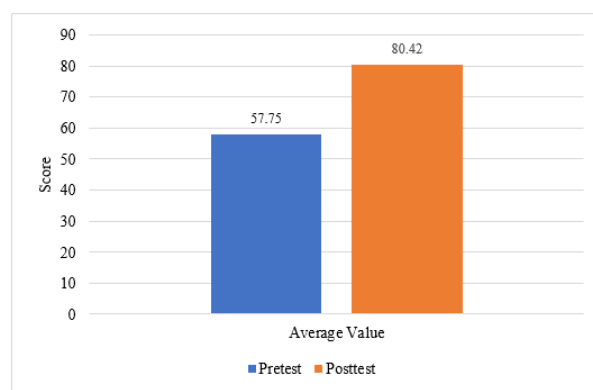


Figure 1: Average pretest and posttest values

Figure 1 shows a difference in the average value, namely the average pretest value of 57.75 and the posttest of 80.42. The final ability of students increased compared to their initial ability. The intervention implemented in the classroom can significantly improve students' species literacy skills in the content dimension. One of the factors supporting this increase is students' better understanding of the material and facts related to the content being studied. In addition, students can apply their knowledge to broader situations and extract meaningful information from other sources. Species literacy involves knowledge of the relationships between species, their roles in the food chain, environmental impacts, and threats to species' survival, such as climate change, habitat loss, and human interactions. This species literacy is essential for maintaining biodiversity and promoting conservation efforts (Tengö et al. 2017).

Classroom learning activities were carried out in groups of 5 groups. The next activity was a focus group discussion (FGD) on mammal diversity and the issue of mammal extinction based on CSP. Then, we conducted species observation activities in the field by directly involving students. CSP-based activities had many benefits in education, the environment, and society. They were carried out outdoors to conduct monitoring in the field (Susbiyanto et al. 2024; Rachmawati et al. 2022; Aripin et al. 2021a).

In addition, using technology as a digital encyclopedia of mammals based on CSP has many specific benefits. The digital encyclopedia utilizes images, maps, and documentation of observation results that can provide more exciting information to help students remember and understand the available information and increase student involvement in completing observation data.

Species diversity is an important part of biodiversity. Thus, it needs to be socialized to help increase awareness. Education can raise students' awareness, which can lead to changes in individual attitudes and behavior as a whole (Lasaiba 2023). Students, as part of the local community, play a very important role in starting to protect the environment because only obtaining information will not be enough; active steps are

needed to increase their concern and participation (Soanes and Lentini 2019). Active participation in learning activities can encourage students to think and understand concepts more deeply and apply knowledge to real situations. This learning allows students to not only receive information but also process and practice what has been learned. Thus, it can significantly improve learning outcomes. In the era of technology, students not only share ideas but also as resources that have the potential to conduct analysis and collaborate between students. In addition, CSP-based digital encyclopedias stimulate students in independent and exploratory learning. The statistical test results in **Table 1** show an increase in students' species literacy in the content dimension after the treatment is given.

Table 1: Statistical test result

Components	Experiment		
	Pretest	Posttest	N-gain
Mean value	57.750	80.417	0.545
Max value	75	93	-
Min value	38	65	-
Normality Test			
Sig. = 0.05	0.050	0.014	-
Not normally distributed			
Wilcoxon Signed Rank Test			
Asymp. Sig. (2-tailed)	0.000		

The normality test ($p > 0.05$) was carried out using the Shapiro-wilk test, indicating that the data obtained were not normally distributed with a significance value of the pretest value of $0.050 = 0.05$ and a post-test value of $0.014 < 0.05$. Based on the results of the normality test, the data were not normally distributed. Thus, a nonparametric test was carried out using the Wilcoxon signed rank test with a significance value of $0.000 < 0.05$. Thus, there is an increase in student species literacy in the content dimension.

The n-gain test was conducted to determine the extent of the increase in students' species literacy before and after the intervention. The result of the n-gain calculation was 0.545, which is included in the moderate category. The n-gain results show that the use of CSP-based digital mammal encyclopedias can significantly increase students' species literacy. The use of digital media in learning aims to improve students' knowledge and skills (Lin et al. 2017). The use of technology in learning is essential because it has the potential to facilitate and improve student learning. Thus, it can be used effectively (Schubatzky et al. 2023; Brändle et al. 2023).

Ease of access also affects the student learning process. Learning independently through digital encyclopedias can help students access materials that allow them to repeat and strengthen their understanding of the material. Accessibility will provide convenience for users in achieving learning goals (Rodenbarger and Hortsch 2020). Students can access the material with various devices, such as smartphones or laptops, to upload data from observations of mammal species or make revisions, which can be done repeatedly as often as students need. Student involvement in CSP activities for developing a digital mammal encyclopedia provides many benefits, including students being directly involved in learning activities to enrich their understanding by connecting theoretical concepts in class with those in the field. These findings indicate that learning in the experimental group can help students understand the material and improve species literacy. The increase is still in the moderate category. Thus, there is still an opportunity for further improvement. **Figure 2** shows the average value for each content dimension indicator.

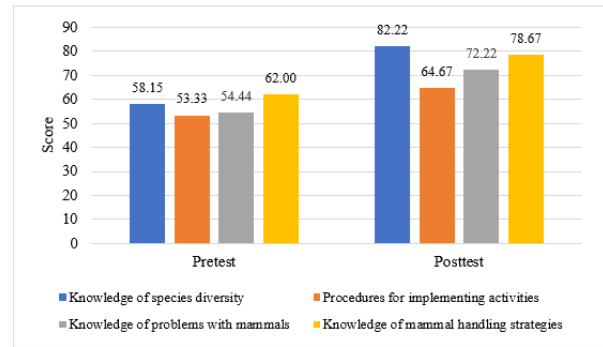


Figure 2: Average value of each indicator

The result of the n-gain calculation based on the average value of each indicator is 0.412, which shows an increase in the moderate category. The average pretest value for the knowledge indicator regarding species diversity was 58.15. The results of these data indicate that efforts are needed to improve understanding of species diversity. Classroom learning is carried out using the CSP-based digital mammal encyclopedia through five stages of learning activities. The first stage is to socialize the use of the digital mammal encyclopedia and understanding of CSP. At this stage, students participate in the socialization of the use of the digital mammal encyclopedia by introducing how to use it. Thus, students know the available features related to the content, descriptions of mammal species equipped with scientific classifications of each species, morphological characteristics, habitats, roles, distribution maps, and information related to conservation. With a user-friendly approach, students can access and utilize this platform to enrich their knowledge of mammals. In addition, socialization was also carried out regarding CSP. Thus, each student understood the activities that scientists will carry out, the stages of CSP activities carried out, and the objectives of developing citizen science.

In the second stage, students conducted FGD by inviting two conservation experts. In this activity, students were able to explore and obtain various information and had the opportunity

to express their opinions regarding mammals and the issue of mammal extinction. The topics discussed in the FGD were:

- (i) Actions to protect the existence of mammals.
- (ii) The impact of human activities on the environment.
- (iii) The role of students as citizen scientists in helping conserve mammals.

The third stage was conducting observations in groups in the field. Each group of students identified the species observed from the morphological characteristics of each species, habitat, role, and conservation status and documented them. After that, students could complete the results of their observations and upload them to the encyclopedia, as in **Figure 3**.

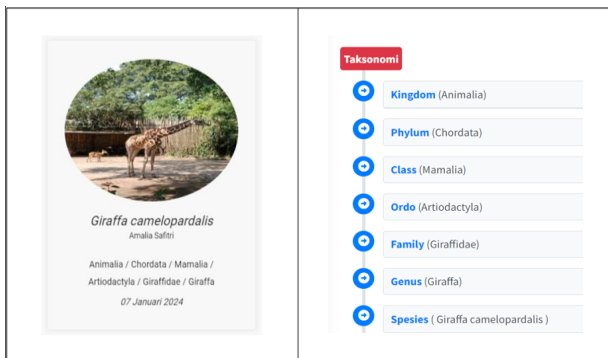


Figure 3: *Giraffa camelopardalis* data

In the fourth stage, students present their observation report through group presentation activities. Group presentations are essential to the process, as each group presents its findings in the field. The reports submitted by student groups include information related to identifying mammal species, environmental data, behavior or habitat of observed species, roles, and conservation status. Through presentation activities, students are expected to be able to explain in a systematic and easy-to-understand manner and respond to any questions asked. This presentation activity is an opportunity to strengthen students' understanding, think critically, and discuss the challenges faced during observations. The fifth stage is to reflect on the activities carried out to evaluate students' experiences during learning activities, such as challenges faced and solutions that can be applied in the future. Reflection activities can also encourage students to consider the impact of activities on understanding conservation and species literacy. Thus, students can identify parts that need to be improved to be better and more effective in subsequent learning activities.

The average pretest score on the implementation procedure indicator was 53.33 and the posttest was 64.67. The increase in the implementation procedure indicator is in the low category compared to the increase in other indicators. The results of the n-gain calculation on the second indicator obtained 0.243. The low average score on this indicator can be caused by several factors, including a lack of understanding of implementing activities, such as using applications, and low student motivation to understand activity procedures. A good understanding of activity implementation procedures is fundamental because it can help the learning process become more effective and achieve learning objectives (Junaedi 2019). The average values of the third indicator regarding knowledge of mammal problems and the fourth indicator regarding knowledge of mammal handling strategies are 54.44 and 62.00, respectively. This can be caused by the lack of information about mammal problems and

handling strategies, which means that students' knowledge about them is still limited. Explanations regarding handling mammals can be done through discussions with experts. Thus, they can exchange ideas and direct experiences in the field.

The interventions carried out in the classroom increased the average post-test score. The CSP activities involved active student participation in the data collection process and contributed to scientific research, improving students' understanding of concepts. Involvement in the learning process can provide opportunities for students to make observations and encourage student interest and motivation (Koomen et al. 2018). The students' series of CSP activities provided broad insights into species diversity and increased awareness of environmental issues. Students conducted FGD activities before conducting species observations in the field with the conservation team to obtain information on mammals' existence and the role of citizen scientists in conserving mammals.

Observations of species in the field are conducted in groups by sharing knowledge and experiences with each other so as to increase mutual understanding of the species observed. Species observation activities in the natural environment are vital laboratory work in biology learning (Kahl et al. 2021). Knowledge of vertebrate species is essential to understanding mammals in ecosystems to conserve biodiversity (Gerl et al. 2021; Dundas et al. 2018). Each group records the required mammal species data and takes photos for documentation.

Group observation of species has many benefits because tasks can be divided according to the student's understanding and motivation in learning. Motivation is a dynamic process influenced by intrinsic and extrinsic factors. This motivation can increase student involvement and improve the ability to achieve the final results of the learning process (Tokan and Imakulata 2019). The observation data collected is then integrated into a digital encyclopedia of mammals. Thus, students have the opportunity to collect and organize information, compile relevant data, work together, and collaborate between groups.

There was an increase in the average score of 22.67% after implementation. This happened because it could be caused by factors such as higher interactivity and active involvement in the learning process, utilizing the digital mammal encyclopedia, and implementing the CSP stages to increase motivation. Learning technology is specifically designed to involve students in learning activities to support the development of student skills in accessing broader information (Wiliyanti et al. 2024; Said 2023; Alioon and Delialioğlu 2019). This confirms the importance of innovation in learning to improve the quality of student learning (Lombardi et al. 2021). The relationship between digital encyclopedias and CSP in learning can provide a richer and more integrated experience. Using digital encyclopedias as the primary source of information combined with direct experience through CSP allows students to understand species better, enrich the learning experience, and strengthen student engagement in learning. Finally, this study adds new information relating to biology education, as reported elsewhere (**Table 2**).

Table 2: Contributions of the study to new information in biology education

No	Title	Ref
1	Media analysis of biology teaching book grade xii: A study based on science literacy category	Glorifica (2021)
2	Experts' validation of the developed 3-dimensional automated model of the human heart to teach a biology concept in Ilorin, Nigeria	Olumorin et al. (2021)
3	Design and Development of 3-Dimensional Model of Human Circulatory System to Teach a Concept of Biology in Senior Secondary Schools	Babalola (2022)
4	Design and development of human excretory system model to teach a biology concept in Ilorin, Nigeria	Olumorin et al. (2022)
5	The effectiveness of the practicum video guide on distance learning in improving biology learning outcomes in enzyme content	Hofifah and Sumiati (2023)
6	Examining the role of biology teachers' beliefs, motivations, and self-reported practices in constructing curves for biology class	Alhassan et al. (2024)
7	The integration of the engineering design process in biology-related STEM activity: A review of Thai secondary education	Tipmontiane and Williams (2022)
8	Problems of teaching practical biology in senior secondary schools	Abdussemmi (2022)
9	Analysis of experts' opinion on the human excretory system model for teaching biology in Nigeria.	Babalola (2023)
10	Development of an animation package in biology for teaching vertebrate, anatomy, and physiology	Ala (2022)

CONCLUSION

Based on the results of the calculation, the pretest value was 57.75 and the posttest value was 80.42. The results of the N-gain calculation increased by 0.545 which is included in the moderate category. The study's conclusion shows that the CSP-based digital mammal encyclopedia can significantly improve students' species literacy, including knowledge of species diversity, activity implementation procedures, mammal problems, and mammal handling strategies. This digital encyclopedia not only allows students to search and obtain data independently but also provides direct experience through active involvement in every process of CSP activities.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

FA contributed develop and create a learning program design and wrote the paper. TH directed the entire research project and established the foundation for research on citizen science, contributed to conceptualization, design a citizen science project, analyzed and contributed the references used, reviewed the manuscript. YS contributed analyzed and contributed the references used, reviewed the manuscript. K contributed analyzed and contributed the references used, reviewed the manuscript.

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