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Project Based Learning: Using Digital Storytelling to Improve Generation Z Students' Botanical Literacy in Botanical Course

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Abstract: This study aims to examine the effectiveness of implementing PjBL combined with DS in enhancing botanical literacy among biology students**.** This research follows a quasi-experimental non-equivalent control group design. The botanical literacy scores of students are normally distributed, and the data variance is homogeneous (sig>0.05). The findings indicate that the implementation of Project-Based Learning (PjBL) supported by digital storytelling can improve students' botanical literacy. The results of the LSD (Least Significant Difference) post-hoc test show no significant difference between the experimental group using PjBL with digital storytelling and the control group using PjBL without digital storytelling. There is an indication that the use of artificial intelligence (AI) in answering post-test questions may have influenced the research results. Nonetheless, digital storytelling remains a promising innovative approach in botany education. Its advantages during the learning process are evident in students' higher engagement, increased creativity in presenting material, and its ability to visualize complex botanical concepts effectively. Further integration of other technologies in learning is necessary, along with stricter control over AI usage during assessments.
Keywords: botanical literacy; project based learning; digital storytelling

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INTRODUCTION

Higher education is essential in advancing sustainability, especially in preparing professionals who can effectively implement sustainable knowledge and practices (Adams et al., 2018; Žalėnienė & Pereira, 2021). One of the key aspects of sustainable education is botanical literacy, which significantly contributes to equipping future biologist, including taxonomists, educators, and researchers, with a comprehensive understanding of biodiversity (Buck et al., 2019). Botanical literacy does not enhances students' understanding of the interrelationship between humans and plants but also fosters environmental awareness and concern for biodiversity. Ultimately, it supports the achievement of global sustainability goals, such as nature conservation and food security, as outlined in the Sustainable Development Goals (SDGs) (Pedrera et al., 2023).

Botanical literacy continues to face significant challenges today, one of which is the declining interest of students particularly Generation Z in botany, along with their limited ability to recognize and describe plants known as plant awareness disparity (Parsley, 2020). PAD hinders public understanding of the role of plants in ecosystems and conservation efforts, ultimately posing a risk to public participation in biodiversity preservation (Kubiatko et al., 2021). Various studies indicate that PAD remains prevalent, including in higher education settings, further emphasizing the urgency of enhancing botanical literacy (Balding & Williams, 2016; Jose et al., 2019; Wulandari et al., 2023).

Botanical literacy is classified by Uno (2009) into four levels consist (1) nominal, (2) functional, (3) structural, and (4) multidimensional, with the multidimensional level being the highest. A decline in botanical literacy among students may lead to a reduced number of qualified botany educators and researchers, which, in turn, would diminish public awareness of botany and conservation. Furthermore, inadequate plant knowledge hinders academic discussions and students' observational skills (Ryplova & Pokorny, 2020). Low botanical literacy directly affects the number of botanists and educators, which has significant implications for achieving several SDGs, particularly those related to biodiversity conservation and food security, especially within the context of local wisdom (Ahrends et al., 2011; Amprazis & Papadopoulou, 2020). A survey conducted at several universities in Malang revealed that students' botanical literacy remains low, with achievement percentages of 48.38% at the nominal level, 43.91% at the functional level, 41.87% at the structural level, and only 35.70% at the multidimensional level. These findings indicate an overall low level of botanical literacy. Although some students acknowledged the importance of botany, they struggled to explain in depth its role in daily life. Moreover, botany-related courses are often perceived as among the most challenging subjects in biological sciences due to the high complexity of the material.

Flower-related content is a central topic in constructivist-based learning within the Structure and Generative Development of Plants course, which is a part of botany studies in the Department of Biology at Universitas Negeri Malang. Pedrera et al. (2023) highlighted the importance of engaging and interactive learning approaches to foster students' interest in botany in the 21st century. This underscores the need for more effective and innovative teaching strategies to enhance students' interest in botany and improve their botanical literacy comprehensively. Local wisdom is closely tied to human life, however, the weak connection between flowers and human interactions poses a barrier to achieving sustainable development (Amprazis & Papadopoulou, 2020). The Malang region has significant potential for incorporating local wisdom into education, which could serve as a means to raise students' awareness of sustainability issues and the application of botanical literacy. Highlighting and engaging with plant-related content can enhance students' comprehension of botany and the significance of environmental sustainability (Pedrera et al., 2023).

One approach that can be applied in botanical education is Project-Based Learning (PjBL), which emphasizes students' active engagement in learning through real-world projects that connect theory with practice. This model enables learners to build knowledge by engaging in meaningful projects as well as creating practical and hands-on products (Brundiers & Wiek, 2013; Krajcik & Shin, 2022). PjBL has been proven effective in enhancing conceptual understanding, critical thinking skills (Hehakaya et al., 2022), creativity (Yustika & Iswati, 2020), as well as fostering students' collaboration and teamwork skills (Saenab et al., 2019). Although PjBL has been implemented in botanical education, its effective in improving botanical literacy remains largerly limited to the nominal and functional levels. Thus, it needs to be integrated with other in-depth strategies to strenghthen students' understanding of botany (Sari et al., 2018).

One strategy that can optimize the implementation of PjBL is digital storytelling (DS), which combines technology with digital narratives to convey information in an engaging and interactive manner (Barrett, 2009). The integration of DS into PjBL has been shown to enhance student motivation, problem-solving skills, and learning outcomes (Hung et al., 2012). In the context of botanical education, DS allows students to connect theoretical concepts with practical applications by creating relevant digital

stories. This approach also supports the development of 21st-century skills, such as creative, critical, and argumentative thinking (Robin, 2008; Yang & Wu, 2012).

Although the integration of PjBL and DS has been demonstrated to improve students' skills across various fields, its application in botanical education remains unexplored. Therefore, this study aims to examine the effectiveness of implementing PjBL combined with DS in enhancing botanical literacy among biology students. The significance of this research lies in developing more innovative and effective teaching strategies while providing educators with references for designing instructional methods that can improve the quality of botanical education in higher education. The findings of this study are expected to contribute to strengthening higher education implementation that supports the achievement of the SDGs, particularly in fostering understanding and awareness of biodiversity conservation and plant sustainability.

METHOD

Research Design

This research design follows a quasi experimental study using a non-equivalent control group design. The first group or experimental class receive Project-Based Learning model combined with digital storytelling (PjBLDS) treatment. The second group, designated as a control group 1 and thaught using the PjBL model. While the third group, control group 2 follow the instructional methods typically used by lecturers, namely laboratory practice and discussion. The study will be conducted by administering a pre-test before the treatment and a post-test after the treatment to both the experimental and control groups. The research design is presented in Table 1 (Leedy et al., 2012).

Table 1. Research design

Group	Pre-test	Treatment	Post-test
Group 1	O_1	X_1	O_4
Group 2	O_2	X_2	O_5
Group 3	O_3	X_3	O_6

Explanation:
O_1 : Pre-test at group 1 (PjBL+digital storytelling)
O_2 : Pre-test at group 2 (PjBL)
O_3 : Pre-test at group 3 (laboratory practice and discussion)
O_4 : Post-test at group 1 (PjBL+digital storytelling)
O_5 : Post-test at group 2 (PjBL)
O_6 : Post-test at group 3 (laboratory practice and discussion)
X_1 : Treatment with PjBL+digital storytelling
X_2 : Treatment with PjBL
X_3 : Treatment with laboratory practice and discussion

The syntax of Project-Based Learning (PjBL) assisted by digital storytelling in the learning process is presented in Table 2.

Table 2. PjBLDS syntax

Projec- Based Learning Steps	Digital Storytelling Making Steps	Learning Activities
Start with essential question	Owning your insight	Students formulate essential questions that are relevant to daily life and guide the creation of the project and topic in digital storytelling

Projec- Based Learning Steps	Digital Storytelling Making Steps	Learning Activities
Design a plan for the project	Owning your emotions Finding the moment	Students develop a plan, select tools and materials for project completion, determine how to convey emotions and feelings in the content, and identify key moments within the digital storytelling content
Create a schedule	-	Lecture and students collaboratively design activities to complete the project
Monitor students and the progress of the projects	Seeing your story Hearing your story Assembling your story	Students monitor each stage of the project's completion, including both the main project and the conceptualization of digital storytelling content
Assess the outcome	Sharing your story	Students share their digital storytelling in video format on social media platforms according to the target audience and evaluate their understanding gained throughout the project
Evaluate the experience	-	Students reflect on the project outcomes, make improvements, and address the initial problem posed

Research Subject

The population in this study consists of all students from the Department of Biology at Universitas Negeri Malang enrolled in the Structure and Generative Development of Plants course for the 2024/2025 academic year. The sample was selected using a random sampling technique after conducting an equivalence test on the student groups. A total of 82 biology students were selected as the sample and divided into three groups. The results of the equivalence test showed a p-value of 0.069 (>0.05), indicating that the three groups were equivalent, allowing for the implementation of a quasi-experimental study.

Research Instrument

The botanical literacy instrument in this study consists of eight multiple-choice questions and four essay questions, designed based on the intended learning outcomes. The instrument was developed by referring to the indicators/levels proposed by Uno (2009). Each item was tested for validity and reliability before implementation. The validity of the botanical literacy instrument was assessed using the Pearson Product Moment, yielding a p-value<0.05, indicating significant validity. Reliability testing using Cronbach's Alpha resulted in a reliability coefficient of 0.6. The implementation instrument includes the Semester Learning Plan (RPS), Lecture Program Unit (SAP), and student worksheets tailored to the research model, namely LKM PjBL-DS for the experimental group and LKM PjBL for the control group.

Data Collection and Analysis

Data collection was conducted from September to November 2024. The measurement of students' botanical literacy was based on predefined indicators and assessment rubrics. The collected data were analyzed using statistical methods, including normality testing with the One-Sample Kolmogorov-Smirnov test (sig > 0.05) and homogeneity testing using Levene's Test for Equality of Variances (sig > 0.05). To assess the effectiveness of the model on botanical literacy, a hypothesis test was conducted using One-Way ANCOVA, with a significance threshold of $p < 0.05$ at a 5% significance level. If a significant effect was found, further analysis was performed using a post hoc test to determine the specific differences using Least Significance Difference analysis. Data analysis was conducted using SPSS for Mac version 26.

RESULTS AND DISCUSSION

The prerequisite for hypothesis testing was conducted through classical assumption tests, which included normality and homogeneity tests. Hypothesis testing required that all data be normally distributed and that data variance be homogeneous. The results of the classical assumption tests are presented in Table 3. The effects of PjBL-DS, PjBL, and the practicum-discussion method on botanical literacy were determined using ANCOVA, with pre-test scores as a covariate. The results of the ANCOVA test are presented in Table 4.

Table 3. Students' botanical literacy normality and homogenitiy test results

Data Group	Normality		Homogenity	
	N	Sig	Score Levene's Tes	Sig
Pre-test of botanical literacy	82	0,060	1,597	0,129
Post-test of botanical literacy	82	0,154	1,315	0,116

Based on Table 4, the botanical literacy scores of students were normally distributed, and the data variance was homogeneous (sig>0.05). Therefore, the hypothesis testing could proceed using one-way ANCOVA to determine the effect of the implemented learning models.

Table 4. Students's botanical one-way ANCOVA test result

Source	Type III Sum of Square	df	Mean Square	F	Sig
Corrected Model	15506.402[a]	3	5168.801	31.561	.000
Intercept	9355.141	1	9355.141	57.124	.000
Tes Awal	2540.997	1	2540.997	15.516	.000
Model	8417.446	2	4208.723	25.699	.000
Error	12774.052	78	163.770		
Total	348071.917	82			
Corrected Total	28280.455	81			

Table 4 indicates that the Project-Based Learning (PjBL) model assisted by Digital Storytelling significantly influenced students' botanical literacy, as evidenced by the ANCOVA result (sig = 0.00, $p < 0.05$). However, further analysis using the Least Significant Difference (LSD) test revealed that there was no significant difference between the PjBL-Digital Storytelling experimental group and the conventional PjBL control group (Table 5).

Table 5. Least significant difference (LSD) analysis results

Group	Pre-test	Post-tests	Interval	Enhancement	Corrected Average	Notation
PjBLDS	41,39	71,09	29,70	72%	71,653	a
PjBL	47,22	69,75	22,53	48%	66,819	a
Laboratory practice and discussion	35,00	42,44	7,44	21%	46,686	b

The research findings indicate that the implementation of Project-Based Learning (PjBL) supported by digital storytelling enhances students' botanical literacy. This improvement is evident from the comparison of pre-test and post-test scores, which showed an increase following the implementation of the learning approach. Digital storytelling plays a crucial role in reinforcing botanical concept comprehension through a narrative-based, visual, and interactive approach that enhances student engagement and motivation (Çetin, 2021; Gürsoy, 2021). Another contributing factor to this improvement is the use of digital media such as illustrations, scriptwriting, videos, and interactive simulations, which enable a broader exploration of botanical content (Davy Tsz Kit et al., 2022).

Nevertheless, the results of the LSD (Least Significant Difference) post hoc test indicate no significant difference between the PjBL digital storytelling experimental group and the PjBL control group without digital storytelling. This suggests that while digital storytelling provides additional benefits in the learning process, it does not drastically enhance botanical literacy compared to conventional PjBL. One possible explanation is that PjBL itself is already an effective learning method for improving students' understanding through direct experience in solving project-based problems (Kimani, 2024; Singha & Singha, 2024). Therefore, digital storytelling may function more as a supplementary tool that enriches the learning experience rather than as a primary factor in improving botanical literacy.

Additionally, there is an indication that the use of artificial intelligence (AI) in answering post-test questions may have influenced the research results. Some students who frequently access AI as an aid in completing assignments may obtain answers without fully understanding the tested concepts (Chen et al., 2023). This is evidenced by the presence of identical responses among students, following a template derived from ChatBot searches. Consequently, the increased scores may not fully reflect their actual comprehension of the material (Rudolph et al., 2023). In the context of digital learning, this issue is a major concern, particularly in evaluating the effectiveness of technology-based learning methods (Fyfe, 2023). While AI can serve as a valuable learning tool, its uncontrolled use in assessments can obscure the true results related to students' botanical literacy.

Although there is no significant difference in final outcomes, digital storytelling remains a promising innovative approach to botanical education, as demonstrated by research conducted by Munawar et al. (2023), which reported improvements in science literacy scores. The advantages of this method during the learning process are evident in higher student engagement, increased creativity in presenting material, and its ability to visualize complex botanical concepts effectively. Furthermore, digital storytelling can provide a more personalized and meaningful learning experience, contributing to long-term student comprehension of the subject matter (Buckingham, 2020; Chan, 2017; Sá et al., 2021). However, its implementation still faces several challenges, such as

limited technological access for some students, the need for educator training, and curriculum readiness to accommodate this method optimally.

Based on these findings, the implications for the future development of botanical education highlight the need for a more strategic integration of digital storytelling with the PjBL model. This approach can be optimized by incorporating other interactive elements such as augmented reality, gamification, or community-based learning to enhance its effectiveness (Pandian et al., 2020; Reddy et al., 2020). Moreover, while it does not yield significant short-term differences, digital storytelling has the potential to serve as a tool that supports more engaging and relevant experiential learning for students in the digital era (Buchholz et al., 2020; Sá et al., 2021).

CONCLUSION

Based on the research results, it can be conclude that (1) Project-Based Learning (PjBL) assisted by digital storytelling effectively enhances students' botanical literacy; and (2) however, the impact of PjBLDS is not significantly different from the PjBL model. Nevertheless, it shows a significant difference compared to the laboratory practice and discussion methods used in the control class. Although there are no significant differences were observed in the final outcomes, digital storytelling still holds potential as an innovative approach in botany education. The advantages of this method are evident in higher student engagement, increased creativity in presenting material, and its ability to visualize complex botanical concepts during the learning process.

RECOMMENDATION

Further studies are needed to explore integrations that can strengthen the implementation of PjBL-digital storytelling in botanical learning. Therefore, future research should investigate how digital storytelling can be optimized in various botanical learning contexts to enhance scientific literacy more comprehensively, including considering strict control on the use of artificial intelligence in academic assessments, particularly for generation z.

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