



THE EFFECT OF SCAFFOLDING OF INFORMATION LITERACY ON THE BOTANICAL LITERACY OF PROSPECTIVE BIOLOGY TEACHERS

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ABSTRACT

The present study aims to determine the effect of the scaffolding of information literacy on the botanical literacy of prospective biology teachers. The current study employed an experimental method with a non-equivalent group design. The respondents comprised 120 students in the Biology Education Program of Malang State University (the academic year 2017/2018), divided into the control and experimental groups. Data collection was based on scaffolding information literacy among prospective biology teachers and subsequent botanical literacy tests in multiple-choice format. The botanical literacy test provides nine indicator references. Reliability testing was done using Cronbach's alpha. Data were analyzed through pre-test covariate analysis ($p < 0.05$) for the control and experimental groups. The present study indicates that the scaffolding of information literacy has a significant effect on botanical literacy among prospective biology teachers. The findings of the current study suggest that innovation in botany learning, in this case, the scaffolding information literacy, can improve the botanical literacy of biology education students. It is necessary to undertake learning innovation with biology education students in a professional manner to enable them to transfer knowledge using scaffolding information literacy to their prospective students. In conclusion, the scaffolding of information literacy has a significant effect on botanical literacy among prospective biology teachers.

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Keywords: botanical literacy; prospective; teachers; scaffolding information literacy

INTRODUCTION

Currently, the global community faces significant challenges in many aspects, such as food, health, fuel, and the environment. Hemingway et al. (2011) noted that plants have essential roles in overcoming these problems. Plants play important roles daily both from the spiritual, economic, ecological, and socio-cultural aspects. In this regard, such challenges can be addressed by increasing botanical awareness among students. However, Leksono et al. (2013) pointed out that most biology teachers cannot design lessons properly due to the lack of understanding about Pedagogical Content Knowledge. It is the knowledge about how to facilitate student learning from botany.

Pedagogic (pedagogic in research using scaffolding information literacy). As suggested by Drea (2011), the implication is improper botanical learning that leads to poor outcomes and threatens biodiversity. Uno (2009) also argued that the study of botany is threatened, leaving many students bereft because of improper lecture method in giving botanical material. Botany is taught by a lack of modern technology and a lack of effective practice, which reduces the students' interest and concern about plants. Therefore, botanical literacy among prospective biology teachers needs to be empowered and improved.

Project-based Learning (PjBL) models implemented in basic botany courses for biology education students have not been found to affect their botanical literacy skills (Sari et al., 2018; Sarafuddin et al., 2020). The characteristic of PjBL

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is students are required to solve problems through projects by aiming at the product as the ultimate goal in studying the natural phenomena related to plants that exist in the surrounding environment and does not require memorizing concepts. However, it is required to be more analytical and think critically by analyzing the information collected. The difficulty in understanding scientific literature is the major problem (Hubbard & Dunbar, 2017; Boholm & Larsson, 2019). In addition, students tend to employ untrustworthy reference sources. Porter (2005) stated that students are often unaware of the role of scientific papers in research processes. Moreover, lecturers do not support students with sufficient information regarding the crucial role of scientific materials. It is essential to introduce scientific-related aspects to students as early as possible through information literacy (Freeman & Lynd-Balta, 2010). The application of a PjBL model with the scaffolding of literacy is needed to empower botanical literacy.

The scaffolding strategy is defined as an effort to assist students in learning activities during the early stages based on the difficulties experienced by the students (Bikmaz et al., 2010; Taber, 2018). Such assistance will gradually be removed with the increasing competence of the students. Assistance can comprise guidance, assignments, encouragement, and outline problems in the learning process, allowing the students to grow with greater independence. The scaffolding strategy plays a pivotal role in improving the regulation of learning and enhancing the performance and achievement of learning (Molenaar et al., 2011). This scaffolding information literacy will provide the earliest possible experience of the role of information literacy in prospective teachers because the information literacy will empower professional abilities. In addition, it is necessary to provide experience to prospective teachers on how to manage the learning process according to the student needs for learning outcomes.

Scaffolding information literacy through assignments is vital in the learning process. Several tasks, such as conducting a scientific reading, identifying and finding appropriate sources of information, analyzing the quality of the information obtained, and using information effectively, have been applied with prospective biology teachers. Cankaya et al. (2017) described information literacy as the ability to seek information, identify and find appropriate sources of information,

evaluate and recognize information, and use information effectively (Uma, 2014; Saglam et al., 2017). Therefore, this research aimed to identify the effect of the scaffolding of information literacy on the botanical literacy of prospective biology teachers. The present study was limited only to interpreting information about botanical literacy toward a prospective biology teacher in the first year.

METHODS

The present study employed an experimental method with a non-equivalent group design. Samples were recruited using a random sampling. The first group was treated with a PjBL model, and the second group was treated with PjBL and scaffolding of information literacy. Each group, before treatment, will be tested pre-test and, after treatment, will be tested post-test. The research design is a 2×2 factorial experiment shown in Table 1.

Table 1. The Research Uses a Non-equivalent Control Group Design

Subject	Pre-test	Intervention	Post-test
Group 1	O ₁	X ₁	O ₂
Group 2	O ₃	X ₂	O ₄

Source: (Leedy & Ormrod, 2018)

Information:

O₁: Pre-test in group 1 (PjBL model)

O₂: Post-test in group 1 (PjBL model)

O₃: Pre-test in group 2 (PjBL model + scaffolding of information literacy)

O₄: Post-test in group 2 (PjBL model + scaffolding of information literacy)

X₁: Treatment with the PjBL model

X₂: Treatment with the PjBL model + scaffolding of information literacy

The population comprised all students majoring in biology (the academic year 2017/2018) at Malang State University. A total of 120 biology students who take botany classes were used in the current study and divided into two groups (control and experimental). Moreover, a PjBL model was employed in both the control and experimental classes; the scaffolding of information literacy was also applied in the experimental class. The scaffolding of information literacy was used as an instrument for collecting data based on several tasks. Those tasks are searching for scientific reading materials, i.e., reference books and scientific journals, from a list provided as part of a research

project task, identifying and finding appropriate sources of scientific information, analyzing the critical quality of information obtained from three reference books and journals (a local paper and two international papers), and using the scientific literature information effectively.

The Test of Scientific Literacy Skills (TOSLS) can be used to measure the scientific information and arguments in higher education, such as to evaluate biology teacher candidates who are focused on botanical literacy (Gormally et al., 2012). There were nine indicators of the TOSL: (1) identify a valid scientific argument; (2) evaluate the validity of sources; (3) evaluate the use and misuse of scientific information; (4) understand elements of research design and how they impact scientific findings/conclusions; (5) create graphical representations of data; (6) read and interpret graphical representations of data; (7) solve problems using quantitative skills, including probability and statistics; (8) understand and interpret basic statistics; and (9) justify inferences, predictions, and conclusions based on quantitative data.

Technological literacy, world literacy, and critical literacy, including botanical literacy, are types of literacy concepts (Uno, 2009; Saglam et al., 2017). Information literacy has different characteristics from other literacy concepts. Information literacy supports all other types of literacy, such as scientific literacy. Information literacy plays an important role in the 21st century. Learning is a necessity to increase information literacy (Bhimani, 2011; Sural & Dede Bali, 2018).

In the present study, 30 multiple-choice questions were designed regarding predetermined learning outcomes. The questions were designed for validity, reliability, difficulty, and differentiation of levels. Reliability testing was undertaken using Cronbach's alpha. The Cronbach's alpha coefficient was selected because it provided an estimate of the proportion of the observed score variance across the items on the test associated with the variance of the actual score (De Champlain, 2010). The instruments consisted of a semester lesson plan and a student worksheet based on a PjBL approach. Botanical literacy was evaluated using statistical tests, including normality, homogeneity, and hypothesis tests. Statistical analysis was used to determine the data distribution, and then the data were analyzed using pre-test covariate analysis ($p < 0.05$).

RESULTS AND DISCUSSION

Table 2 presents the results of the analysis of covariance. F-value for scaffolding information literacy is 141.473 with a p-value of 0.000. Given the p-value is $< \alpha$ ($\alpha = 0.05$), this is considered a significant difference. Thus, H_0 , which states that there will be no difference in the application of scaffolding of information literacy, is rejected, and the research hypothesis stating that there is a difference in the application of scaffolding of information literacy is accepted. Therefore, the scaffolding of information literacy affects botanical literacy significantly.

Table 2. The Effect of Scaffolding Information Literacy on the Botanical Literacy of Prospective Biology Teachers

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected model	6422.652 ^a	2	3211.326	150.282	0.000	0.720
Intercept	2904.833	1	2904.833	135.939	0.000	0.537
X	3570.777	1	3570.777	167.103	0.000	0.588
CLASS	3023.091	1	3023.091	141.473	0.000	0.547
Error	2500.140	117	21.369			
Total	61453.000	120				
Corrected total	8922.792	119				

Note: ^aR-Squared = 0.720 (adjusted R-squared = 0.715)

A corrected rate summary for each class is presented in Table 3. The results show that the level of botanical literacy among students receiving the scaffolding strategy is significantly higher than that in the control group. The mean for botan-

ical literacy among prospective biology teachers in the experimental class increased by 38.20% on the post-test result, whereas the control class experienced an increase of 19.51%, lower than the experimental class.

Table 3. The Corrected Rate of Experimental and Control Classes

Group	Pre-test t	Post-test t	Interval	Enhancement	Corrected Rate
Experimental	54.933	75.917	20.983	38.20%	76.063
Control	55.367	66.167	10.800	19.51%	66.021

PjBL was applied in both the experimental and control groups. In contrast, the scaffolding of information literacy was applied only in the experimental group and found to have a significant effect on the botanical literacy of prospective biology teachers compared with the control group. Skill in botanical literacy is measured based on the nine indicators in the TOSLS instrument, as follows: (1) identification of valid scientific arguments; (2) use and evaluation of effective sources of information; (3) differentiation of the presence or absence of scientific information; (4) understanding of the elements of research design and how it impacts scientific findings/conclusions; (5) creation of a graphical representation of the data; (6) reading and interpretation of the graphical representation of the data; (7) problem-solving process using quantitative skills, including probability and statistics; (8) understanding and interpretation of basic statistics; and (9) justification of inferences, predictions, and conclusions employing quantitative data.

Based on our observations, in the first semester of the structure of plant development class, the prospective biology teachers still had significant problems in understanding basic botany. For example, students readily understood that transportation tissues in plants consist of the xylem and phloem. However, it was an entirely different matter when the question was changed as to why the angiosperms group is more dominant than other plants regarding transportation tissue structure. Uno (2009) affirmed that teachers in biology classes generally over-emphasize vocabulary practice, which focuses on definitions and labeling, as well as recognizes the correct answer in learning science.

Students with high memorization skills are commonly greatly appreciated for their thinking, analytical, and evaluative skills. However, commonly, while such memorization skills are helpful for students during examinations, the information is not retained after the test, and thus

students often fail to show botanical literacy. High-level thinking skills promote the conceptual understanding of botany in both students and citizens. Botany is a science gained through the process of investigation, and therefore it is necessary to provide more opportunities for students to do the science themselves. Thus, the PjBL approach is a solution as an innovative learning model to develop the investigative activities of prospective biology teachers.

According to Table 3, botanical literacy increased in both the scaffolding and non-scaffolding groups. The mean of botanical literacy for prospective biology teachers in the experimental class increased by 38.20% on the post-test results, whereas the control class increased by 19.51%, lower than the experimental class. The application of the PjBL model improves the quality of learning and contributes to higher levels of cognitive development (Lasauskiene & Rauduvaitė, 2015; Saripudin et al., 2015; Syukriah et al., 2020). However, the project-oriented learning model requires the students to enrich their learning with relevant concepts. The application of the PjBL model necessitates that students integrate knowledge from various information sources and several related disciplines, including scientific materials, such as books and papers, through scaffolding information literacy. PjBL naturally requires many academic skills, such as understanding scientific articles, writing, and processing data using appropriate statistics, in constructing conceptual understanding through assimilating subjects in different ways (Zajkov & Mitrevski, 2012; Capraro et al., 2013).

The botanical literacy skills of prospective biology teachers with the application of the scaffolding strategy were significantly higher than those of prospective teachers in the control group (Table 3). The TOSLS instrument developed by Gormally et al. (2012) measured the evaluation of scientific information and arguments among undergraduate students. The opportunities to de-

velop skills such as argumentation and scientific reasoning are significant but tend to be neglected in the education system. Moreover, the stages of the PjBL model begin focusing on a question or problem (Tamim & Grant, 2013; Aldabbus, 2018). Based on these opinions, it is apparent that the stages of the PjBL model are compatible with the TOSLS instrument in the following respect, they are: (1) identifying valid scientific arguments; (2) using and evaluating effective sources of information; (3) distinguishing the presence or absence of scientific information; and (4) understanding the elements of research design and how this affects scientific findings/conclusions. However, as indicated by Sari et al. (2018), the PjBL model itself does not affect botanical literacy.

The present study reveals the difficulties for prospective biology teachers in understanding and analyzing critical scientific papers in the PjBL stage, such as in botany learning. It is a science that involved the investigation process. Students have high opportunity to find their own concepts. Thus, the PjBL approach is an innovative learning model for developing the activities of prospective biology teachers. Therefore, the scaffolding of information literacy is needed. Specific skills, such as reading, understanding, and interpreting scientific articles, are the most difficult tasks for students (Porter, 2005; Alghail & Mahfoodh, 2016). Thus, the scaffolding of information literacy is integrated into the learning process through a PjBL model. The scaffolding of information literacy is needed to simplify the acquisition of information literacy skills by prospective biology teachers, which reduces the complexity through assignments and guidance from lecturers.

Scaffolding provides some assistance to solve problems during the initial stage of learning and an opportunity to become independent gradually. It requires a lecturer (or a more experienced peer) as a pedagogical agent to diagnose, clarify, and guide the learning task. Scaffolding can be both static and dynamic. According to Molenaar et al. (2011), in static scaffolding, the lecturer does not assist but only gives instructions that help in learning activities for all students. Dynamic scaffolding requires pedagogical agents to diagnose, clarify, and provide support for learning tasks (i.e., monitoring students' learning progress and providing scaffolding when required in the learning process). In an innovative learning setting, both static and dynamic scaffolding can support and improve the regulation of cognitive activity, in turn improving learning and attainment (van de Pol et al., 2010; Wu et al., 2017).

Mishra (2013) also defined scaffolding as a concept closely related to the idea of the Zone of Proximal Development (ZPD). In the PjBL model, students need to study and work in groups according to their ZPD and require the assistance of lecturers or skilled colleagues, based on which they can become increasingly independent.

A component of the scaffolding of information literacy in the present study was analyzing and critiquing the quality of information obtained from a local paper and two international papers during a semester. The information in recent bibliographic and internet sources is often untrustworthy. Instruction in biological information helps the development of greater depth in the criticality of learning materials and assessment. Similar to Porter (2005), more attention regarding focus and time was given to students over a semester for assignments and project-based work.

In addition, scaffolding information literacy plays a vital role in evaluating the quality of research papers through scientific writing. Scientific writing assistance was undertaken to guide prospective biology teachers as an outcome of the PjBL model. Plagiarism is a fraud and in violation of legitimate dealing. Scaffolding information literacy is correlated with the second indicator of TOSLS, which covers organizing, analyzing, and interpreting quantitative data and scientific information. Specifically, the TOSLS sub-indicators, including: (1) organizing, analyzing, and interpreting quantitative data and scientific information; (2) creating graphical representations of data; (3) reading and interpreting graphical representations of data; (4) solving problems using quantitative skills, including probability and statistics; (5) understanding and interpreting basic statistics; and (6) justifying inferences, predictions, and conclusions based on quantitative data.

Uno (2009) emphasized that botanical literacy needs to be enhanced among prospective biology teachers. Botanical literacy is concerned with the economic welfare of a country related to food in the international market. These days, countries need a supply of scientists, engineers, and technically trained personnel to produce new high-tech products. To enhance botanical literacy, students need solid foundations for building science experience, understanding the scientific process, and conducting investigations that lead to an understanding of biological content. Another key to improving botanical and scientific literacy is through investigative instruction, which has been advocated for years by several publications and science education groups; one of these is project-based modeling.

The results of the present study showed that scaffolding information literacy to develop botanical literacy led to significantly higher scores in the experimental class than in the control class. Saglam et al. (2017) stated that there are many different concepts of literacy, such as technological literacy, world literacy, and critical literacy, including botanical literacy, as introduced by Uno (2009). Information literacy has characteristics that differ from those of other literacy concepts: information literacy can influence and support all other types of literacy. Information literacy was considered an essential ability in the 21st century, and in this regard, learning was a necessity, paving the way for enhancing information literacy (Bhimani, 2011; Sural & Dede Bali, 2018).

The development of information technology in the 21st century shows the increasing importance of information literacy. Previously, information sources were dominated by print media, such as books, newspapers, journals, and offline government-based publications, but now information is available in more diverse forms, such as via databases and the internet. The development of information technology has had a substantial impact on education and will continue to change the methods of learning, programs, and the roles of teachers and students (Saglam et al., 2017; Ratheeswari, 2018). Owing to the need for education in the 21st century, it is necessary to inculcate the competencies required for teachers to become literate, mainly using instructional technology in the learning process.

Drea (2011) noted that botanical literacy among prospective biology teachers needs to be improved due to the importance of food security and biodiversity issues. It may be possible to utilize and exploit food safety and the threat of biodiversity to highlight its relevance. The role of plants is related to the survival of humankind. This notion can be embedded in learning activities at the school level, ultimately providing more effective opportunities for exploitation in the higher education system. To address today's food crisis and prospects is necessary. Some studies that have been done in recent years have shown an alarming decline in botanical studies in higher education institutes.

CONCLUSION

The present study indicates that the scaffolding of information literacy has a significant effect on botanical literacy among prospective biology teachers. The findings of the current study suggest that innovation in botany learning, in

this case, scaffolding scientific literacy, can improve the botanical literacy of biology education students. It is necessary to undertake learning innovation with biology education students in a professional manner to enable them to transfer knowledge using scaffolding information literacy to their prospective students.

REFERENCES

- Aldabbus, S. (2018). Project-based learning: implementation & challenges. *International Journal of Education, Learning and Development*, 6(3), 71-79.
- Alghail, A. B. A., & Mahfoodh, O. H. A. (2016). Academic reading difficulties encountered by international graduate students in a Malaysian university. *Issues in Educational Research*, 26(3), 369-386.
- Boholm, Å., Larsson, S. (2019). What is the problem? A literature review on challenges facing the communication of nanotechnology to the public. *Journal of Nanoparticle Research*, 21, 86.
- Bhimani, N. (2011). Information literacy: A 21st-century graduate skill. *Middlesex Journal of Educational Technology*, 1(1), 44-50.
- Bikmaz, F. H., Celebi, O., Ata, A., Ozer, E., Soyak, O., & Recber, H. (2010). Scaffolding strategies are applied by student teachers to teach mathematics. *The International Journal of Research in Teacher Education*, 1, 25-36.
- Capraro, R. M., Capraro, M. M., & Morgan, J. R. (2013). *STEM project-based learning: an integrated Science, Technology, Engineering, and Mathematics (STEM) approach (2nd ed)*. Rotterdam: Sense Publishers.
- De Champlain, A. F. (2010). A primer on classical test theory and item response theory for assessments in medical education. *Medical Education*, 44(1), 109-117.
- Drea, S. (2011). The end of the botany degree in the UK. *Bioscience Education*, 17(1), 1-7.
- Freeman, E., & Lynd-Balta, E. (2010). Developing information literacy skills early in an undergraduate curriculum. *College Teaching*, 58, 109-115.
- Gormally, C., Brickman, P., & Lutz, M. (2012). Developing a Test of Scientific Literacy Skills (TO-SLS): measuring undergraduates' evaluation of scientific information and arguments. *CBE Life Sciences Education*, 11(4), 364-377.
- Hemingway, C., Dahl, W., Haufler, C., & Stuessy, C. (2011). Building botanical literacy. *Science*, 331(6024) 1535-1536.
- Hubbard, K. E., & Dunbar, S. D. (2017). Perceptions of scientific research literature and strategies for reading papers depend on academic career stage. *PloS one*, 12(12), e0189753.
- Lasauskiene, J., & Rauduvaite, A. (2015). Project-based learning at university: teaching experiences of lecturers. *Procedia - Social and Behavioral Sciences*, 197, 788-792.

- Leedy, P., & Ormrod, J. E. (2018). *Practical Research: Planning and Design*. New York City: Pearson
- Leksono, S. M., Rustaman, N., & Redjeki, S. (2013). Kemampuan profesional guru biologi dalam memahami dan merancang model pembelajaran konservasi biodiversitas di SM. *Cakrawala Pendidikan*, 32(3), 408-419.
- Mishra, K. R. (2013). Vygotskian perspective of teaching-learning. *Innovation: International Journal of Applied Research*, 1(1), 21-30.
- Molenaar, I., Van boxtel, C. A. M., & Sleegers, P. J. C. (2011). Metacognitive scaffolding in an innovative learning arrangement. *Journal Instructional Science*, 39(6), 785-803.
- Porter, J. R. (2005). Information literacy in biology education: an example from an advanced cell biology course. *Cell Biology Education*, 4(4), 335-343.
- Ratheeswari, K. (2018). Information communication technology in education. *Journal of Applied and Advanced Research*, 3(1), 45-47.
- Saglam, A. Ç., Çankaya, I., Üçer, H., & Çetin, M. (2017). The effect of information literacy on teachers' critical thinking disposition. *Journal of Education and Learning*, 6(3), 31-40.
- Sari, M. S., Sunarmi, S., Sulasmi, S., & Eko, S. (2018). Pengaruh model pembelajaran berbasis proyek terhadap keterampilan literasi botani mahasiswa calon guru biologi. *Jurnal Pendidikan Biologi*, 9(2), 1-11.
- Saripudin, A., & Wardani, S. (2015). Characterized Project based learning to improve critical thinking skill.
- Safaruddin, S., Ibrahim, N., Juhaeni, J., Harmilawati, H., & Qadrianti, L. (2020). The Effect of Project-Based Learning Assisted by Electronic Media on Learning Motivation and Science Process Skills. *Journal of Innovation in Educational and Cultural Research*, 1(1), 22-29.
- Sural, S., & Dedejali, D. (2018). A study of curriculum literacy and information literacy levels of teacher candidates in department of social sciences education. *European Journal of Educational Research*, 7(2), 303-317.
- Syukriah, S., Nurmaliah, C., & Abdullah, A. (2020, February). The implementation of project-based learning model to improve students' learning outcomes. In *Journal of Physics: Conference Series* (Vol. 1460, No. 1, p. 012064). IOP Publishing.
- Taber, K. S. (2018). Scaffolding learning: Principles for effective teaching and the design of classroom resources. *Effective teaching and learning: Perspectives, strategies and implementation*, 1-43.
- Tamim, S. R., & Grant, M. M. (2013). Definitions and uses: case study of teachers implementing project-based learning. *Interdisciplinary Journal of Problem-based Learning*, 7(2), 72-101.
- Uma, V. (2014). Information Literacy in the Digital Era: Best practices of IGM Library, University of Hyderabad. In *National Conference on Role of Library Associations in Promoting Information Literacy in the Knowledge Society*, Vijayawada.
- Uno, G. E. (2009). Botanical literacy: How and what students should learn about plants. *American Journal of Botany*, 96(10), 1753-1759.
- van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher-student interaction: A decade of research. *Educational Psychology Review*, 22, 271-296.
- Wu, C. H., Chen, Y. S., & Chen, T. G. (2017). An adaptive e-learning system for enhancing learning performance: Based on dynamic scaffolding theory. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(3), 903-913.
- Zajkov, O., & Mitrevski, B. (2012). Project-based learning: dilemmas and questions! *Macedonian Physics Teacher* 48, 1-11.