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Scientific writing skills activity: A strategy for empowering botanical literacy

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ABSTRACT

Botanical literacy makes students more familiar with the potential of botany in their area, especially plants that are beneficial to their lives. Science Writing Task has been proven to be able to increase students' scientific literacy. However, there has been no study discussing the effect of Science Writing Skills on botanical literacy. This study aimed to determine the effect of the Science Writing Task in improving students' botanical literacy. This research uses a mix-methods design strategy with an embedded model. The research using a cluster random sampling technique. The research subjects were 84 students of the Department of Biology in the 2018/2019 academic year. The research conducted at the Plant Structure and Development course. Quantitative data analysis used the ANCOVA test. Qualitative data analysis used data reduction. The results showed differences in the botanical literacy scores of students who were taught learning without the Science Writing Task and learning with the Science Writing Task, where learning with the Science Writing Task had higher botanical literacy. Based on qualitative data, students' understanding of botanical literacy is getting better, this can be seen from students' answers during learning. This study concludes that the Science Writing Task affects improving student botanical literacy.

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INTRODUCTION

Global society must face complex challenges associated with food, health, and environment. However, students often lack literature skills on botanical subjects and not familiar with plants (Drea, 2011). Wandersee and Schussler (in Strgar, 2007) coined the term of "plant blindness" as the human inability to observe and understand the importance of plants on their surrounding environment. "Botanical literacy" was first proposed by Uno (2009) which refers to biological literation emphasizing on the botanical materials. Uno then expanded the indicators of botanical literacy into four levels: nominal, functional, conceptual, and multidimensional (Uno, 2009).

One of the factors which causes botanical illiteracy in the class is many teachers only emphasize the importance of memory skills based on factual knowledge (Dunlosky et al., 2013). Meanwhile, the critical thinking, analysis and evaluation skills are not well-developed during that process. Hence, to respond to this problem, it is important to develop a strategy to improve botanical literacy in the teaching process (Uno, 2018). Several researches in Biological Education expressed that there is a phenomenon of botanical illiteracy or plant blindness in the society (Balding & Williams, 2016; Hemingway et al., 2011; Jose et al., 2019). The observation result on the first-year college students taking Basic Botany Course, such as Plant Structure and Development in the Universitas Negeri Malang (UM) Department of Biology, showed that 70% students were not familiar with plants after conducting the test using the botanical literacy test instrument (Uno, 2018). Further observational test based on their educational experience in schools showed that many students have the perception that botany is a boring subject as it requires a lot of memorizations. Pettit et al. (2014) described that the declining interest on botany subjects on the undergraduate level will lead to a fewer prospective educators or researchers with sufficient knowledge of botany which then may lead to a lower level of botanical knowledge in the society.

One of the strategies to overcome the botanical illiteracy is through scientific writing (Balgopal & Wallace, 2013). Through Scientific Writing students practice communicating their ideas so that their literacy will develop (Krajcik & Sutherland, 2010). Yore, Hand, and Prain (1999) stated that scientific writing is an epistemological tool that allows the development of knowledge and logical thinking through self-improvement towards scientific literation. Besides, scientific writing is also one of the important tools in problem-solving and it is also considered as a part of scientific development. Therefore, scientific writing skills are important to be developed for an academician. Ritchie et al., (2011) also explained that scientific writing, reading, and verbal communication is the goals that wants to be achieved through scientific literacy, which implies that these three skills are important to reach scientific literacy.

Scientific writing allows students to perform an independent study and establish their own perspective (Kramer & Kusurkar, 2017). Nonetheless, this autonomy also requires a supervisor from their lecturers (Kusurkar & Croiset, 2015) who evaluate student's development (G. Hansen & Ringdal, 2018; Schildkamp et al., 2020; Sullivan, 2020). Moreover, scientific writing also supports students to construct their independent thinking and knowledge (Poole et al., 2021). Hence, if scientific writing is repetitively trained to the students, then it is expected to help students to improve and expand their process of thinking, as well as acts based on scientific thinking (Poole et al., 2021).

On the other hand, feedback during the learning process is also important to motivate students to improve their learning quality (Andersson & Palm, 2017). Formative evaluation is not always applied in the long term which makes it difficult to observe its effectiveness to the students (Aslam & Khan, 2021). According to the meta-analysis performed by Dignath and Büttner (2008), a formative intervention doesn't need a long-time exposure to improve students' self-regulated learning. In addition, this self-regulated learning is also affected by the independent study done by students. As mentioned by Dresel and Haugwitz (2008), self-regulated learning also affects students' motivation and study result.

Moreover, there any many biology-based researchers that emphasize the importance of scientific writing (Ritchie et al., 2011; Tonissen et al., 2014; Yore et al., 1999) to build the scientific literacy, including botany (Pettit et al., 2014a). However, only a few studies that can prove that scientific writing can empirically influence the study process. Besides, mastering biological subjects, including botany, is an essential skill required by teachers (M. H. H. Hansen & Sillasen, 2020). Therefore, this study aimed to determine whether scientific writing activity can influence the botanical literacy of the prospective Biology Course Teacher.

METHODS

Participant

As many as 84 participants (11 male and 73 female) from first-year students 2018/2019 of the Department of Biology, Universitas Negeri Malang, were randomly selected to participate in this study. A random sampling technique was utilized for the sample collection method to prevent the subjectivity on determining the experimental class and control class.

Instruments

The botanical literacy test (Uno, 2009), which consists of four different levels; nominal, functional, conceptual, and multidimensional level, was used in this study. This test consists of 25 items: 20 items of multiple choices (5 different answers) and 5 items of essay. The expected outcome of this test is the level of students' botanical literacy. The study flow was started with pre-tests and continued with post-tests. The questions for post-test have been tested for its validity and reliability on 20 students in the previous study. The results of the validity test using the Pearson test show that all items have a sig value <0.05, so all items are feasible to use. While the results of the reliability test using Cronbach Alpha show a value of 0.83, which means the instrument is reliable.

Design and Research Procedure

This research was carried out using mixed method with embedded model (Creswell, 2012). This section was carried out to obtain quantitative and qualitative data; in which the qualitative data supported the quantitative data. The schematic is shown at Figure 1.

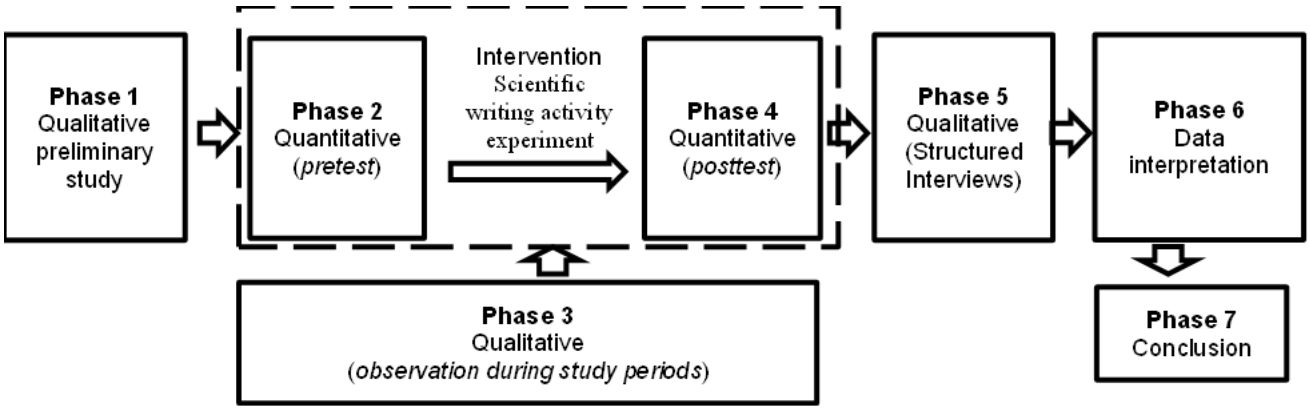

Figure 1. Schematic of mixed methods with embedded model (Creswell, 2012)

For the 1st phase, the qualitative research was conducted by performing a preliminary study on the students taking Plant Structure and Development at start of the course. Afterwards, the quantitative research was done using the Quasi experimental pre-test and post-test control group design. The Quasi Experiment was conducted for one semester. The quantitative data obtained from the pre-test (2nd phase) and post-test (4th Phase) represents the level of botanical literacy. Qualitative data from the intervention (3rd Phase) were obtained from observation. Tasks were given to the experimental class by giving the scientific writing task using, meanwhile verbal communication tasks using PjBL model were given to the control class. The scientific writing task has been evaluated using the scaffolding formative assessment in the form of Writing and Concept Understanding that adapted form Larkin (2015) and peer-review evaluation. The Writing and Concept Understanding category consists of eight aspects: abstract, organization, introduction, knowledge synthesis, relation between key-knowledge concepts, summary, accuracy, and references. However, we only focused on introduction, botanical synthesis, and relation between Botanical-key concept with the choosen topic, and summary. The writing task is a product from project-based learning model with mobile learning media with scientific article as the expected product. These tasks were gradually given throughout the semester and has been informed to the students in the beginning of the class. The project-based learning model were started with one selected topic, namely plant exploration from surrounding environment which focused on one plant. Further, the students were asked to describe the plant by focusing on the structural variation, function, and their development in a population. Students were also asked to analyze the roles of the plant by

using secondary data from the reference book which can help to identify and utilize its good roles, whether for food, health, and environment.

Furthermore, the following questions were asked to the participants during the 5th Phase:

1. Did your motivation to study the Plant Structure and Development increase after receiving scientific writing task?
2. Did the scientific writing task force you to understand better about the concept and material associated with the Plant Structure and Development?
3. Based on your experience, did the scientific writing task improve your botanical literacy? Please explain why.
4. Did you face any obstable while completing the writing task related to plant structure and development? Please explain briefly.
5. Do you think that this scientific writing task is meaningful to you? Please briefly explain the reason.

In the 6th phase, the collected quantitative and qualitative data were analyzed and interpreted. The confirmation phase was performed by using the quasi-experimental and triangulation. The mixed-method design was carried out to expand and deepen the understanding of the research questions. Moreover, the specific aim of the quantitative data analysis was to empirically determine the effect of the scientific writings project towards botanical literacy. The last phase (7th phase) was carried out to draw the conclusion.

Data analysis

Quantitative data obtained from both pre-test and post-test of the botanical literacy were analyzed using Analysis of Covariance (ANACOVA). The results of pre-test were used as the covariate variable for the students' prior knowledge. The qualitative data obtained from the observation and structured interviews given to the students who participated on experimental class was then analyzed using content analysis (Cohen et al., 2018).

RESULTS AND DISCUSSION

The results showed that the scientific writing activity were able to improve and increase the botanical literacy of the prospective Biology Course Teacher.

Botanical Literacy

The results of botanical literacy analysis that obtained from pre-test and post-test is presented in Table 1. Based on Table 1, the significance value of Class < 0.05, which means that Ho was rejected, and Ha was accepted. This indicated that there are significant differences on the level of students' botanical literacy between classes given with scientific writing assignments and classes given with verbal communication tasks.

Table 1.
Results of Botanical Literacy Analysis

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	6627.527[a]	2	3313.764	36.970	.000
Intercept	1014.433	1	1014.433	11.317	.001
Pretest_botanical_literacy	3873.573	1	3873.573	43.215	.000
Class	2799.335	1	2799.335	31.230	.000
Error	7260.439	81	89.635		
Total	285730.004	84			
Corrected Total	13887.966	83			

Descriptive analysis was also carried out to calculate the difference in the mean posttest scores of botanical literacy in each class to see how big the difference in the mean was in each class. The results of this analysis can be seen in Table 2. Based on Table 2, the corrected average differences between classes being taught with scientific writing tasks and verbal communication tasks was 11.99079.

Table 2.
Corrected Average

Treatment	Pre-test Average	Post-test Average	Difference	Increasement	Corrected Average
Experiment	42.01952381	62.61357143	20.59405	49.01066398	62.88075
Control	42.12428571	51.15714286	9.032857	21.44334792	50.88996

Measurements for each aspect were carried out to see how many participants scored botanical literacy at the not enough, enough, good, and excellent levels. The results of formative assessment through the scientific writing and concept understanding are presented in Figure 1. The results of this measurement indicate that most students have good botanical literacy in each indicator. Only a small number of students are at the level of enough and not enough.

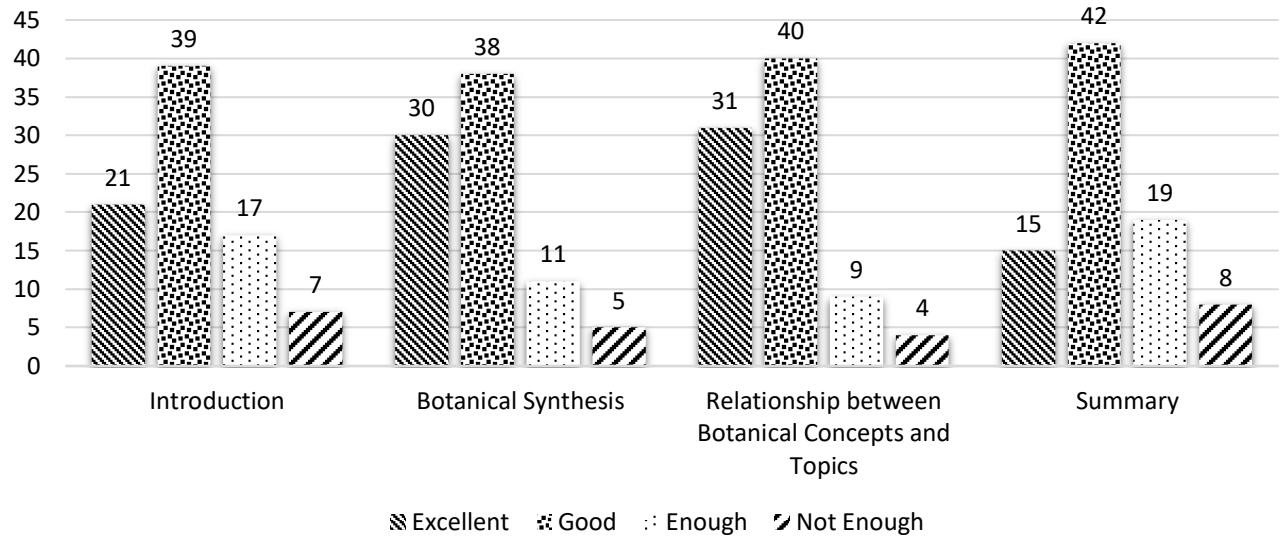

Figure 1. The Results of Formative Assessment of Scientific in Each Indicator

The Results of a Qualitative Approach

The results of open questions given to the experimental classes are as follows.

1. **Did your motivation to study the Plant Structure and Development increase after receiving scientific writing task?**

In general, students answered that it was challenging to do writing tasks. In addition, they also felt responsible because the research data would be obtained from themselves.

These results are as shown by the following respondents:

"*I have never written scientifically, so I feel the need to learn more*" (Respondent no 58)

"*The assignment of this course for scientific writing makes me study harder*" (Respondent no 24)

2. **Did the scientific writing task force you to understand better about the concept and material associated with the Plant Structure and Development?**

Students stated that in their science writing project tasks, they were given a rubric that demanded botanical synthesis and relationship between main botanical concepts and the topic of the article.

These results are as shown by the following respondents:

"*When writing scientifically, I use the latest sources, so I get new information about the material in lectures*" (Respondent no 8)

"*I get new information from articles when writing scientifically*" (Respondent no 21)

"*Scientific writing makes me understand material that previously confused me*" (Respondent no 76)

3. **Based on your experience, did the scientific writing task improve your botanical literacy? Please explain why.**

The students answered that the lecturer gave a pre-test with a botanical literacy test at the beginning of the lesson. According to the results of pre-test, the level of students' botanical literacy was categorized as low. Some of the answers explained that botanical synthesis and relationship between material

concepts and topics given through rubric were able to improve the level of botanical literacy. These results are as shown by the following respondents:
"*I got a lot of information about new plants that are beneficial to humans*..." (Respondent no 14)
"*I became more aware of the function of each plant that I studied*" (Respondent no 16)

4**. Did you face any obstable while completing the writing task related to plant structure and development? Please explain briefly.**

The main obstacle in science writing tasks is lacking on understanding the concept of plant structure and development material, which made students received several feedbacks from friends and lecturers. These results are as shown by the following respondents:
"*I find it difficult to understand scientific articles that I get from the internet, especially those in English*" (Respondent no 66)
"*I have difficulty writing scientifically using many references*" (Respondent no 51)

5. **Do you think that this scientific writing task is meaningful to you? Please briefly explain the reason.**

Students stated that the scientific writing tasks using their own research data through observing the surrounding plants was more meaningful than a test which required a lot of memorization. These results are as shown by the following respondents:
"*Yes, I can practice understanding the function of each plant, besides that I can also practice expressing my ideas scientifically*" (Respondent no 27)

The results presented on Table 1 indicated a significant difference in the mean of botanical literacy between classes taught with PjBL + scientific writing assignments and classes taught with PjBL + oral communication. In addition, the average increasement in the experimental class taught with PjBL + scientific writing tasks was higher than the class taught with PjBL + oral communication. This result is in line with previous studies conducted by (Wright, 2008) showing that science writing can trigger students to expand their knowledge and thinking. Through scientific writing, students will practice organizing various sources of knowledge (O'Flaherty & Costabile, 2020) that they encounter, so that it will improve their literacy.

Several studies have been conducted to investigate how scientific writing improves various aspects of both students' cognitive and scientific behavior. For example, writing science can increase the complexity of writing scientific explanations (Klein, 1999). Keys et al. (1999) who used scientific writing activities as a tool for learning laboratory activities in secondary science found that scientific writing can improve students' understanding of the nature of science. Hand, Hohenshell, and Prain (2007) explained that there was an improvement in students' understanding of cell concepts and molecular biology. They found that various types of non-conventional writing did help students to learn biology.

The results of this study indicated that the effectiveness of scientific writing tasks is also supported using an appropriate learning model, namely Project-Based Learning. Discussion and feedback provided by the lecturers while students are working on a project can directly form their conceptual framework about the theory/material used in the project (Koh et al., 2010). In addition, the use of project-based learning can also develop students' logical thinking skills (Sasson et al., 2018). Chen and Yang (2019) explained that project-based learning can improve student learning outcomes. However, in the review, the improvement is also influenced by several things, such as the time of instruction given, group size, school location, learning stages, and the type of project given to students (Chen & Yang, 2019). The effectiveness of Project-Based Learning to improve learning outcomes has also been carried out in several field of sciences, such as science (Tesi Muskania & Wilujeng, 2017), wave and optical materials (Suryandari et al., 2018), biology in biotechnology materials (Movahedzadeh et al., 2012), healthy living habits and stress management (Lucas & Goodman, 2015), technical knowledge related to space engineering (Rodríguez et al., 2015), and engineering courses (Cifrian et al., 2020).

The results of this study indicated that after treatment, there was an improvement on the level of botanical literacy, from less to enough, and from enough to good, although none of the participants belong to high level botanical literacy yet. The criteria that were mostly improved based on the feedback given by both friends and lecturers were indicators of synthesizing plant botanical material and connecting the concepts of structure and plant development. These results indicated that scientific writing assignments were able to improve the botanical literacy of prospective biology teachers compared to verbal communication tasks. The result of botanical literacy improvement is not separable from the application of rubric of writing and concept understanding (Larkin, 2015) as the formative

assessments. The rubric that was used emphasized the synthesis of botanical material and the relationship of botanical concepts with the selected topic. Rubrics, as formative assessment instruments, are more effective than checklists and rating scales.

Formative assessment, such as rubrics, allows students to improve the quality of their scientific writing to achieve a better description of the assessment than what was previously obtaine. The improvement criteria that were mostly performed according to the feedback from both friends and lecturers were synthesizing botanical material, especially plant structure and development, and connecting the concept of plant structure and development. The criteria consist of four descriptions of the rating levels: less, sufficient, good, and excellent. Students with rubric instruments were able to do self-reflection towards the evaluation through discussion with friends and lecturers, as well as reviewing each criterion and the evaluation to improve the article writing skills. The discussion activity was chosen because this activity is expected to be able to understand students' abilities and knowledge (Herranen et al., 2020). The use of rubrics is more effective than checklist and rating scale instruments as rubrics consist of criteria and descriptions of performance levels (Brookhart, 2013).

Giving review during the learning process also increases students' awareness to always improve the quality of their learning. Trautmann (2009), who analyzed the impact of providing feedback on revised research reports written by undergraduate science students in a computer-supported collaborative environment, concluded that receiving peer reviews is positively associated with a better revision. The quality improvement in learning is also determined by the attitude of the teacher in conducting the assessment (Schildkamp et al., 2020). Teachers with negative attitudes towards formative assessment (psychological factors) are unlikely able to work on their data literacy and assessment (knowledge and skills). In contrast, teachers who collaborate with other teachers and students (social factors) tend to learn from these interactions (knowledge and skills) (Schildkamp et al., 2020).

Botanical literacy improvement through scientific writing activities can be demonstrated through the Uno botanical literacy instrument (Uno, 2009). The improvement in botanical literacy achieved through scientific writing activities forces students to improve botanical literacy from a nominal level to a conceptual level through the process of thinking. For example, one of the questions asked by the students was as follows: "When viewed from the structure of the vegetative organs, why are plants in the surrounding environment dominated by groups of plants with closed seeds?". On the other hand, the improvement of students' literacy is also influenced by the emotional intelligence (Akpur, 2020), the will to become a good educator (Kasalak & Dağyar, 2020), the training received in their childhood (Dong et al., 2020; Justice et al., 2020), etc.

Students should be able to develop thinking process to improve botanical literacy because they are faced with various plants in their surrounding environment. This statement is in accordance with the opinion proposed by American Association for the Advancement of Science (AAAS) (2011) that learning biology requires new skills to overcome the challenges of the 21st century, including the ability to logically and rationally respond to the growing challenges, such as the challenges on preserving the environment, as well as improving human health and quality of life (Ydesen & Andreasen, 2020). In addition, understanding and learning science are expected to improve students' experience in developing their literacy (Hellgren, 2019). Baker et al. (2009) expressed that to achieve multidimensional literacy levels in all scientific domains, then several stages are required to be done gradually.

Effective science writing skills can deepen the understanding of a topic by forcing authors to present logical arguments supported by previous research and present results (Turbek et al., 2016). Norris and Phillips (2003) added that writing skills require critical thinking in processing information. Klimova (2014) stated that many students have oral communication skills, but only few that capable to write well. Skills in scientific writing are more complex in developing logical thinking, engaging students in scientific discourse, and promoting the meaningfulness of scientific findings along with its explanations (Yore et al., 1999).

The limitation of this research is the limited number of respondents. In addition, the participants in this study were first-year students, so their experience in scientific writing still needs to be trained at the beginning of the meeting. The results of this study can be a reference for teachers or lecturers in choosing the right strategy to improve their students' scientific literacy, especially botanical literacy. Practicing students' scientific writing skills in the early years is also very useful for the continuity of

their studies in the following year. Things that need to be considered in subsequent research are the characteristics of the respondents, especially those related to the year of study, because their skills in reasoning will be different.

CONCLUSION

Scientific writing activities can increase botanical literacy from a nominal level to a conceptual level. Formative assessment provides feedback to students to assist students in developing scientific writing skills that have an impact on improving botanical literacy. The interaction between scientific writing and formative assessments makes students become more motivated and faster to improve the quality of their learning.

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