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The Improvement of Prospective Teachers' Life-long Learning during the Plant Diversity Course with 5E+e Inquiry

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abstract

Not a few students who have difficulty interpreting the material being studied in terms of life encourage the need for a paradigm shift in science learning, which is directed at lifelong learning. In this paper, an entrepreneurship-oriented 5E (Engagement, Explain, Exploration, Elaboration, and Evaluation) inquiry learning program is developed, which is also often called 5E+e. This research investigates the improvement of lifelong learning for the prospective teachers during the 5E+e inquiry in the plant diversity course. The quasi-experimental method with a one-group pretest-postest design was used. The research subjects were taken by purposive sampling, namely the fifth-semester students of the Biology Education Study Program at one of the Teachers Institution in Central Java with 31 participants. Data were gathered using a questionnaire filled out by students before (pre) and after (post) the treatment of the 5E+e inquiry learning and observation. The data analysis was carried out in both quantitative and qualitative-descriptive manners to make a comprehensive conclusion. The results revealed that the average lifelong learning score of prospective teachers compiled with rubrics had increased between before (2.68) and after being given the program (3.26) with a maximum score of 4.00. Thus, it can be concluded that the entrepreneurship-oriented inquiry learning program applied to the plant diversity course can increase the lifelong learning of prospective teachers.

1. Introduction

The rapid development of science has increasingly been felt in various aspects of life, eventually resulting in the Industrial Revolution 4.0. One indication is the increasingly convergent connectivity and interaction among humans, machines, and other resources. On the other hand, the Industrial Revolution 4.0 movement in various sectors often overrides biological resources' sustainability aspects (Ayu, 2017). Indonesia has a wealth of abundant biological natural resources, such as biodiversity in tropical forests. Therefore, strategic efforts are needed to balance scientific development and the preservation of sustainable biological resources. Hence, the learning of science, especially biology, must be oriented to providing lifelong learning for future generations, especially the integration of advances in biology and technology that can produce useful innovation and provide a real influence on life (Hayat & Rustaman, 2017). Science learning, which emphasizes mastery of concepts without the provision of lifelong learning, worsens unpromising conditions despite having a diploma at various education levels, thus challenging educators of pre-service teachers and education practitioners to find solutions (Rustaman, 2016). This is in line with the statement that the need for sustainable skills development will continue to be perceived by everyone of all ages because of many jobs in the future that have not existed today (Cummins & Kunkel, 2015).

Lifelong learning has become a keyword in almost all countries because of its increasing influence on education policies in the global world (Regmi, 2015b). Even today, Lifelong learning has become an international development agenda (Preece, 2013). For example, in Singapore, lifelong learning is a big topic in human resources, employment, entrepreneurship, and national education. The government has implemented lifelong learning in education to survive in this country (Ng, 2013). In other countries, such as China, lifelong learning has become a global phenomenon that significantly changes the basic form of a conventional national education system. It has the power to offer real changes for social goals that are maintained to a certain extent (Wang et al., 2017). Meanwhile, in Europe, lifelong learning is an EU priority that has been going on for a long time, emphasizing the main needs pursued by everyone (Ingham et al., 2016).

Lifelong learning must have meaningful and enjoyable learning goals. Student transformative learning results from happiness, joy, success, and transformative dispositions for lifelong learning and its various challenges, sufferings, and difficulties (Li, 2016). Such learning has been positioned pragmatically to support the country's modernist development projects, culminating in the proclamation to move from "made in China," a manufacturing-based economy, to "created in China," a knowledge-based economy (Shan, 2017).

To achieve its objectives, lifelong learning needs to be formulated in the formal education curriculum. This has been done in Ghana, which integrates lifelong learning in the National Qualification Framework (NQF). The application of the NQF in Ghana is based on the reports from several countries in the world that have shown the successful implementation of lifelong learning in the field of formal learning (Owusu-Agyeman, 2017). The curriculum formulation about lifelong learning is not only about the implementation strategy but also about the assessment that must be prepared properly as the results of the research (Nguyen & Walker, 2014), which found that lifelong learning assessment in a sustainable manner can develop students' abilities and knowledge expansively.

Answering these challenges, it is necessary to make a paradigm shift in science learning, especially biology. Learning that still pays attention to the principles of science but is more directed at providing lifelong learning to students on an ongoing basis. Based on this view, Biology learning or science learning cannot be separated from inquiry learning because both have relevant characteristics. It can even be interpreted that science's essence is inquiry itself, meaning that the essence of science has the same principles as inquiry (Rustaman, 2005).

Many experts have carried out various studies on inquiry learning. One of them is research on students' guidelines in developing an understanding of Scientific Inquiry (Stone, 2014). Other researchers are concerned with an assessment on inquiry, i.e., assessing the inquiry framework level as a heuristic for teacher professional development. This study compares students' involvement/activeness while learning with teachers who have long taught and with teachers who have just taught (Wheeler et al., 2015). Likewise, the research on the development of inquiry-based learning research in science education emphasizes the meaningfulness of inquiry, which is treated as scientific workability developed, applied, and measured during the learning process and as the acquisition of learning (Rustaman, 2005).

Based on some relevant research, there has been no inquiry research on Biology learning developed with an entrepreneurial orientation. This is an opportunity for further research. Entrepreneurship-oriented inquiry is to invite students to apply the experiences they have learned with the principles of inquiry into new situations to find authentic answers to problems that are solved individually or collaboratively and integrated with entrepreneurial values. Therefore, the authors offer entrepreneurship-oriented inquiry learning programs in biology courses as an appropriate strategy for providing lifelong learning for students. The learning program is an integration of the syntax of the 5E (Engagement, Exploration, Explain, Elaboration, and Evaluation) inquiry model, which was adapted from the Bybee framework (Bybee, 2009) with the values of entrepreneurship designed by the Consortium for Entrepreneurship Education (2004), so it is named inquiry 5E+e.

The 5E+e inquiry learning program was applied to the plant diversity course. This course is chosen because the content has the potential to be developed with entrepreneurship. For example, when students learn the concept of "branching patterns," they can determine what species are suitable for canopy plants in a garden. Another example is those who study the concept of "leaf skeleton" would think of making an herbarium or leaf skeleton creation, or when students learn the concept of "inflorescences," they can think of plants that are suitable to be used to make bouquets, wall hangings, or gardens. There are still many other concepts from this course that can be oriented towards entrepreneurship (Cronquist & Takhtajan, 1981).

When students study this course with the inquiry 5E+e learning program, it is expected that it will be able to provide students with lifelong learning. Students become more skilled at complex thinking, always process in advance every time they get information, are skilled in communication, collaborate well with teams, and make habits of mind the best practice in every learning (Marzano et al., 1994). The research problem is how to measure the improvement of prospective teachers’ lifelong learning before and after being given the program using a questionnaire in a rubric form. Besides, the development of prospective teachers' lifelong learning at each stage of the program being applied (basic, development, advance, and professional) is also measured using observation sheets in a rubric form. The lifelong learning standards measured include complex thinking standards, information processing, communication, collaboration, and habits of mind (Marzano et al., 1994).

This research focuses on "How is the improvement of prospective teachers' lifelong learning during the plant diversity course with 5E+e inquiry program?" It specifically addresses the following research questions: 1) what is the average score of the prospective teacher's lifelong learning before and after being given the 5E+e program? 2) what is the average score of prospective teachers' lifelong learning at each stage of the 5E+e program? And 3) how is the impact of the implementation of the 5E+e inquiry program on students' skills in learning?

2. Method

This research focuses on improving prospective teachers' lifelong learning during lectures on plant diversity with the 5E+e inquiry learning program. The research method used was a quasi-experiment with a one-group pretest-posttest design. This design is done by comparing pre-test and post-test results in the group being tested (Sugiyono, 2001).

This study's population were all prospective teachers in the fifth semester of the Biology Education Study Program at one of the Teachers Institution in Central Java. The research subjects were class VB, which came from the study population, amounting to 31 students who took the plant diversity course. The sampling technique used in this study was purposive sampling, meaning that the sample determination was due to certain considerations that met the criteria.

Data were collected using a questionnaire and observation sheet in the form of a rubric developed based on Marzano's life-long learning framework (Marzano et al., 1994). There are 20 rubric items created that represent five life-long learning standards, consisting of three items for complex thinking, three items for information processing, three items for effective communication, three items for collaboration, and eight items for habits of mind consisting of self-regulation, critical-thinking, and creative-thinking indicators. The rubric is made with a rating scale of 4, 3, 2, and 1 with descriptions according to the respective rubric items' content. Also, the data were collected using observation sheets.

The data collection procedure was carried out as follows: 1) the questionnaire was collected with two measurements; namely, the initial measurement (pre) carried out before the implementation of the program and the final measurement (post) after the implementation of the program. Each student was asked to choose one of the four best statements according to his situation on each item in the rubric so that the choice represents the life-long learning skills of the student, and 2) Observation sheets were collected by observing the activities and skills shown by students during program implementation.

The data collected from the initial and final measurements of the life-long learning rubric were then analyzed quantitatively by calculating each standard's total mean and mean. Besides, the calculation of n-gain of the initial and final scores of the prospective teachers' life-long learning was carried out. The data collected through the observation sheet were analyzed descriptively to strengthen the quantitative data. Then, triangulation was carried out to obtain a comprehensive interpretation of the data.

3. Result and Discussion

The research data that have been collected using prepared instruments can be described in two parts, i.e., the improvement of students' life-long learning as a whole and the improvement of students’ life-long learning based on their respective standards. Both types of data were analyzed descriptively. The explanation of the two types of data and the discussion is as follows.

Comprehensive improvement of life-long learning students

Overall, the data on the improvement of students' life-long learning collected through the rubric before and after the program implementation is illustrated in Figure 1. The data in

Figure 1 show that the mean score of students’ life-long learning improvement can be categorized as good, where the initial measurement mean score is 2.68 and the final measurement score after program implementation is 3.26 from a total score of 4.00.

Likewise, the N-gain value between the pre-test and post-test scores is 0.45 of the medium category. This means that there is a significant increase in the state before and after the program is given. The data are strengthened by the results of observations made at each learning stage, as shown in Table 1. Table 1 indicate the same interpretation as Figure 1 that students’ life-long learning represents good development at each stage. Thus, it can be stated that the 5E+e inquiry program has a significant influence on improving students’ life-long learning in the plant diversity course.

Specifically, the data in Figure 1 and Table 1 show that all life-long learning standards signify improvement. Among these five standards, the "Habits of Mind standard" shows a more progressive development. Based on Figure 1, the Habits of Mind initial measurement's standard score is at the third-highest position, which is a mean of 2.68, while the final measurement is the second-highest position with a mean score of 3.34. Likewise, with the data in Table 1, the Habits of Mind standard in stages I (basic) and II (development) are still in the third highest position, but in stages III (advance) and IV (proficient), it develops into the second-highest position. This condition indicates positive progress towards students' thinking habits during on plant diversity course with entrepreneurship-oriented inquiry learning programs.

Some facts from these developments can be described from observations. Firstly, when conducting practical work, the students tend to accomplish one type of work together, even just focusing on core activities. Therefore, the practical activity becomes inefficient and lacks planning. After participating in several courses with this program, students' habits develop rapidly, and they can do thorough planning before practicum, including preparing tools and materials needed in detail, arranging proportional strategies for group assignment, and reacting more sensitive to feedback. Secondly, in taking measures, the students would always consider carefully (not impulsively) and work tenaciously to find solutions even at the end of their knowledge. More importantly, the students finally own their respective standards at work.

Several previous studies stated that students' habits of mind developed well after being given formative assessment intensively during learning, given feedback, self-assessment, and peer assessment regularly (Sriyati et al., 2010). The students' habits of mind improvise well in the elective biology courses through learning, which has been given many conceptual problems (Gloria, 2017).

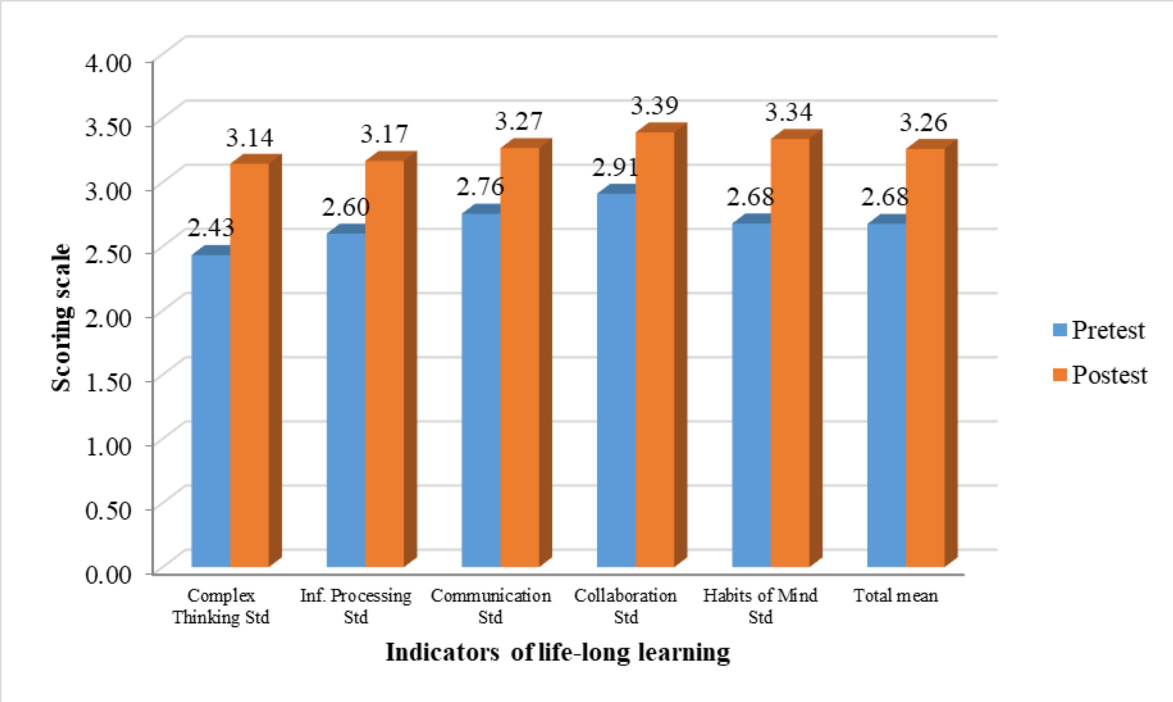

Figure 1. The total mean of students' life-long learning

Table 1. Life-long learning observation results at each program stage

No	Standards	Program stages			
		I	II	III	IV
1	Complex Thinking	2.01	2.41	2.96	3.30
2	Information Processing	2.20	2.52	3.09	3.44
3	Effective Communication	2.46	2.74	3.17	3.54
4	Collaboration	2.49	2.89	3.32	3.60
5	Habits of Mind	2.23	2.58	3.19	3.56
	Mean Score	2.28	2.63	3.15	3.49

Improvement of students life-long learning at each standard

This second part describes the improvement of life-long learning of the students who take part in the plant diversity course with the entrepreneurship-oriented inquiry program based on their respective standards. There are five life-long learning standards measured: complex thinking, information processing, effective communication, collaboration, and habits of mind. All these standards are described as follows.

Complex thinking standards

In this first standard, three items were measured using the rubric, comparing, classifying, and error analyses. The data on the improvement of life-long learning from the complex thinking standard are illustrated in Figure 2. Based on Figure 2, the mean of complex thinking standards increases, where the pre-program score is 2.43, and the post-program score reaches 3.14 from a total score of 4.00.

In this standard, the mean of all items has increased from the initial condition to the final condition after being given the program, and the pattern of improvement of the three items is consistent. Of the three items on the complex thinking standard, the items that experienced a higher increase were of "comparing," that is, with a final score of 3.27. Meanwhile, the "error analysis" item's score is 3.13, and the score of the "classifying" item is 3.03. A higher increase in "comparing" items than other items were due to learning activities in the plant diversity course, which had more hands-on activities by comparing plant species' characteristics.

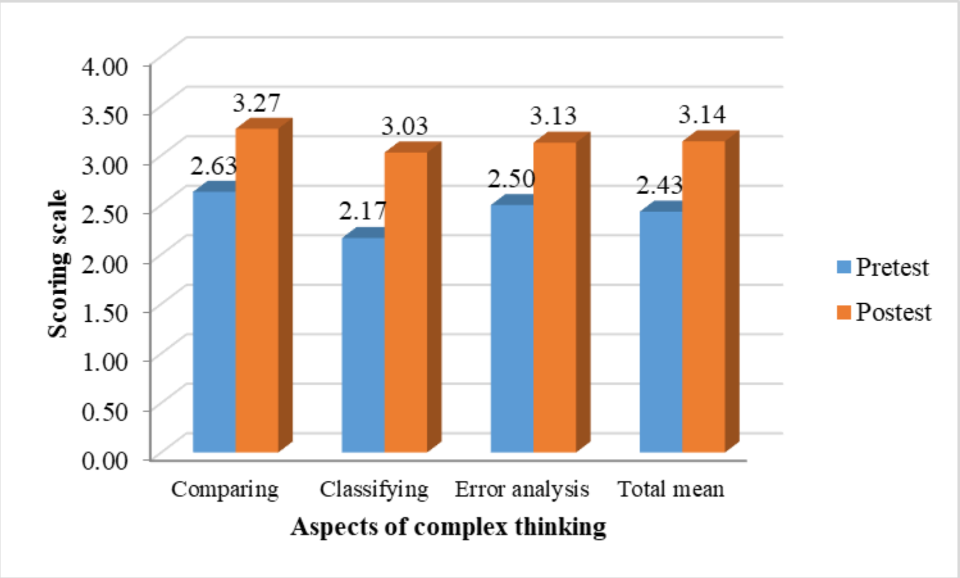

Figure 2. Mean Score of Complex Thinking Standards

Information processing standards

In the information processing standard, three indicators are measured, i.e., effectively interpreting and synthesizing information, recognizing where and how projects would benefit from additional information, and accurately assessing the value of information. The research data that describe the improvement of life-long learning in information processing standards are described in Figure 3. The data in Figure 3 show that life-long learning means students' scores on information processing standards have increased, from its initial measurements of 2.60 to a final of 3.17 from a total score of 4.00.

The scores of all items in the information processing standard have increased from the initial to final measurements. Among the three, the items of "accurately assessing the value of information" experienced a higher increase than other items with a final score of 3.27. The item is merely in the second-highest position at the initial measurement. The data indicate students' habits after following the program applied in the lectures on plant diversity. Usually, when the students get assignments or conduct specimen observation activities, they will immediately open a smartphone to find the main information about the object of observation, so they are very dependent on the smartphone every time they get the task.

After the implementation of the program, the students' habits change. When obtaining the task of observing specimens, the students identify the characteristics of the object observed in detail according to the guidelines on the Worksheet, instead of relying on the smartphone. Smartphones have more functioned as a tool to see whether the concepts found during the observation activities are correct. Thus, the students become more careful in assessing information that supports the concepts being studied.

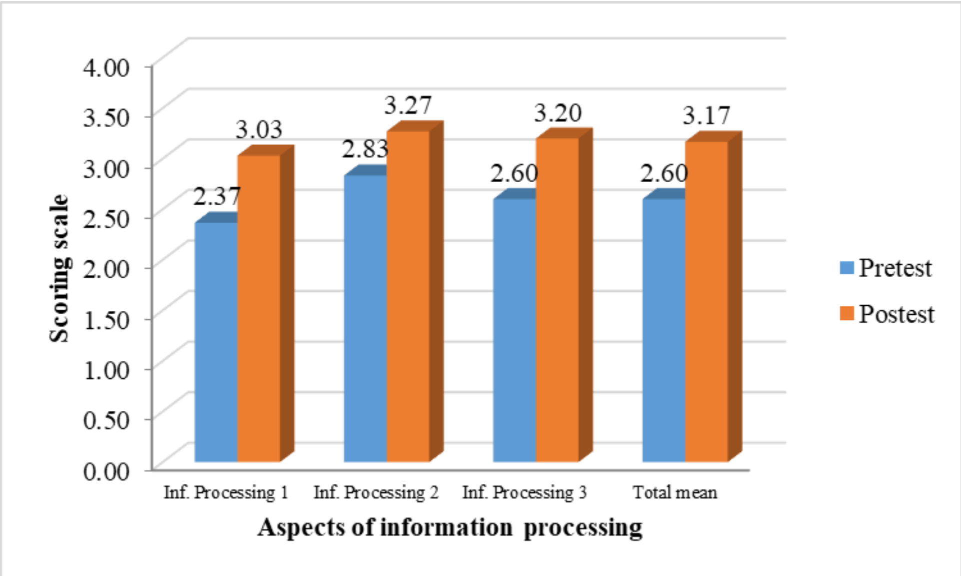

Figure 3. Mean score of information processing standards

Effective communication standards

This study's effective communication standard measures three life-long learning indicators, i.e., expressing ideas clearly, effectively communicating with diverse audiences, and creating quality products. The data on the improvement of life-long learning in effective communication standards are illustrated in Figure 4. In terms of the mean score, the students' life-long learning scores on effective communication standards have improved, with an initial score of 2.76 and a final score of 3.27 from a total score of 4.00.

The specific analysis of Figure 4 shows that items that have a significant increase over other items are of "effectively communicating with diverse audiences" with a final score of 3.47, which means that the learning program developed can train students' skills and mentality to communicate with diverse people's characters. The improvement is in consequence of encouragement toward the students to communicate with all their team members while working and alternately presenting their work in front of the class.

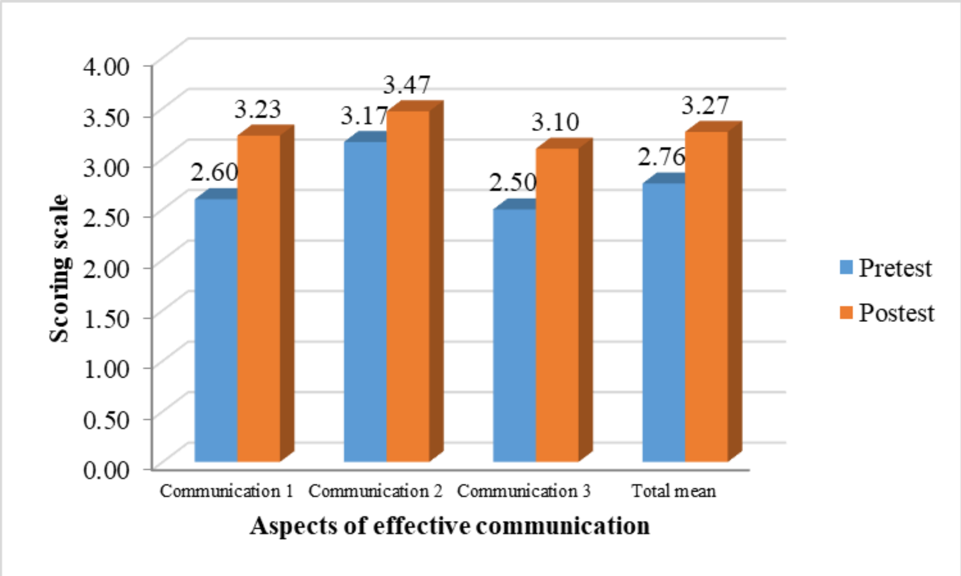

Figure 4. Mean score of effective communication standards

Collaboration/ cooperation standards

There are three indicators measured in the collaboration standard in this research, i.e., working toward achieving group goals, effectively using interpersonal skills, and effectively performing a variety of roles. The data on the collaboration standard are illustrated in Figure 5. On average, the collaboration standards of life-long learning based on Figure 5 show an increase, where the initial score is 2.91, and the final score is 3.39 from the total score of 4.00.

The specific analysis shows that all items in the collaboration standard experience an increase in general. There is one item that has a significant increase, i.e., "effectively using interpersonal skills." The improvement is due to many students who were guided to collaborate well with the team and understand each other's level of knowledge and character.

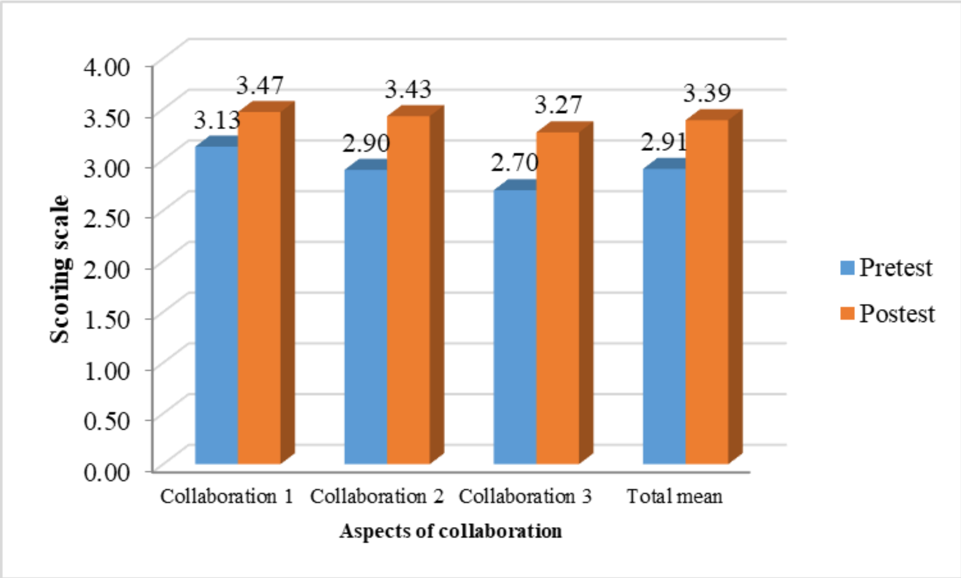

Figure 5. Mean Score of Collaboration Standards

Habits of mind standards

The habits of mind standard in Marzano's life-long learning framework have three indicators, i.e., self-regulation, critical thinking, and creative thinking. In this paper, the three indicators are measured using eight rubric items. The research data on the habits of mind standard are described in Figure 6. The research data in Figure 6 show that, on average, the improvement of students' life-long learning in the habits of mind standard is very good. This is indicated by the initial score of 2.68, which increased sharply to 3.34.

Specifically, from the data in Figure 6, we can analyze that all items show an increase in the scores. However, the highest score on this standard is item 5, which is "is sensitive to the feelings and level of knowledge of others." The data represent that during the learning process with this program, the students feel trained to be more careful in carrying out every action, know how to deal with their friends one by one with diverse character and level of knowledge, and become more critical in responding to each problem and situation.

The field's findings support the facts shown by the research data through the observation during the learning activities. Some findings that have been compiled include 1) on mean, the students become more skilled in complex thinking, such as in the process of identifying species, where the students always make comparisons with the reference characteristics and several other objects before determining the concept and also become observant in analyzing errors in lab work or experiments conducted to minimize errors. For example, the students identify that Hibiscus rosa-Sinensis' branching pattern is sympodial; 2) the students become accustomed to systematically processing information. When obtaining assignments, they become more selective in assessing the information that is received and do not rush to use it as a reference, become more effective in using various information-gathering techniques, and can synthesize information gathered from various sources; 3) they become more trained in communicating in front of many people and can create good learning products; 4) the students have more flexible interpersonal and can perform various roles in the team's duties; and 5) the habits of mind are established in every action, such as: becoming more aware of what to prepare, what is needed, and what to do, acting carefully, carrying out tasks to the maximum extent of knowledge, and having standards in doing works.

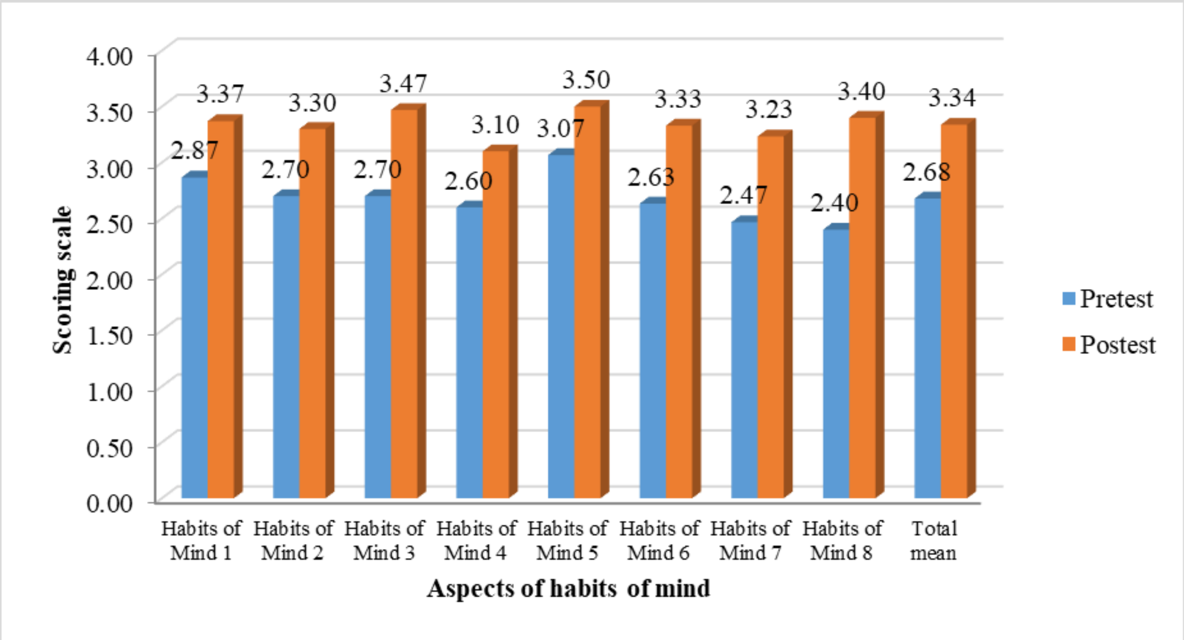

Figure 6. Mean score of habits of mind standards

In addition to these findings, the students' involvement in the plant diversity course with the inquiry 5E+e program must lead to the emergence of various entrepreneurship-oriented products based on the content of the material being studied. Some of the products successfully created by students include oshibana (a kind of painting of leaves and flowers (calyx & corolla) with fine fiber characteristics), leaf skeleton (a creation made from plant leaf material by utilizing the repetition of the leaves), and shampoo made from papaya leaves (the students analyzed that papaya leaves have a fairly good saponin content as the main ingredient in making shampoo). The products made are an implementation of the content of the entrepreneurship-oriented subject matter, which focuses on life-long learning, that is, learning that is carried out to provide students with life skills and the utilization of the potential of living natural resources in a sustainable life. Some of the products produced and the processes carried out are shown in Figure 7.

The findings of this research indicate that the inquiry learning oriented towards creating products and emotional approaches can train creative-thinking skills and improve students' achievements. The results of the research are in line with the previous research that the creative-thinking skills of students who take learning with Differentiated Science Inquiry combined with Mind Map (DSIMM) models are higher than those of students who learn with Differentiated Science Inquiry (DSI) models and conventional models (Zubaidah et al., 2017). Therefore, in the DSIMM model, students are directed to study inquiry-oriented work. Likewise, students who study inquiry with an emotional approach can improve their learning outcomes. The results show that students who learn high emotional inquiry have better scores than those who learn low emotional levels (Nasution, 2018).

Figure 7. Activities and products of lectures on plant diversity with the 5E+e inquiry program provide lifelong learning for prospective biology teachers. (a) The process of making products in the course of plant diversity; (b) Shampoo products; (c) Oshibana products; (d) Leaf skeleton products.

Another research suggests that inquiry-based learning with a communicative approach can train exploratory talk for science education students. Students are trained to communicate scientific content with argumentative and factual scientific explanations (Löfgren et al., 2013). Inquiry-based learning on the acid-base material influences increasing students' understanding of concepts and learning motivation (Özgür & Yılmaz, 2017). The principle of inquiry learning is learning about the scientific process by guiding students to learn independently. This is as a result of the research that suggests that the process of science can be improved by learning activities, allowing students to have the experience, fulfill the nature of science, and get involved in learning science (El-Islami et al., 2018).

Different research explains that the Plant Anatomy course program based on Marzano's learning dimension can improve quantitative literacy and Habits of Mind of students (Nuraeni et al., 2015). As we know, Habits of Mind is one of the standards in life-long learning. Other experts observed that Life-long learning could improve the self-efficacy of prospective teachers in information literacy that is quite high (Demirel & Akkoyunlu, 2017) and can develop oneself to have the skills to become a teacher (Chang & Koo, 2017). In developing life-long learning abilities, students must channel them according to their talents to have good self-regulation. This is like the research results stating that self-regulation can develop better in those who are talented than in those who are not (Tortop, 2015).

Also, life-long learning' should guide the post-2015 education agenda for the Least Developed Countries (LDCs), which refers to a group of 49 countries that are off-track in achieving most of the Millennium Development Goals (MDGs) and the Education for All goals. United Nations and Global Thematic Consultation Group have proposed that 'providing quality education and life-long learning' is an overarching post-2015 education agenda (Regmi, 2015a).

Thus, it is time for entrepreneurship to be integrated into the curriculum of science education, especially biology. This is based on the need for independent human resources and the ability to create job vacancies. Besides, biological contents, such as the wealth of biological natural resources, can be developed through entrepreneurship. However, this requires good control so that its utilization is not excessive. Therefore, the entrepreneurship carried out in science education must be directed to the provision of life-long learning.

4. Conclusion

After attending plant diversity courses with 5E+e inquiry learning programs, life-long learning skills of students show a significant improvement. This is indicated by the total mean and average data in each standard, i.e., complex thinking, information processing, effective communication, collaboration/ cooperation, and habits of mind standards. Similarly, the results of observations and findings gathered strongly support the data obtained using the life-long learning rubric. Thus, it can be concluded that the 5E+e inquiry carried out at the course of plant diversity can provide students with life-long learning. The 5E+e inquiry provides positive experiences for prospective biology teachers. They become more skilled at complex thinking, are accustomed to processing information systematically, are better trained in communication, have more flexible interpersonal collaboration with teams, and build the Habits of Mind in every action. Therefore, this learning program is recommended to be integrated into the science education curriculum, especially in Indonesia. For further research, it is necessary to explore more about ethnobotany's potential in each plant species, which is the potential to be oriented towards entrepreneurs with a vision of life-long learning.

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