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Inquiry skills for biology teacher candidates in plant anatomy practicum

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ABSTRAK

Inquiry skills merupakan kemampuan dasar penting yang harus dimiliki oleh guru sains. Inquiry skills mendasari implementasi standar proses pembelajaran sains. Penelitian deskriptif ini bertujuan untuk memperoleh gambaran tentang penguasaan inquiry skills yang dimiliki oleh mahasiswa calon guru biologi pada praktikum anatomi tumbuhan. Metode penelitian yang digunakan dalam penelitian ini adalah metode deskriptif. Subjek penelitian dalam penelitian ini adalah mahasiswa calon guru biologi (n=42). Instrumen yang digunakan dalam penelitian ini adalah tes inquiry skills dan wawancara. Hasil penelitian menunjukkan bahwa rata-rata inquiry skills mahasiswa adalah 43,36. Hasil ini masih di bawah indikator ketuntasan dalam penguasaan keterampilan yaitu 75. Perolehan skor inquiry skills pada indikator mengidentifikasi masalah (29,76), merancang percobaan dan melaksanakan percobaan (50,79), menganalisis dan interpretasi data (54,76), mengkonstruksi penjelasan (42,86), menghasilkan argumen dari sejumlah bukti (43,33) dan mengkomunikasikan informasi (38,69). Kesimpulan dari penelitian ini adalah pengalaman belajar praktikum verifikatif yang selama ini dialami oleh mahasiswa ternyata belum dapat mengembangkan inquiry skills mahasiswa secara maksimal, sehingga perlu dirancang program perkuliahan baik di kelas maupun praktikum di laboratorium untuk mengembangkan kemampuan inquiry skills mahasiswa.

Keywords:

Inquiry skills

Prospective biology teacher

Plant anatomy practical work

ABSTRACT

Inquiry skills are important basic skills that science teachers must possess, inquiry skills underlie the standard implementation of the science learning process. This descriptive study aims to obtain an overview of the mastery of inquiry skills possessed by prospective biology teacher students in plant anatomy practicum. The research method used in this research is descriptive method. The research subjects in this study were prospective biology teacher students (n=42). The instruments used in this research are inquiry skills tests and interviews. The results showed that the average inquiry skills of students was 43.36, still below the indicator of completeness in mastering skills, namely at number 75. The acquisition of inquiry skills scores on the indicators of identifying problems (29.76), designing experiments and carrying out experiments (50.79), analyzing and interpreting data (54.76), constructing explanations (42.86), generating arguments from a number of evidences (43.33) and communicating information (38.69). The conclusion from the results of the study shows that the verification practicum learning experience that has been experienced by students has not been able to develop student inquiry skills optimally, so it is necessary to design lecture programs both in class and lab work to develop students' inquiry skills.

INTRODUCTION

Inquiry skills are basic abilities that must be possessed by students, especially prospective biology teacher students (Lou et al., 2015). Inquiry skills are not only important as standards in science teaching, but also become important standards in teaching in order to prepare prospective science teachers (Bruckermann et al., 2017; Emden & Sumfleth, 2016; National Research Council, 2013). Scientific investigation requires inquiry skills and scientific knowledge so that these two things underlie scientists when conducting an investigation of something. Inquiry skills are needed by students in an effort to construct scientific knowledge (National Research Council, 2013). Inquiry skills are also important for students to carry out activities in the laboratory or practical work which are essential activities and become an integral part of science learning (Sekerci & Canpolat, 2017). The demands on the standard of teaching science in universities in America also make inquiry skills an ability that must be possessed by students (National Research Council, 2013). An inquiry learning experience will be held if students have good inquiry skills (Sekerci & Canpolat, 2017).

Inquiry skills are absolute abilities that must be possessed by students. Inquiry skills are fundamental in the standard of the science learning process, including biology. Students must have inquiry skills, because these are abilities that must be taught and trained to students when they later play a role as science teachers (Bruckermann et al., 2017).

Inquiry and inquiry learning have become part of substantial teacher education curricula, especially in science teaching in the 21st century (Fitzgerald et al., 2017; Marshall et al., 2016; National Research Council, 2000; Wang et al., 2014). Inquiry skills are essential in science education (Yakar & Baykara, 2014). Inquiry learning is the most effective learning to help students build their intellectual understanding, practice science process skills, and help students master concepts (National Research Council, 2000). Based on this statement, the (National Research Council, 2000) concluded that science teachers should design learning (science learning experiences) through inquiry. Inquiry learning experiences will be held if teachers and students have inquiry skills.

Learning through the experience of inquiry or inquiry is the core of science teaching that must be carried out by science teachers (National Research Council, 1996, 2007, 2012, 2013) so that science teachers must be able to organize learning experiences like scientists discovering knowledge. The National Science Teacher Association (National Science Teaching Association (NSTA), 2009) states that science content and investigative skills can be developed through research-based learning. (National Research Council, 2000) also states that teacher capacity development should be through continuous inquiry activities in developing science learning skills.

Inquiry skills include several aspects. Aspects in inquiry skills include formulating problems, formulating hypotheses, planning/implementing investigations, using mathematics to calculate/classify, using data to make conclusions, and communicating the steps and results of the investigation (National Research Council, 2000). These abilities must be possessed by a science teacher.

Inquiry skills are abilities that can help students carry out scientific procedures or scientific investigations as scientists do (National Research Council, 1996, 2007, 2012, 2013). Inquiry skills can also help students construct scientific knowledge. The results of previous studies reveal that this ability has not been fully mastered by students, especially prospective science teacher students, so that this becomes an obstacle for students when they have to implement scientific teaching standards that must be scientific (Lou et al., 2015; Setiono, 2017). Practicum learning experiences in universities that are dominantly verification are one of the factors causing the low inquiry skills of prospective science teachers, including biology teachers.

Inquiry skills need to be understood by prospective teacher students before conducting inquiry learning experiences. Inquiry skills occupy an important position in teaching science, so this ability is one of the abilities that must be developed and provided (Lou et al., 2015). In this study, the author wants to reveal how these inquiry skills are mastered by prospective biology teacher students. This description is expected to help lecturers design learning strategies, especially practical learning in the Plant Anatomy course in the laboratory which can develop the inquiry skills of prospective biology teacher students.

METHOD

This research is a descriptive study that aims to explain the phenomenon of student inquiry skills mastery in the Plant Anatomy Practicum course. This research was conducted at a private university in the city of Bandung in the Biology Education Study Program even semester of the 2016/2017 academic year. The research subjects were 42 students who took the Plant Anatomy Practicum course. The research data is in the form of inquiry skills test results and interviews conducted at the end of the Plant Anatomy practicum course. The data from the inquiry skills test and interviews were analyzed quantitatively and qualitatively.

Plant Anatomy Practicum activities implemented in this research are in the form of practical learning experiences that are proof or verification of knowledge obtained from theory. Practicum is carried out starting from the material of cells and their parts, basic tissue systems, vascular bundle network systems and organology.

Data was collected through an inquiry skills test which was developed based on indicators of inquiry skills (National Research Council, 2012) and interviews with students. Interviews were conducted based on interview guidelines that had been prepared previously. Interviews were conducted to obtain information about the implementation of the plant anatomy practicum and the obstacles faced by students during the plant anatomy practicum.

The research data are then analyzed and compared with predetermined success indicators. The parameter used to see the achievement of inquiry skills is the achievement of learning completeness scores in the Plant Anatomy course (at number 75). The criteria for completeness are based on the breadth and depth of the material content that must be mastered, the basic abilities of students, and the carrying capacity of learning facilities, especially in the laboratory.

RESULTS AND DISCUSSION

The research data shows that the mastery of student inquiry skills in the Plant Anatomy practicum is still categorized as low. This is indicated by the acquisition of the average student inquiry skills score which only reached 43.36, still far from the predetermined completeness criteria, namely 75. The achievement of inquiry skills in each measured indicator can be seen in Table 1.

Table 1. Inquiry skills score on each indicator and sub-indicator

No	Inquiry Skills Indicator (National Research Council, 2012)	Inquiry Skills Sub Indicator	Score	Score Average
1	Identify the problem	Formulating research questions	23.81	29.76
		Formulate a hypothesis	35.72	
2	Designing experiments and carrying out experiments	Determine the research design	64.29	50.79
		Determine practical work steps	44.05	
3	Analyze and Interpret data	Analyze and Interpret data	54.76	54.76

4	Constructing explanation	Using concepts/principles to explain findings	42.86	42.86
5	Generate arguments from a number of evidences	Give the right argument based on the findings	35.71	43.33
		Constructing conclusions	45.24	
6	Communicating information	Make pictures of observations	38.69	38.69
	Average		43.36	43.36

Table 1 shows that students' inquiry skills are still low, especially on indicators of identifying problems and communicating information. The score obtained on the indicators of designing and carrying out experiments, analyzing and interpreting data, constructing explanations and generating arguments from a number of evidences is higher than the two previously mentioned indicators but the score is still lower than the score criteria set as an indicator of success, namely at 75.

The practical learning experience that has been carried out so far is still verification, so that the experience has not been optimal in providing students' inquiry skills. The verification practicum does not provide a scientific learning experience for students. This has an impact on the mastery of student inquiry skills.

In the indicators of identifying student problems, one of them is required to produce research questions that allow them to be investigated. The ability to identify problems requires the ability to predict and reason well (Ermayanti et al., 2016). If these two abilities are still low, then students will have difficulty generating research questions that allow them to be investigated.

Interviews were conducted to complete information from students. The intended information is regarding the implementation of the practicum and its obstacles. It was viewed from the side of the students participating in the practicum activities. Table 2 shows the results of the interviews.

Table 2. Results of interviews with students

No	Interview questions	Student Answer
1	Have the plant anatomy practicum activities that have been carried out so far been effective?	1. Not yet effective, because the practicum activities that have been carried out so far have not fully helped me understand plant anatomy material 2. Group activities in practicum are less effective, because only certain groups of people do the practicum.
2	Can the plant anatomy practicum program that has been carried out so far be able to trigger your curiosity to explore more information about the material being studied?	1. The practicum activities are less varied, because each practicum activity has the same activities. 2. The practicum activities are monotonous so it doesn't motivate me to do the practicum activities.
3	What is the plant anatomy practicum program that has been helping you to understand more deeply related to the concepts being taught?	1. Not yet, because the information obtained through practical activities is not clear, so it is confusing. 2. Practice procedures that have not been mastered hinder the practicum process carried out
4	Can the plant anatomy practicum program that has been carried out so far be able to train inquiry skills?	Not yet, because the practicum that has been carried out so far is still theoretical proof, so it has not trained the ability to make discoveries through inquiry steps
5	Does the student activity sheet (LKM) provided help you in carrying out practical activities?	1. The MFI provided is sufficient to help with practical activities. 2. The MFI helps direct practical activities
6	Do you want the practice of plant anatomy that has been done so far to be continued?	If possible, practicum activities are more varied so that they are not boring and train other abilities.

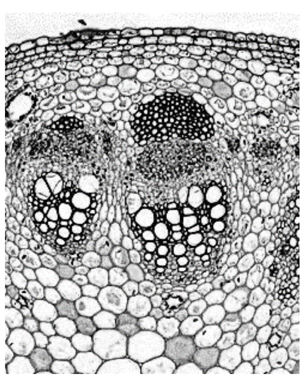
The results of interviews and measurements of student reasoning show that the reasoning possessed by students is still low. As many as 56% of students have reason in the category of formal operations. This will be an obstacle for some students to construct research questions that are appropriate and relevant to what will be researched. Examples of questions on indicators identifying problems are shown in Figure 1.

> Before conducting the experiment, the lecturer showed the results of observing onion cells with 120x and 400x magnifications to students. Students are asked to look at the two pictures. Based on this context, which research question do you think is the most appropriate to start an investigation based on the above context?
>
> a. What is the difference between Allium tuber cells at low magnification and high magnification?
> b. At which magnification will Allium tuber cells be seen more clearly?
> **c. What cell organelles can be seen under a microscope magnification of four hundred times?**
> d. Will the difference in microscope magnification affect the resulting image resolution?

Figure 1. Inquiry skills questions on identifying problems (Setiono, 2017)

Formulating research questions that are rational and allow for research requires rational considerations. In this condition, students are required to reason and predict. In addition, the attitude of curiosity is an attitude that can underlie the emergence of interest and from this interest will lead to student motivation to ask questions (Lou et al., 2015). In addition, formulating research questions is a process skill that requires habituation. If the teacher or lecturer does not provide this learning experience, students will have difficulty identifying and formulating the research question. The verification practicum learning experience that has been experienced by students does not train these abilities, so that if students are required to construct questions, they will have difficulty.

In communicating indicators, students still have difficulty in drawing observations under a microscope. This can be seen from the difficulty of students comparing the observed images with the schematic images presented. Figure 2 contains examples of questions on this indicator.



Pay attention to the cross section of the image of the bar on the side

The picture on the side is a snippet of the results of observations of cross-sectional cross-sections of dicotyledonous plant stems on primary growth. The following is a schematic of the bar image that you think best fits the observed image on the side…

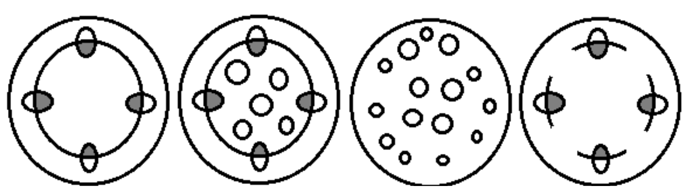


Figure 2. Inquiry skills questions on indicators of communicating information (Setiono, 2017)

Communicating skills require students to collect data as completely as possible. If students do not get enough data, it will be difficult to construct complete information about the observations (Demircioglu & Ucar, 2015). Complete perception also affects students' ability to communicate information (Tonissen et al., 2014). Complete perceptions can be obtained by students from various sources of information collected.

Based on the results of interviews with students, information was obtained that students did not have a complete source of information about drawings of anatomical structures that must be explained. Therefore, students have difficulty perceiving the information in question. Students' difficulties in perceiving images are also known from the Student Activity Sheet (LKM) that students fill out. On average, students have difficulty in providing information on the observed images under a microscope. The difficulty in providing descriptions of the observed images indicates that students have incomplete information in their working memory, making it difficult to perceive and communicate the observed images. Lack of information can cause problems in making image representations of observations under a microscope (Ermayanti et al., 2016).

Low inquiry skills were also identified in other indicators, namely the indicators of designing experiments and carrying out experiments, analyzing and interpreting data, constructing explanations, and generating arguments from a number of evidences. Designing and carrying out experiments is not an easy activity to do. Students need sufficient procedural knowledge in order to properly design experiments. In addition, this ability also requires metacognitive abilities from students in order to be able to make designs and work procedures that are relevant and appropriate to the demands of research questions (Lou et al., 2015). The practical experience experienced by students so far does not require students to design experiments so that students find it difficult to make experimental designs. The verification practicum learning experience causes students to have limited procedural knowledge, so that students have difficulty when they are required to design and carry out experiments.

The ability to analyze and interpret data in this study includes the ability to explain images and construct images from observations of plant anatomical structures under a microscope. This ability requires sufficient conceptual, factual and metacognitive knowledge so that students can explain and construct appropriate images. In addition, analyzing and interpreting data in the form of images from observations requires a high level of capable reasoning ability (Ermayanti et al., 2016).

Observation of the results of the work on the LKM shows that on average students have difficulty in providing accurate information from the observed images. Students also have difficulty making the right picture according to the observations. This obstacle is a sign that factual, conceptual, and metacognitive abilities of students are still lacking so that students experience obstacles when they are required to analyze and interpret the data from observations under a microscope.

Based on Table 2, it is known that the plant anatomy practicum that has been carried out so far has not been effective and has not trained students' inquiry skills. This can be an obstacle for students in constructing knowledge and inquiry skills. Ideally, practicum learning held should provide experience for students in conducting investigations like scientists conducting investigations to answer research questions posed (Lazonder & Harmsen, 2016; Oppong-Nuako et al., 2015).

Intensive guidance from more experienced lecturers or assistants is also one of the efforts that can be made to develop student inquiry skills. In addition, there needs to be collaboration between students and lecturers to conduct an investigation, this will help students get the right experience on how to conduct an investigation (Kuter, 2013).

Inquiry-based practicum is one of the suggested strategies in practicum learning in universities. (Kudish et al., 2015) stated that practicum for students should require students to think and reason, so that inquiry learning, especially in the laboratory, is ideal for students to do. Inquiry-based learning is a learning strategy based on social constructivism learning theory (Oppong-Nuako et al., 2015). The learning process will occur when students interact, ask questions and construct new knowledge from experiences gained by students in everyday life and from students' prior knowledge (Oppong-Nuako et al., 2015). Learning experience through practical activities is a learning experience that allows students to gain experience in inquiry.

Practicum in the laboratory is an important element in science teaching (Demircioglu & Ucar, 2015). (Katchevich et al., 2013) state that learning activities in the laboratory can support the mastery of high order learning skills such as making observations, planning and carrying out experiments, asking research questions, formulating hypotheses and analyzing experimental results. (Wang et al., 2014) stated that inquiry can develop a number of process skills including: 1) identifying and defining problems, 2) formulating hypotheses, 3) designing experiments, 4) collecting and analyzing data and 5) interpreting data and describing meaningful conclusions. Inquiry-based learning allows students not only to learn content but also allows students to learn the process of science (Lazonder & Harmsen, 2016; Ural, 2016).

The positive influence of inquiry learning carried out in the laboratory will be obtained if practicum learning is well planned and mature. Lecturers must prepare practicum activities as well as possible, for example, when lecturers prepare activity sheets to help with practicum activities, the tasks that are prepared must be clearly formulated so as not to confuse students. Lecturers must also prepare practical assistants. The practicum assistant must have sufficient knowledge and skills in accordance with the practicum teaching standards set by the lecturer.

CONCLUSION

Verificative practical learning experience cannot provide sufficient learning experience for students to develop inquiry skills. The results showed that the average inquiry skills of students was 43.36, still below the indicator of completeness in mastering skills, namely at number 75. The acquisition of inquiry skills scores on the indicators of identifying problems (29.76), designing experiments and carrying out experiments (50.79), analyzing and interpreting data (54.76), constructing explanations (42.86), generating arguments from a number of evidences (43.33) and communicating information (38.69). Inquiry skills are important skills that must be possessed by students. This ability is important as the basis for the implementation of science teaching in universities in accordance with the expected standards. If this ability is not possessed, it will become an obstacle in the implementation of science teaching according to standards, so this ability needs to be developed from the start. To develop inquiry skills, lecturers need to prepare learning strategies that can provide inquiry skills experiences for students. One of the strategies that lecturers can implement to develop these inquiry skills is inquiry, this inquiry can be implemented in the classroom or in learning in the laboratory.

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