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Needs analysis for developing a laboratory manual of Cryptogamic botany to build scientific character on student biology education

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Abstract

The Cryptogamic botany course is supported by practical activities. The laboratory activities involve the observation of the morphology and taxonomy of lower plants. Observational activities focusing on lower plants require precision, creativity, curiosity, and objectivity from each participant. However, the available practical guide does not explicitly address these scientific characteristics. The objective of this research is to gather preliminary information and analyze the need for the development of a Cryptogamic botany practical guide aimed at fostering scientific character among students. This study is descriptive in nature, with data collection conducted through questionnaires and interviews involving 73 students and 4 lecturers responsible for the Lower Plants (Cryptogamic botany) course as respondents. The data were analyzed descriptively based on the percentage of respondent answers for each aspect in question. The results showed that 84.3% of the students strongly agreed, and 15.7% agreed, on the need for a practical guide integrated with scientific character. Furthermore, 58.8% of students preferred that this integration be explicitly presented in the practical guide, while others preferred it to be incorporated in the form of questions. All lecturers agreed on the integration of scientific character in the practical guide, with 25% favoring explicit inclusion, 25% supporting its incorporation through questions, and 50% advocating for it to be framed within a learning model. The development of a Cryptogamic botany practical guide integrating scientific character is deemed essential.

Abstrak. *Mata kuliah Cryptogamic botany ditunjang oleh kegiatan praktikum. Kegiatan pengamatan dengan objek tumbuhan rendah menuntut ketelitian, kreatifitas, rasa ingin tahu dan objektifitas terhadap data dari setiap praktikan. Panduan praktikum yang tersedia belum memuat secara eksplisit karakter ilmiah yang dimaksud. Tujuan penelitian adalah untuk mengumpulkan informasi awal dan untuk menganalisis kebutuhan untuk pengembangan panduan praktikum Cryptogamic botany dalam rangka membangun karakter ilmiah para praktikan. Penelitian ini merupakan penelitian deskriptif. Pengumpulan data menggunakan instrumen berupa kuesioner dan wawancara yang melibatkan 73 mahasiswa dan 4 orang dosen pengampu mata kuliah Tumbuhan Rendah (Cryptogamic botany) sebagai responden. Data dianalisis secara deskriptif berdasarkan penghitungan persentase jawaban responden pada setiap aspek yang dipertanyakan. Hasil penelitian menunjukkan bahwa kebutuhan mahasiswa terhadap panduan praktikum yang terintegrasi karakter ilmiah dengan persentase 84,3% sangat setuju dan 15,7% menyatakan setuju. Sebanyak 58,8% mahasiswa menghendaki pengintegrasiannya dipaparkan secara jelas di dalam panduan praktikum, dan yang lainnya menghendaki dituangkan dalam bentuk pertanyaan. Seluruh dosen pengampu mata kuliah menyatakan setuju untuk pengintegrasian karakter ilmiah dalam panduan praktikum secara jelas (25%), 25% menghendaki dituangkan dalam bentuk pertanyaan. dan dikemas dalam suatu model pembelajaran (50%). Panduan praktikum Cryptogamic botany yang mengintegrasikan karakter ilmiah menjadi hal yang penting.*

A. Introduction

Cryptogamic botany is a branch of botany that studies lower plants (nonseed plants), including algae, fungi, lichens, mosses, and ferns. The Cryptogamic botany course encompasses both theoretical and practical competencies for students, making practical activities a vital component. Consequently, to achieve these competencies, students are required to develop both conceptual understanding and science process skills through practical exercises. According to the *Merriam-Webster Dictionary*, a practicum is a program that involves the supervised practical application of previously learned theory. Practicum activities involve practice and the expression of skills possessed by learners, embodying a "learning-by-doing" approach and producing experiential learning (Kolb, 2018), thereby deepening their understanding of the subject matter. Practicum exercises are scientific activities designed to hone students' abilities through experiments, observations, and demonstrations that elucidate the relationship between theory and phenomena, and are conducted both in the laboratory and in the field (Duda & Susilo, 2018; Cains, 2024). Laboratory practice is the only setting capable of developing students' scientific process skills (Nahadi et al., 2016). Practicums are useful for enhancing students' observational skills, improving practical abilities, and serving as a means of practicing the use of equipment (Kandriasari et al., 2023).

The practicum activities conducted thus far have been supported by a laboratory manual, which serves as a manual for students to observe lower plant objects, encompassing both morphological and anatomical observations. The laboratory manual includes the title, the objectives of the activity to be achieved, the equipment and materials needed, and the steps for the practicum activity. It provides a comprehensive guideline for practicum implementation, detailing procedures for preparation, execution, data analysis, and reporting (Fitriani, 2019). A well-designed practicum guide should holistically address students' learning needs, ensuring that they not only comprehend the material but also develop essential scientific skills such as observation, analysis, and data interpretation. One indicator of a successful practicum is the quality of the practicum guide itself (Lubis & Herlina, 2022). A structured and clear practicum guide aids student in developing crucial laboratory skills, including observation techniques, tool usage, species identification, and data collection and analysis. Effective practical activities require not only a well-structured practicum guide but also supporting equipment, including a fully equipped laboratory with necessary tools and materials (Reimers et al., 2020).

Base on of observations and experience, practicum of Cryptogamic botany has not been optimally conducted by the students, and the existing practicum guide has not sufficiently directed them to conduct detailed and thorough observations of lower plant objects. Practicing with lower plants requires meticulousness, dedication, and a high level of curiosity, as observations often need to be conducted microscopically, demanding detailed examination under microscope. Although only 12.9% of the students reported difficulties with microscopic observations, 48.4% indicated challenges in creating sketches or drawings base on their observations. This finding indicates that the practicum guide should not only direct students to conduct detailed observations but also motivate them to be creative in seeking additional information related to the observed objects. Despite the research by Cahyani et al. (2021) showing that a "cooking recipe-based practice" yields relatively good learning outcomes in biology, there remains a significant need develop a practicum guide. Such a guide would serve as a crucial resource for students to identify and determine the names of invertebrate species (Malahayati & Sholikhah, 2022), enhancing critical thinking skills and student collaboration (Fitriani, 2019).

Laboratory activities in biology serve as an essential component of the learning process to reinforce biological concepts. These activities can foster curiosity, innovation, creativity and promote scientific honesty (Fitriani, 2019). Thus, practical activities also have the potential to involve attitudes or character development. Laboratory activities and the development of scientific character are closely related, as practical work provides hands-on experience that enhances critical thinking and problem-solving skills (Yoon et al., 2018), fosters scientific attitudes (Setiadi & Rosyida, 2021), and sharpens observational abilities. Scientific traits such as precision, creativity, curiosity, and objectivity naturally emerge when students engage in the process of scientific investigation.

Hodson's (2014) research reveals that laboratory activities allow students to gain a deeper understanding of the scientific process, from data collection to result analysis, which ultimately strengthens their scientific character, including traits such as precision and objectivity. The study by Ajizah et al. (2022) reported that the values of meticulousness, diligence, and honesty were evident when students conducted microbiology practical activities, such as in the practices of media prepartion, inoculation and isolation of the microbe, microbial colony morphology, counting of microbial colonies (total plate count), and Gram's staining. Therefore, a practical guide that integrates these scientific characters is necessary. However, it is crucial to first understand the specific needs of both students and lecturers concerning a practical guide that can support the achievement of competencies and learning objectives for the Cryptogamic course.

B. Material and method

This study employs a qualitative descriptive method, which involves describing research data obtained through questionnaires and interviews. The respondents of the study consisted of 73 students who had enrolled in the Cryptogamic botany course in the Biology Education Study Program in Banjarmasin, as well as 4 lecturers who taught the Cryptogamic botany course. The research procedure is carried out four steps, which are briefly explained in Figure 1.

The questionnaire comprises 15 (fifteen) questions related to the need develop a practical guide for Cryptogamic botany. The questionnaire encompasses aspects of the learning strategies for the Lower Plant Botany course, the laboratory manual that has been used thus far, the components of the existing practical guide, the challenges or difficulties experienced during practical sessions, the scientific attitudes that may emerge during practical work, the importance of integrating scientific character, and the mechanism for incorporating character into the laboratory manual. Data were collected using a research instrument consisting of a needs analysis questionnaire distributed through the Google Forms application. The questionnaire used is a qualitative questionnaire with some open and some closed questions. The open questions include alternative practical activities, types of obstacles faced when carrying out practical work on low plants. The closed questions include the laboratory manual used, the need for a laboratory manual that is integrated with characters, and the mechanism for integrating its characters.

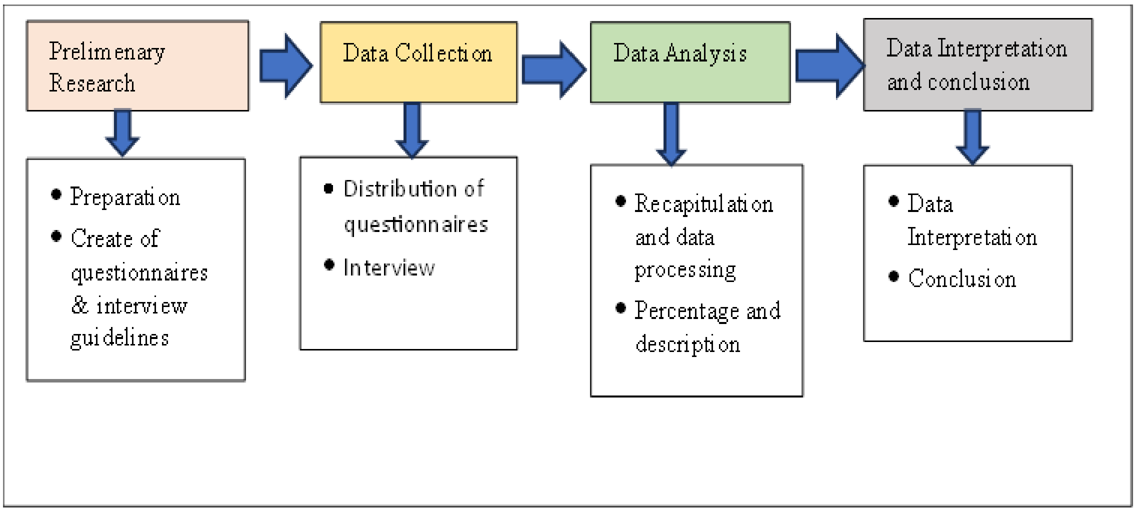

Figure 1 Steps of the research

Data were collected using a research instrument in the form of a needs analysis questionnaire, which was distributed via *Google Form*. The questionnaire responses were then calculated via Formula 1 by Wahyudin (2020) and Marista et al. (2023).

$$p = \frac{F}{N} \times 100\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Formula 1}$$

Description:
p = final percentage result
F = number of responses for each item,
N = total number of respondents

C. Results and discussion

On the basis of the needs analysis distributed via Google Forms, the students indicated that the existing practical guide content includes objectives, tools and materials, and activity procedures. However, 84.3% of the students strongly agreed, and 15.7% agreed on the necessity of developing a practical guide for the Cryptogamic botany course. According to 56.7% of the students, accuracy is required during practical activities, 10% indicated a need for curiosity, and 18.6% stated that cooperation is necessary. Consequently, 54.9% of the students strongly agreed, and 45.1% agreed on the need for a practical guide that incorporates these scientific characteristics. Moreover, 58.8% of the students desired a clear presentation of these characteristics in the developed practical guide.

The needs analysis survey of the course lecturers and practical supervisors of Cryptogamic botany revealed that 100% of the lecturers supported the inclusion of scientific characteristics in the practical guide. The inclusion can be explicit (25%) or integrated into a learning model (75%). The results of the needs analysis serve as a reference for developing the existing Cryptogamic botany practical guide. In accordance with Fitriani (2019), needs analysis is used to identify existing potentials and problems. The analysis stages identified the following potential and needs issues identified by the researchers:

Material analysis

The scope of the Cryptogamic botany course includes *Schizophyta* (split plants), *Thallophyta* (thalloid plants), *Fungi* (mushrooms/molds), *Bryophyta* (mosses), and *Pteridophyta* (ferns). The learning outcomes of the course include developing an attitude of meticulousness, creativity, responsibility, and independence in solving learning problems; the ability to conduct Cryptogamic botany practical activities in both the laboratory and the field; and the ability to analyze the morphological and cytological characteristics of lower plants. Consequently, to achieve these learning outcomes, the course is accompanied by practical activities that cover all the topics within its scope. For the division *Schizophyta*, the focus is on blue–green algae (*Cyanophyta*), with practical activities grouped together with microscopic observations of green algae (*Chlorophyta*) and diatoms (*Bacillariophyta*) from the *Thallophyta* division, conducted in Practical Activity 1. Practical Activity 2 covers macroscopic algae, including green algae (*Chlorophyta*), brown algae (*Phaeophyta*), and red algae (*Rhodophyta*).

On the basis of the questionnaire responses and interviews, the teaching of the Cryptogamic botany course in three Biology Education Study Programs at universities in Banjarmasin clearly involves both theoretical and practical components (Table 1).

Table 1 Learning strategies for lower plants (Cryptogamic botany)

No.	Learning Strategies	Percentage (%)
1	In theory	20
2	Theory and Laboratory activities	60
3	Special practical course	20

When the learning process does not include practical activities, the introduction and comprehension of lower plants are facilitated through assignments. These assignments instruct students to observe and photograph lower plants, accompanied by presentations of their observations. Additionally, theoretical learning is conducted via various media, including videos about lower plants. To conduct Cryptogamic botany practical activities, practical guidebooks and student worksheets are generally used, as outlined in Table 2.

Table 2 Types of laboratory manual used

No.	Types of Laboratory Manual	Percentage (%)
1	Laboratory manual book	54,9
2	Student worksheets	41,2
3	Laboratory manual book and Student worksheets	3,9

The laboratory manual and student worksheets used serve as references for students in conducting practical activities. The information obtained through questionnaires and interviews revealed that the existing practical guides already contain standard components (Table 3).

Table 3 Components of the laboratory manual

No.	Components	Percentage (%)
1	Practical Identify	2,00
2	Practical Purposes	33,3
3	Tools and Materials	19,5
4	Practical activity procedures	29,4
5	Observation results	13,7
6	Analysis and discussion	2,10
7	Conclusion	0,00

These components typically include objectives, tools and materials, practical work procedures, and data analysis (Fitriani, 2019). The laboratory manual is designed on the basis of the learning outcomes or competencies intended to be achieved for each activity topic. The laboratory manual, which is based on the basic competencies outlined in teaching materials (*handouts*), will support the understanding of learning concepts, making *handouts* essential for use in biology education (Rahmi et al., 2023). With the use of these guides or worksheets, it is believed that the understanding of concepts in each practical learning material will be effectively supported.

Obstacles for students in conducting Cryptogamic botany practical activities

The questionnaire results also indicate that students still encounter various difficulties and obstacles when conducting practical activities, as detailed in Table 4.

Table 4 Difficulties and obstacles to practical activities in Cryptogamic botany

No.	Difficulties and Obstacles	Percentage (%)
1	Taking samples/specimens	12,9
2	Morphological observation	6,5
3	Microscopic observation	12,9
4	Determine observed focus	9,7
5	Make sketches/drawing objects-based observations	48,4
6	Looking for supporting references	9,7
7	Collaboration	0,0

Creating sketches or drawing observation results in a representative manner requires accuracy and creativity, including seeking information sources to compare with observation results. In the research by Amalia et al. (2021) on the development of science literacy-based modules, features such as "*Let us Find Out*" are included, using indicators to search for or utilize various media/reference sources in solving problems to measure students' creative character. A person can be considered creative if they can solve a problem in an innovative, meticulous, and confident manner (Pasani & Damayanti, 2018).

Criteria for desiring a laboratory manual of Cryptogamic botany

The findings from the Google Forms survey indicate that, during practical activities, students are expected to demonstrate meticulousness, collaboration, and a high level of curiosity, as presented in Table 5. However, the existing laboratory manual does not clearly direct students to adopt these attitudes.

Table 5 Required attitudes when conducting lower plant practical

No.	Required Attitudes	Percentage (%)	
		Students	Lecturers
1	Speed in observing	9,8	0,0
2	Carefully	3,2	50,0
3	Thoroughness/carefull-ness	56,7	100,0
4	Collaboration	18,6	100,0
5	Couriosity	10,7	100,0

Through laboratory activities, students verify or discover facts related to learning concepts, thereby strengthening their understanding of these concepts. According to Kubiatko et al. (2021), factual knowledge about monocotyledonous plants positively correlates with students' attitudes toward plants. This attitude significantly influences their interest in botany, ecology, and zoology but not in microbiology, health, or nutrition. Thus, laboratory activities foster curiosity about the learning material, ultimately strengthening the concepts being taught. By conducting practical activities, students discover new things through object observation, discussion, and reading additional sources to seek further information, which indicates that they possess a good scientific attitude of curiosity (Amintarti et al., 2018).

Attention to detail, curiosity, and cooperation are indicators of a scientific attitude. A scientific attitude is an important part of scientific character (Kuhn, 1997). According to *the National Academies of Sciences, Engineering, and Medicine* (2017), scientific character encompasses adherence to moral principles such as integrity, objectivity, accountability, honesty, fairness, diligence, patience, creativity, cooperativeness, critical thinking, and independence. Scientific character in education is an approach that emphasizes the use of scientific methods, critical thinking, and values of honesty and integrity in the teaching and learning process. The 21st Century Education Framework developed by the World Economic Forum (WEF) identifies 16 skills for the 21st century, which are grouped into three categories: foundational literacies, competencies, and character qualities (Hindrasti et al., 2020). Character qualities include curiosity, initiative, persistence/grit, adaptability, leadership, and social and cultural awareness. According to Purnama & Hasruddin (2019), fostering true lifelong learners can be achieved by implementing learning models that involve active participation (*learning by doing*). Strengthening student character is the responsibility of every course (Kurniawaty et al., 2023).

A thorough understanding of the characteristics of a group of organisms and careful attention to determining whether they match the description of each trait are necessary for identifying an organism (Gafur, 2014). He further formulated several steps used in describing characteristics and classifying a living organism, which can be related to various scientific attributes. For example, observing and collecting data about a living organism involves attitudes or traits such as honesty, attention to detail, diligence, objectivity, hard work, and creativity.

Table 6 The necessity of incorporating scientific characters in the laboratory manual

No.	Level of needs	Percentage (%)	
		Students	Lecturers
1	It is necessary	54,9	25,0
2	Need	45,1	75,0
3	No need	0,0	0,0

According to Pluck & Johnson, stimulating curiosity can be achieved through various challenging methods, including inquiry-based learning and problem-based learning (Bialik et al., 2015). Therefore, meticulousness, curiosity, and cooperation should be integrated into the practical guide being developed. Consequently, 75% of the lecturers stated that it is very necessary, and 25% stated that it is necessary to include scientific characteristics in practical guidelines, as presented in Table 6.

The required design of a Cryptogamic botany laboratory manual

Given the urgent need to integrate scientific characteristics into practical guides, survey results indicate that the development of such an integrated guide is strongly agreed upon by 75% of lecturers and 84.3% of students (Table 7).

Efforts to build students' characteristics include integrating them into the learning process. By applying scientific character in biology learning, students will not only better understand the biological material but also develop attitudes and skills as critical thinkers. To support teaching and learning activities, it is necessary to develop integrated science learning tools with character education (Nugroho et al., 2021).

Table 7 The need for developing a laboratory manual integrated with scientific character

No.	Degree of Agreement	Percentage (%)	
		Students	Lecturers
1	Strongly agree	84,3	75,0
2	Agree	15,7	25,0
3	Somewhat disagree	0,0	0,0
4	Disagree	0,0	0,0

With respect to its integration into practical guides, 58.8% of the students wanted it to be clearly explained, and 50% of the lecturers preferred scientific character integration to be incorporated into a specific learning model, as detailed in Table 8.

Table 8 Mechanism for incorporating scientific characters into the laboratory manual

No.	Mechanism of integration	Percentage (%)	
		Students	Lecturers
1	Clearly, presented in the Laboratory Manual	58,8	25,0
2	Implicitly included in the procedure steps	19,6	0,0
3	Framed in the form of a question	17,6	25,0
4	Packaged in an instructional model	4,0	50,0

Integrating character education into each subject is one approach that can not only foster good character but also improve academic ability (Zubaidah, 2019). Character development in students has been successfully carried out by Bahri et al. (2021) through *problem-based learning* (PBL) in biology, resulting in significantly improved student motivation (Sari, 2018). There are differences in creative thinking skills between students treated with problem-based learning and those treated with double loop problem solving (Permata et al., 2022). Using the PBL model enhances creative thinking skills in knowledge competence (Sahida & Zarvianti, 2019). Courses that integrate laboratory activities and combine problem-based learning can help students connect theoretical concepts with facts discovered through laboratory activities (Budner & Simpson, 2018). Integrating scientific character development into laboratory manuals is crucial. By embedding scientific character development into the laboratory manual, students can learn concepts in a more structured and systematic way while developing skills, thereby enhancing the effectiveness of practical learning and its benefits for students. Therefore, the Cryptogamic botany laboratory manual will be developed by integrating scientific characteristics clearly presented and packaged in the problem-based learning (PBL) model. According to Schwartz (2015), character education in higher education should be integrated into at least one mandatory course. Thus, when students conduct practicals using a PBL-based laboratory manual that includes a mechanism for integrating scientific character, it is expected that scientific character will gradually develop throughout the learning process.

D. Conclusion

On the basis of the data obtained through questionnaires and interviews, it can be concluded that the needs of lecturers and students for the development of the Cryptogamic botany laboratory manual include the following: 1) the main challenges faced by students during practical sessions are difficulties in creating sketches/illustrations of their observations and in executing procedural activities; 2) the desired criterion for the Cryptogamic botany laboratory manual, according to both lecturers and students, is the explicit inclusion of scientific attitudes; and 3) the required design for the Cryptogamic botany laboratory manual should clearly present these scientific character and be packaged within an instructional model.

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