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Exploring Problem-Solving Skills and Scientific Attitudes in Field Botany: Cibodas Botanical Garden Study

Yusuf Ibrahim [1], Cita Tresnawati [1], Fitri Aryanti [1], Gurnita Gurnita [1]

[1] *Faculty of Teacher Training and Education, Pasundan University, Bandung 40153, Indonesia*

Abstract **– Problem-solving skills are an essential competency for addressing global challenges. However, educators have not fully understood the most effective methods for fostering problem-solving skills in students. The purpose of this study is to examine the problem-solving abilities and scientific attitudes of students taking the Phanerogams Botany field course at the Cibodas Botanical Garden in Indonesia. This research was conducted using a descriptive method on 40 third-semester students from the Biology Education Study Program at a private university in Bandung. Data were collected through the use of learning implementation observation sheets, student worksheets, and an attitude scale questionnaire (numerical rating scale). The problem-solving ability instrument, which was developed for the purposes of this study, consisted of five questions. The scientific attitude instrument, which was also developed for this study, consisted of four indicators, which were translated into 20 questions. The findings indicate that the Phanerogamae Botany field course has a beneficial effect on students problem-solving abilities, encompassing the identification stage and the evaluation of strategies employed. Furthermore, this field study plays a significant role in fostering students' scientific attitudes, including curiosity, honesty, open-mindedness, and the capacity to collaborate effectively.**

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Corresponding author: Yusuf Ibrahim,
Faculty of Teacher Training and Education, Pasundan University, Bandung 40153, Indonesia
Email: yusuf.ibrahim@unpas.ac.id

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1. Introduction

The problem-solving skills are among the main objectives of the college curriculum as they equip the graduates with skills to deal with the complicated problems at the workplace. The essence of the challenges on the education of science highlights the desirability of proper methods and instructing models of learning science so as to make contributions on the effective implementation of problem-solving skills [1]. The teaching strategy should therefore be adjusted to encourage other factors like collaboration among learners with different levels of experience other than problem solving talents [2]. Past experiences indicate that different types of problems require varying levels of information processing and application of skills, which would necessitate the use of varying methods of teaching [3]. In addition, problem-solving ability requires effective and productive assessment strategies to determine the ability in science, engineering and teacher education scenarios. Such assessment should provide concrete information, allow students to make a choice and the combination of alternative ways of assessment [4]. In addition, it is assumed that the examination of the various strategies used by students in solving biological problems of different magnitudes would play an important role in interpreting the process of problem-solving among students [5].

Being able to find solutions to problems has also been proven a very important element in quite a lot of research. It teaches that the biggest aspect towards success in the professional life is the capability to change to difficult circumstances that may be faced. To succeed in their work life, students require so many skills. These are having the capacity to identify problems, think critically and creatively, perform duties diligently, assess their own thoughts, manage organizations, be flexible, develop solutions and analyze outcomes [6].

Level of creativity involves developing new solutions to certain situations which in turn determines the ability to identify and implement solutions to complex problems [7]. The key to developing problem-solving skills is creating a learning environment that will help motivate the students to be able to develop their problem-solving skills. An example is the effectiveness of introducing ecology lessons in the curriculum that has shown to raise awareness to the pupils [8]. The academic achievement is positively affected strongly by student-centered learning and problem-based learning [9].

And the aim of biology teaching is not in mere transferring (in the object-soul zone), but to shape and mould in students strong, critical, constructive as well as scientific attitudes. There are multiple research conclusions on the role of developing a scientific attitude in science learning, and these are developing curiosity, self-confidence, which makes biological knowledge less confusing to the student and allows him to use it better [10]. It has also been found that the positive attitudes can be raised a great deal by laboratory experiences which has proved to be a good method of getting the students to form positive attitudes towards science [11]. There is a strong correlation between positive attitude towards science and academic performance among students particularly when the topic of study is applicable in their day-to-day lives [12]. Other studies show that educators are able to influence positive attitude of pupils to science not only through the student-centered educational experience which can be performed in the classroom but also because it can promote scientific literacy and its relevance to the realities of the day-to-day life of the students themselves [13].

Field trips help in inculcating the observation ability, critical thinking and environment management in the learners. Also, the field trips may improve the retention, conceptual knowledge, and successful practice of students. However, several constraints must be considered, including financial constraints, large student numbers, and the limited effectiveness of the trips [14]. Field studies have the potential to enhance students higher-order thinking skills (HOTS). When designed effectively, field courses have the potential to foster deeper skill development compared to what can be achieved through conventional teaching methods [15], [16]. Teachers develop the confidence to integrate field lectures with biology teaching, thereby enhancing the interest and relevance of the subject matter for their students [15]. It has been demonstrated that students who participate in field lectures demonstrate a significantly higher level of interest and academic achievement in biology lessons than those who do not take part.

It is therefore recommended that biology teachers receive training in order to learn how to best engage students during field trips, with the aim of maximizing the benefits derived from such activities [17].

Field lectures are a pedagogical strategy that facilitates direct experiential learning through engagement with the subject matter in a natural setting, thereby enhancing students understanding. The activity was conducted as part of the biology education study program at a private university in Indonesia. One such course is the Phanerogamae Botany course. The preliminary study yielded findings indicating that students encountered challenges in analyzing and solving problems directly during field lectures at the Cibodas Botanical Gardens in Indonesia. Students encounter difficulties in integrating field experience with the theoretical knowledge acquired in the classroom. In light of the aforementioned issues, the research project aims to investigate the problem-solving abilities and scientific attitudes of students enrolled in the Phanerogamae Botany field lecture at the Cibodas Indonesia Botanical Gardens.

2. Methodology

This section details the research design, research participants, research instruments as well as the methodology of data analysis to be used in the study. A descriptive research design aimed to investigate the level of problem - solving skills and science attitude of the students who participated in the field lecture of Phanerogamae Botany at the Cibodas Botanical Gardens in Indonesia [18]. The sampling method entailed a purposive sampling in which the classes were selected based on their capabilities as they became exposed to field studies. The lowest mark of 75 that was set in the experiment was initially imposed on students. Following this, the students were occupied with the lecturing process of field trips and finally a test was taken. The observations and interpretations that were then made later (detailed) were done to verify the impact of the field trip lecture on the problem-solving capacity and the attitude of the students to science.

The participants in this research were 40 third-semester students enrolled in the Biology Education Study Program at a private university in Bandung.

The research steps are as follows:

1. Determining research objectives for the Phanerogamae Botany field study,
2. Research planning,
3. Sampling,
4. Data collection,
5. Data analysis,
6. Interpretation of results,
7. Reporting of results,
8. Recommendations,
9. Evaluation.

The categories used to assess problem-solving ability were adapted from those proposed by [19]. The categories of results for the assessment of problem-solving ability are presented in Table 1.

Table 1. Categorization of problem-solving ability results

Percentage	Category
90% ≤ A < 100%	Very Good
75% ≤ B < 90%	Good
55% ≤ C < 75%	Enough
40% ≤ D < 55%	Less
0% ≤ E < 40%	Very Less

Meanwhile, the assessment of students' scientific attitudes is categorized based on [20], which can be seen in Table 2.

Table 2. Categorization of student scientific attitude value

Value Interval (%)	Category
80-100	Very Good
66-79,9	Good
56-65,9	Enough
40- 45,9	Less
<40	Very Less

The data is presented in percentage form and processed based on several stages developed and adapted from those described by [18]. These stages include:

1. The Student Worksheet Instrument Data from the Phanerogamae Botany Field Lecture were analyzed based on the assessment criteria. Each indicator was assigned an assessment score, and the percentages were calculated. The data were then categorized.
2. A descriptive analysis was conducted to ascertain a comprehensive overview of student performance during field lectures, based on the observational field notes. The objective of this analysis was to ascertain the learning outcomes of students enrolled in Phanerogamae Botany field courses.

The data analysis of the Scientific Attitude Scale Instrument encompasses a number of key aspects, including curiosity, honesty, open-mindedness, and collaboration. Each of these is processed based on the score obtained for each question item, which is then categorized and analyzed descriptively in order to obtain an overview of students' scientific attitudes.

3. Results

This section reports the findings derived from the analysis of students' problem-solving skills and scientific attitudes developed during the Phanerogamae Botany field course.

3.1. Student Problem-Solving Ability

The results related to students' problem-solving skills observed throughout the field lecture activities are outlined. Their abilities were evaluated during the Phanerogamae Botany field lecture conducted at the Cibodas Botanical Gardens, and the outcomes are presented in Figure 1.

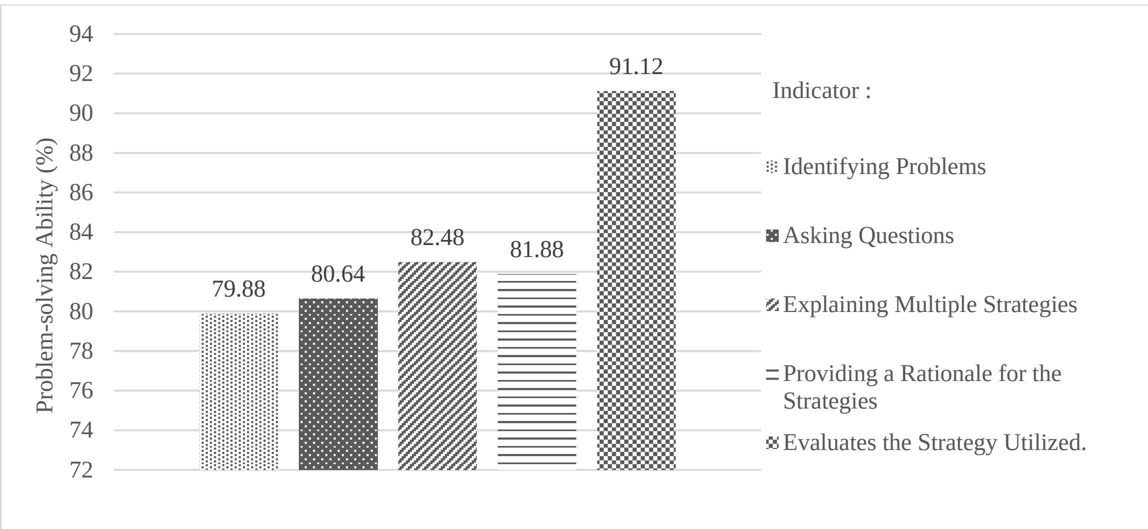

Figure 1. Percentage of students problem-solving ability for each indicator in the Phanerogamae Botany field lecture

As illustrated in Figure 2, the mean value of students problem-solving abilities for each indicator falls within the “good” and “very good” categories.

The highest mean value is observed in the indicator that evaluates the strategy utilized. In light of these findings, it can be concluded that the Phanerogamae Botany field lecture activities at the Cibodas Botanical Gardens were effective in fostering students capacity to evaluate the strategies employed.

In addition, the indicators for identifying problems, asking questions, explaining multiple strategies, and providing rationale for the strategies employed exhibited a value range of 79-83%, thereby indicating that these indicators fall within the “good” category.

(a) *(b)* *(c)* *(d)*

Figure 2. Phanerogamae Botanical field lecture activities at the Cibodas Botanical Gardens (a) Direction of students by the supervisor; (b) Exposure by the supervisor to plants found in the field; (c) Discussion between the supervisor and students in the field

Prior to the commencement of the field lecture activities, the Phanerogamae Botany field lecture activities commence with a briefing delivered by the supervisor to the students’. These activities include explanations of the procedures to be followed by students during observations, the completion of student worksheets, and the activities that are prohibited during the observation period. Additionally, other technical matters are addressed. Subsequently, the supervisor provided an elucidation of the diverse array of plant species observed, encompassing an in-depth analysis of their classification, evolutionary relationships, and distinctive morphological characteristics. This was followed by a detailed examination of the Gymnospermae and Angiospermae groups, which are of particular interest in this field of study.

Finally, the students were directed to undertake further observations of additional plant species. Furthermore, the supervisor initiated a question-and-answer session to facilitate a collective discourse on the subject of plants observed in the field, the impact of human activities on habitat destruction, and the optimal methods for ecosystem protection. This discussion session serves to reinforce the knowledge previously acquired in the classroom. In this field study activity, students engage in documentation sessions, recording and collecting plant samples (if the plant population is large and not protected) to facilitate more detailed observations conducted in groups.

3.2. Student Scientific Attitude

Field lecture activities in the Phanerogamae Botany course conducted at the Cibodas Botanical Gardens were used to examine students problem-solving abilities.

The results obtained from these activities provide an overview of students problem-solving performance during the field lectures, as presented in Figure 3.

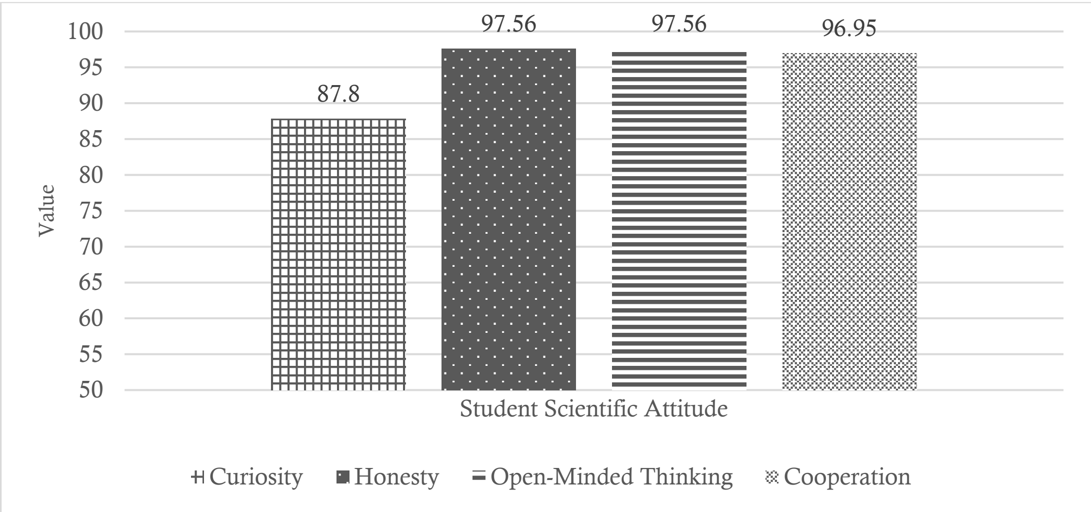

Figure 3. Assessment of students' scientific attitudes in field lectures

Figure 3 shows that students scientific attitudes in field practicum activities generally range from 87 to 100. This illustrates that, based on the category of scientific attitude values, the results are in the very good category. Nevertheless, the findings of the research indicate that there is a correlation between the values of honesty and open-mindedness. An honest and open-minded attitude is of the greatest value among the scientific attitudes under consideration. This is because both are the foundation for fieldwork activities, wherein ideas and research results can be discussed freely and without prejudice.

In light of the explanation above, it can be posited that field practicum activities have the potential to cultivate students' scientific attitudes. This is evident from the classification of scientific attitudes presented in Table 3.

Table 3. Grouping of scientific attitudes among students in field practicum activities

Attitude Group	Sum	%	Value	Average
High Scientific Attitude	25	60.98	81,73 - 88,46	85,10
Low Scientific Attitude	16	39.02	55,77 - 76,92	66,35

As shown in Table3, the proportion of students exhibiting high scientific attitudes is greater than the proportion of students exhibiting low scientific attitudes. This indicates that field practice activities have a positive impact on students' scientific attitudes. This can be interpreted as high scientific attitudes being demonstrated by the results of field practice activities.

The results of field practice allow students to apply the theory they have learned in class to practical situations.

4. Discussion

In this part, findings of the research will be discussed concerning the theories and past studies. The results of this research article prove that the problem-solving abilities of students in the field trips in Phanerogamic Botany efficacy have a positive correlation with all the indicators that were noted across the entire course. The field trips in Phanerogamic Botany can also assist students to acquire scientific attitudes. The problems encountered by the students in studying in the field provide an opportunity to explore innovative problem-solving, in order to seek solutions readily and creatively. The steps involved in this process are the initial stage of the identification of the problem and the final stage of implementation of application of the corresponding solutions by the students. Being creative and cognitive in problem-solving are related closely and mutually supportive of one another. Activities based on lectures that include real-life scenarios in field lectures, and problem-solving must provoke development of new ideas to the students [21]. The outcome concurs with the previously conducted researches who have established that there is a positive correlation between problem solving ability, and creative thinking [22]. People with greater problem-solving skill have been reported to portray more skill in creative thinking.

The fact that the average score of some of the indicators in the course of rating the strategy is very high can be attributed to some reasons.

First, by way of field study, students have been inculcated in thinking. Second, students can work well on elaborating collaboration and observation skills. Third, the students possess a high rate of flexibility and therefore out of these three factors, the students can be able to formulate the theories they have studied in their classes to the situation in the field. This finding is in line with the result of [23], students on field trips acquire real life experience and develop better understanding. Moreover, there is also a chance that field experiences and learning in the field will promote the acquisition of some new skills. Such skills are communication, analytical thinking, creativity thinking, teamwork, and problem-solving ability [24], [25], [26]. The Phanerogamae Botany field trip proved to be an effective way for students to address emerging issues through group discussions and presentations. The majority of students were able to identify potential risks to the ecosystem at the Cibodas Botanical Garden, including the impact of human activities on ecosystem damage and the necessary steps to protect the ecosystem. Modern thinking equips students with the ability to effectively face life and professional challenges [27], [28].

The indicator for identifying the problem shows the lowest average value compared to the other indicators. This is due to the fact that when identifying problems in the field, some students still have some limitations in observing. For example, the vastness of the Cibodas Botanical Garden makes it difficult for students to observe carefully and identify relevant problems. Another cause is the limited time available to allow data and information to be collected, which forces students to work quickly, leading to important details being missed. The findings of this study align with [29], which indicate that the limitations of fieldwork include restricted time for observation, resulting in suboptimal understanding, and the need to move between locations, which can disrupt students' concentration and enthusiasm [29]. Even though the indicator in question exhibits the lowest average value, this percentage is nevertheless included in the "good" category. This phenomenon may occur because problems are identified in a group setting, facilitating cognitive interaction between students. This can lead to more efficient utilization of time and knowledge acquisition. Group learning activities have several advantages. They facilitate the teaching of essential skills such as collaboration and effective teamwork. Additionally, they encourage students to support and motivate one another, which can help them manage stress and boost self-confidence when confronted with challenges in their chosen field [30]. The activity, which is designed to identify the problem above, entails presenting students with problems regarding changes in the balance of the ecosystem and plant diversity in the Cibodas Botanical Gardens. As a consequence of the fieldwork conducted by the students, they are able to present the principal issues that exist in the field.

This includes the ability to explain the various factors that contribute to these issues, such as climatic factors or the effects of human activity.

The ability to carry out identification is related to students' cognitive development, which will help facilitate their understanding so that conducting field lectures will motivate students to identify problems [31]. In addition, the indicator asks questions, explains several strategies, and provides reasons for the strategies used to have relatively similar average values. These three indicators are also included in the good category. In the indicator of asking questions, students are able to formulate problems found in the field and break them down into several questions for which solutions must be found so that the balance of the ecosystem is maintained properly. The problem formulation for each student is very diverse, which of course requires a comprehensive answer from the results of the student's thoughts through observations in the field as primary documents, supplemented by sources from secondary documents related to the problems raised. Students who are able to effectively articulate the complexities of a given problem are more likely to devise novel and ingenious solutions, which can offer fresh perspectives within the context of the problem at hand [32], [33].

The indicators then shed light on several strategies that the students can use in a bid to find possible solutions to the posed issues. Students also learn how to calculate presumptive temporary answers, thus making it easier to approach data collection in a more intensive manner. The presence of varying conjecture or solution options in the nature of these helps students to think creatively and critically when they make decisions, enhances their ability to solve the problems, makes them more active in the learning process, builds self-confidence in their ability to make decisions, and builds self-confidence in the problem-solving process [34], [35]. Finally, the indicator provides justifications of the chosen strategy. This is where the students are required to conducted field searches according to the guideline provided in the student worksheet to obtain field observation data. Also, they receive library search data in order to reinforce them. Hypotheses development, data gathering, and data management may be carried out in cooperation with groups, hence supporting communication between the members of the group. Communication within a group is a very important factor. It helps the group members to express their thoughts, pass instructions and provide encouragement to each other either verbally or in writing in a straightforward and efficient way [36], [37]. In the activity of a scientist or an academic, communication skills are also significant since the scientific attitudes will be constructed with the help of good communication skills [38].

Practical work is an essential element in developing scientific attitudes, students' confidence in the knowledge gained, expanding students' experiences, and strengthening learning outcomes, thus ensuring that these results remain in students' memory for a longer period [38], [39]. Field practice allows students to interact directly with their surroundings, fostering curiosity and a desire to learn more deeply [38]. The goal of field practice would be to arouse creativity in the students to explore and be able to comprehend what was taking place in the immediate world around them. This interest makes them pose questions and demand answer to them by getting direct impressions about them. Further, students learn the principles of academic integrity at the fieldwork and this makes them encouraged to make correct observations and write up the data without any manipulations. The teaching goal of this is to enhance building of scientific attitudes. Further, the work experience in the field could be done in groups and this helps in discussion and exchange of ideas which could improve the knowledge and teaching of the students. Consequently, they are able to get different opinions of their friends or other people.

The term "scientific attitude" is multifaceted, encompassing two distinct meanings: attitude towards science and attitude of science [40]. The initial perspective relates to a person's inclination towards scientific fields. The second viewpoint concerns the intrinsic perspective that emerges after studying science. Individuals who exhibit this attitude tend to behave consistently in various situations. The research findings indicate no significant differences in values related to honest and open-minded scientific attitudes. This demonstrates that both emphasize the significance of integrity in the scientific process. An honest attitude necessitates that researchers report findings in an accurate manner, whereas an open mindset encourages researchers to accept new facts even if they conflict with their initial beliefs. A scientific attitude related to honesty can be developed through practical activities. This includes compiling reports based on actual findings, explaining concepts using one's own understanding, and providing relevant examples to support explanations. In addition, students are trained to report facts and data accurately and to include appropriate evidence when drawing conclusions [41].

An honest scientific attitude, as carried out by students in the field, entails the reporting of all evidence found in the Botanical Gardens ecosystem in Cibodas, even if the results found are contrary to hypotheses or expectations. An open-minded scientific attitude, on the other hand, means that students value the opinions and findings expressed by members of other groups.

Every student has the right to express their ideas and receive feedback from their classmates during discussions. This admirable attitude of honesty and open-mindedness can be developed through field practice activities. This is in accordance with the findings of [42], which shows that honesty and open-mindedness can be developed through practical activities [42]. As posited by [43], honesty and open-mindedness are crucial in the context of scientific problem-solving [43].

Learning about the environment through scientific attitude of curiosity means with curiosity, students engage their senses in learning about the various flora that they will see when they go on a field trip to the Cibodas Botanical Garden. As an illustrative example, students rely on their vision to look at and view certain features of the plants they come across. More so, they will listen to the explanation taught by resource persons or other lecturers who are relevant using their sense of hearing. Also, they are provided with the use of smell when analyzing plants, where the pupils will smell the flowers or some leaves and participate in corresponding discussions on the smell as the evidence of the plant species or climate in the environment. Also, they may touch the soil and leaves in order to determine the variety of textures with the help of sense of touch. There are some instances where students can even touch a particular part of plants especially in field lectures related to medicinal plants to give them an idea about the plants.

Students with a high level of curiosity can also be identified by their attention and enthusiasm when participating in field activities. Additionally, students with high curiosity tend to seek out additional information about the species they observe. Students use various sources to find information, then reinforce their findings with the lecturer. Students who demonstrate a high level of curiosity tend to have a desire to ask further questions when they encounter concepts they do not understand. They are often encouraged to seek additional information beyond what is provided by their instructors. Furthermore, they showed enthusiasm in seeking answers to the questions posed by their instructors during the explanation [44]. Involving various senses while learning can help strengthen memory of the information obtained.

The term "cooperative attitude" as used in this study refers to the active participation of each student during both field practice and presentations. The scientific attitude of cooperation is demonstrated by students who collaborate with their group members in solving problems and conducting practical activities. Furthermore, a cooperative attitude is demonstrated by the cohesiveness of each group, which is manifested in activities among members.

These activities are reflected in discussing, offering and accepting opinions, respecting colleagues' opinions, accepting disagreements, or distributing group tasks evenly. Students involved in collaborative learning processes tend to achieve better learning outcomes than those who study independently [45]. Collaborative learning can facilitate student interaction to improve cooperation [45]. The research findings indicate that after completing field practice, students demonstrate improved scientific attitudes. Students with high scientific attitudes tend to have a strong determination to succeed and high achievement motivation [41].

5. Conclusion

Overall, the results of the current research indicate that Phanerogamae Botany field course positively affects the students in problem-solving skills, especially the ability to recognize and assess the strategies to solve the problem. Moreover, involvement in field-based learning activities helps in building the scientific disposition of the students such as curiosity, honesty, open-mindedness, and cooperation. These findings suggest that field courses provide meaningful learning experiences that support both cognitive and affective aspects of biology education. From an educational perspective, these results highlight the importance of integrating field-based learning into biology courses to enhance student engagement and skill development.

Field lectures enable students to apply theoretical knowledge in real-world contexts, encouraging active learning, collaboration, and reflective thinking. Therefore, biology educators are encouraged to design and implement well-structured field activities as part of their routine teaching practices to develop problem-solving abilities and scientific attitudes.

Despite these positive findings, this study has several limitations. The research was conducted at a single field study site with a limited number of participants. Future research could explore different field sites, involve a larger and more diverse student population, and use diverse research instruments or procedural approaches to further explore the relationship between field-based learning, problem-solving skills, and scientific attitudes.

References:

[1]. Iwuanyanwu, P. N. (2020). Nature of problem-solving skills for 21st Century STEM learners: What teachers need to know. *Journal of STEM Teacher Education, 55*(1), 27–40. Doi: 10.30707/JSTE55.1/MMDZ8325

[2]. Huang, Y. (2022). Effectiveness of inquiry-based science laboratories for improving teamwork and problem-solving skills and attitudes. *Journal of Research in Science Teaching*, *59*(3), 329-357. Doi: 10.1002/tea.21729

[3]. Jonassen, D. H. (2011). *Learning to Solve Problems: A Handbook for Designing Problem-Solving Learning Environments.* Routledge

[4]. Price, A., et al. (2022). An accurate and practical method for assessing science and engineering problem-solving expertise. *International Journal of Science Education*, *44*(13), 2061-2084. Doi: 10.1080/09500693.2022.2111668

[5]. Prevost, L. B., & Lemons, P. P. (2016). Step by step: Biology undergraduates' problem-solving procedures during multiple-choice assessment. *CBE—Life Sciences Education*, *15*(4), ar71. Doi: 10.1187/cbe.15-12-0255

[6]. Aliu, J., & Aigbavboa, C. (2020). Reviewing problem-solving as a key employability skill for built environment graduates. *Collaboration and Integration in Construction, Engineering, Management and Technology: Proceedings of the 11th International Conference on Construction in the 21st Century, London 2019*, 399-403. Springer International Publishing. Doi: 10.1007/978-3-030-48465-1_67

[7]. Weisberg, R. W. (2016). *Creativity: Understanding innovation in problem solving, science, invention, and the arts*. John Wiley & Sons.

[8]. Roesch, F., Nerb, J., & Riess, W. (2015). Promoting experimental problem-solving ability in sixth-grade students through problem-oriented teaching of ecology: Findings of an intervention study in a complex domain. *International Journal of Science Education*, *37*(4), 577-598. Doi: 10.1080/09500693.2014.1000427

[9]. Bara, G., & Xhomara, N. (2020). The effect of student-centered teaching and problem-based learning on academic achievement in science. *Journal of Turkish Science Education*, *17*(2), 180-198. Doi: 10.36681/tused.2020.20

[10]. Juhji, J., & Nuangchalerm, P. (2020). Interaction between scientific attitudes and science process skills toward technological pedagogical content knowledge. *Journal for the education of gifted young scientists*, *8*(1), 1-16. Doi: 10.17478/jegys.2020.XX

[11]. Kapici, H. O., Akcay, H., & de Jong, T. (2020). How do different laboratory environments influence students' attitudes toward science courses and laboratories?. *Journal of Research on Technology in Education*, *52*(4), 534-549. Doi: 10.1080/15391523.2020.1750075

[12]. Aguilera, D., & Perales-Palacios, F. J. (2020). Learning biology and geology through a participative teaching approach: the effect on student attitudes towards science and academic performance. *Journal of Biological Education*. Doi: 10.1080/00219266.2019.1569084

[13]. Bellová, R., Balážová, M., & Tomčík, P. (2023). Are attitudes towards science and technology related to critical areas in science education?. *Research in Science & Technological Education*, *41*(3), 1117-1132. Doi: 10.1080/02635143.2021.1991298

[14]. Nwokocha, G. C. (2024). The influence of fieldtrip as a practical skill acquisition technique in biology education. *Asian Journal of Education and Social Studies*, *50*(6), 269-279. Doi: 10.9734/ajess/2024/v50i61413

[15]. Ordon, K. J., Bartelheimer, M., & Asshoff, R. (2021). Biology student teachers' interest and self-efficacy in planning and conducting field trips after participation in a university course. *Environmental Education Research*, *27*(1), 88-109. Doi: 10.1080/13504622.2020.1849565

[16]. Foo, S. C., & Foo, K. K. (2022). Purposeful field trip: Impact on experiential learning opportunities and critical thinking skills. *Pertanika Journal of Social Sciences & Humanities*, *30*(1), 1-30. Doi: 10.47836/pjssh.30.1.01

[17]. Ugwu, C. B. A. (2023). Enhancing students' interest and achievement in senior secondary school biology through field trip teaching approach. *Sapientia Foundation Journal of Education, Sciences and Gender Studies (SFJESGS)*, *5*(4), 161–170.

[18]. Creswell, J. W., & Creswell, J. D. (2017). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.* Sage Publications.

[19]. Usman, U., Hendriyani, M. E., & Rifqiawati, I. (2022). Profil kemampuan pemecahan masalah mahasiswa melalui pembelajaran PJBL terintegrasi STEM. *Bio-Lectura*, *9*(2), 192-197. Doi: 10.31849/bl.v9i2.11177

[20]. Novallyan, D., Safita, R., Gusfarenie, D., & Sumitro, S. (2021). Analisis Sikap Ilmiah Mahasiswa Pada Praktikum Mata Kuliah Biologi Umum Di UIN Sulthan Thaha Saifuddin Jambi. *Biodik*, *7*(4), 177-182. Doi: 10.22437/bio.v7i4.16045

[21]. Khoiriyah, A. J., & Husamah, H. (2018). Problem-based learning: Creative thinking skills, problem-solving skills, and learning outcome of seventh grade students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *4*(2), 151-160. Doi: 10.22219/jpbi.v4i2.5804

[22]. Imaroh, R. D., Sudarti, S., & Handayani, R. D. (2022). Analisis korelasi kemampuan berpikir kreatif dengan model Problem Based Learning (PBL) pada Pembelajaran IPA. *Jurnal Pendidikan MIPA*, *12*(2), 198-204. Doi: 10.37630/jpm.v12i2.580

[23]. Kervinen, A., Uitto, A., & Juuti, K. (2020). How Fieldwork-Oriented Biology Teachers Establish Formal Outdoor Education Practices. *Journal of Biological Education*, *54*(2), 115–128. Doi: 10.1080/00219266.2018.1546762

[24]. Saefudin, & Permana, A. (2020). Implementation of Field Trps With Various Strategies to Improve Students Critical Thinking Skills. *Jurnal Bioconcetta*, *6*(2), 79-93.

[25]. Hastika, A. D., & Supriatno, B. (2024). Exploring Students' Perceptions of Outdoor Biology Learning Activities in Botanical Garden. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2379-2387. Doi: 10.29303/jppipa.v10i5.6718

[26]. Mackenzie, S. H., Son, J. S., & Eitel, K. (2018). Using outdoor adventure to enhance intrinsic motivation and engagement in science and physical activity: An exploratory study. *Journal of outdoor recreation and tourism*, *21*, 76-86. Doi: 10.1016/j.jort.2018.01.008

[27]. Manurung, A. S., Fahrurrozi, E. U., & Gumelar, G. (2023). Implementasi berpikir kritis dalam upaya mengembangkan kemampuan berpikir kreatif mahasiswa. *Jurnal Papeda*, *5*(2).

[28]. Kim, J. Y., et al. (2018). The role of problem solving ability on innovative behavior and opportunity recognition in university students. *Journal of Open Innovation: Technology, Market, and Complexity*, *4*(1), 1-13. Doi: 10.1186/s40852-018-0085-4

[29]. Novitasari, R., Gunawan, H., & Nurhidayati, I. (2023). Implementasi Metode Outdoor Learning Pada Pembelajaran PAI Di Sekolah Alam Aminah Sukoharjo Tahun Ajaran 2021/2022. *Al'Ulum Jurnal Pendidikan Islam*, 92-104. Doi: 10.54090/alulum.138

[30]. Sella, E., et al. (2023). Psychological benefits of attending forest school for preschool children: A systematic review. *Educational Psychology Review*, *35*(1), 29. Doi: 10.1007/s10648-023-09750-4

[31]. Juriah, J., & Zulfiani, Z. (2019). Penerapan Model Problem Based Learning Berbantu Media Video Untuk Meningkatkan Hasil Belajar Peserta Didik Pada Konsep Perubahan Lingkungan Dan Upaya Pelestarian. *Edusains*, *11*(1), 1-11. Doi: 10.15408/es.v11i1.6394

[32]. Fitriani, A., et al. (2020). PBLPOE: A Learning Model to Enhance Students' Critical Thinking Skills and Scientific Attitudes. *International Journal of Instruction*, *13*(2), 89-106. Doi: 10.29333/iji.2020.1327a

[33]. Matanıarı, R., et al. (2020). Portraying students' critical thinking skills through research skill development (RSD) framework: A case of a biology course in an Indonesian University. *Journal of Turkish Science Education*, *17*(2), 302-314. Doi: 10.36681/tused.2020.28

[34]. Ningrum, W. A., Sumarno, S., & Sulistyowati, S. (2023). Peningkatan keterampilan berpikir kritis melalui model problem based learning berbantuan LKPD Pada Kelas X-1 SMAN 9 Semarang. *Jurnal Pendidikan Guru Profesional*, *1*(1), 30-39. Doi: 10.26877/jpgp.v1i1.167

[35]. Wibawanti, A., Murdiono, M., & Muryati, T. (2023). Peningkatan Keterampilan Berpikir Kritis Melalui Model PBL dalam Muatan IPA pada Siswa Kelas V. *Educatif Journal of Education Research*, *5*(1), 175-183. Doi: 10.36654/educatif.v5i1.162

[36]. Shin, M. H. (2018). Effects of Project-Based Learning on Students' Motivation and Self-Efficacy. *English teaching*, *73*(1), 95-114. Doi: 10.15858/engtea.73.1.201803.95

[37]. Ariyansyah, A. (2018). Penerapan Beberapa Keterampilan Abad 21 Melalui Metode Kuliah Lapangan (Field Trip) untuk Meningkatkan Kualitas Pembelajaran Taksonomi Tumbuhan Tingkat Rendah. *Oryza: Jurnal Pendidikan Biologi*, *7*(1), 1-9. Doi: 10.33627/oz.v7i1.11

[38]. Taufiq, M., & Rokhman, F. (2020). Scientific communication skills profile of prospective science teachers based on sociocultural aspects. *Jurnal Pendidikan IPA Indonesia*, *9*(2), 187-193. Doi: 10.15294/jpii.v9i2.24366

[39]. Rustaman, N. Y. (2005). *Strategi belajar mengajar biologi.* UM Press.

[40]. Kusuma, A. K., Utami, B., & Mulyani, B. (2021). The relationship between students' problem solving skills and scientific attitude with students' learning outcomes on stoichiometry at tenth grade at high school in Boyolali, Central Java, Indonesia. *Journal of Physics: Conference Series*, *1842*(1), 012027. Doi: 10.1088/1742-6596/1842/1/012027

[41]. Yusuf, M., & Andariana, A. (2022). Pengukuran sikap ilmiah mahasiswa pada materi pengaruh aspek geografis terhadap sebaran hewan. *LaGeografia*, *20*(3), 281. Doi: 10.35580/lageografia.v20i3.33280

[42]. Kusherawati, L., Windyariani, S., & Setiono, S. (2020). Profil sikap ilmiah siswa kelas VIII SMP, melalui model pembelajaran guided inquiry laboratory experiment method (gilem. *Biodik*, *6*(2), 168-175. Doi: 10.22437/bio.v6i2.9307

[43]. Rohaeti, E., & Prodjosantoso, A. K. (2020). Oriented Collaborative Inquiry Learning Model: Improving Students' Scientific Attitudes in General Chemistry. *Journal of Baltic Science Education*, *19*(1), 108-120. Doi: 10.33225/jbse/20.19.108

[44]. Khotimah, U. L., Suryanda, A., & Heryanti, E. (2024). Hubungan sikap ilmiah dengan kemampuan berpikir kritis siswa pada materi perubahan lingkungan. *Jurnal Education and Development*, *12*(3), 150-157. Doi: 10.37081/ed.v12i3.6402

[45]. Qureshi, M. A., et al. (2023). Factors affecting students' learning performance through collaborative learning and engagement. *Interactive Learning Environments*, *31*(4), 2371-2391. Doi: 10.1080/10494820.2021.1884886