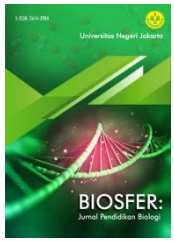
Biosfer: Jurnal Pendidikan Biologi, 18(1), 221-231 (2025)

Biosfer: Jurnal Pendidikan Biologi

Journal homepage: http://journal.unj.ac.id/unj/index.php/biosfer



Problem solving in plant ecology: Enhancing cognitive learning outcomes

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ARTICLE INFO

Article history
Received: 17 December 2024
Revised: 24 January 2025
Accepted: 28 January 2025

Keywords:
Cognitive Learning Outcome
Plant Ecology
Problem-solving
Textbook

ABSTRACT

Cognitive learning outcomes (CLO) are the most important part of learning. CLO the basis of students' understanding for further learning. CLO play an important role in students' readiness to face the real world. Therefore, CLO needs to be facilitated in learning. CLO is related to the problem-solving process. This study aims to produce a problem-solving-based textbook to improve conceptual understanding in the Plant Ecology course. This research and development follow the 4D model consisting of define, design, develop, and disseminate. The instruments used in this study were questionnaires, validation sheets, and problem-solving-based test instruments in the form of essay questions. Data collection techniques used were observation, questionnaires, and tests. To determine the feasibility of problem-solving-based test instruments, the data analyzed were the results of validation by material experts and media experts. To determine the practicality of problem-solving-based tests, the data analyzed were the results of lecturer validation and student responses. The result of problem-solving-based textbook that has been compiled has met the validity criteria and practicality. In addition, problem-solving-based textbooks have an effect on CLO. Therefore, problem-solving-based textbooks are highly recommended in improving students' CLO. This means that there is an influence of problem-solving-based textbooks on CLO in the Plant Ecology course. Therefore, problem-solving based textbooks are highly recommended in improving students' CLO.

INTRODUCTION

Problem-solving skills play an important role in everyday life (Widyaningtyas et al., 2024). Problems that arise in life have varying complexities. Problem solving is a mental process that includes actions that find, analyze and solve problems. The purpose of problem solving is to eliminate and find the best solution (Schäfer, Reuter, Leuchter, et al., 2024)). In addition, problem solving is said to be decision making (Wang et al., 2022). Problem solving is a form of high-level thinking (Antonio & Prudente, 2024). Problem solving is not a separate topic but is integrated into the learning process (Aydoğan & Özyürek, 2020). Problem solving is an effective way to explore new ideas (Jannah & Saifuddin, 2024). Problem solving as an activity that is mechanistic, systematic, and often associated with an abstract concept (Schäfer, Reuter, Karbach, et al., 2024). Problem solving is an activity that requires knowledge of the subject matter and the selection of appropriate cognitive strategies to find a means to achieve the desired results (Destiansari et al., 2024). Problem solving is an action that has various mental processes and skills when reaching the correct conclusion. An individual with high problem-solving skills can effectively use knowledge and can easily solve the problems faced.

The skills to carry out problem solving are not only related to the accuracy of the solution obtained, but also the skills demonstrated since recognizing the problem, finding alternative solutions, choosing one alternative as a solution, and evaluating the answers that have been obtained. Problem solving skills are considered the most complex intellectual function (Surur et al., 2022). Problem solving skills include thinking and reasoning skills, which also include metacognitive and critical thinking skills (Leasa & Pelamonia, 2024). In addition, problem solving is closely related to cognitive abilities. The cognitive abilities in question are logical abilities from remembering to creating (Susanti, 2018). Students who have problem-solving skills will be able to make decisions with careful consideration. In solving problems, students will involve analytical and creative thinking.

Effective problem solving requires a truly sequential approach. Problem-solving skills, namely (a) identifying problems, (b) identifying several problem-solving solutions, (c) choosing one solution from the problem (Greenstein, 2012). Problem solving consists of defining the problem, exploring the problem, planning a solution, implementing the plan, and evaluating the results (Costley et al., 2024). Problem solving also involves students' willingness to accept challenges. Accepting challenges in this context means that students are willing to find the right method to solve the problem (Ashman et al., 2020). In general, problem solving consists of Understanding the problem, devising a plan, executing the plan.

Problem solving can be a direction or reference for the learning process, it is included in procedural abilities (Dulger & Ogan-Bekiroglu, 2024). Through problem solving, students are directed to understand the concept as a whole (Rini et al., 2024). In understanding the concept, students begin to remember a concept, understand, apply, apply, evaluate, and create (Anderson & Krathwohl, 2001). Problem solving contributes to concept mastery (Schäfer et al., 2024; Wang et al., 2022). Content mastery is needed for the use of problem-solving strategies. Conversely, problem-solving performance increases as a form of mastery of specific concepts (Aydoğan & Özyürek, 2020).

Mastery of concepts in plant ecology courses is needed to train students in solving environmental problems. Plant ecology is one of the sciences that aims to protect the surrounding environment. In plant ecology, students are taught to understand the existence of plants in an area, their roles, symbiosis, and other things that support balanced interactions in the ecosystem. Problem-solving skills are needed to address current environmental problems wisely. The results of the initial trial showed that 73% of students were not yet able to recognize environmental problems, and were not optimal in understanding ecological concepts. Students' CLO is still limited to the cognitive level of remembering, understanding, and applying. The ability to analyze has not been facilitated properly. In fact, CLO plays a very important role, to be the basis for application and evaluation in plant ecology.

CLO has not been facilitated properly, because there are no adequate textbooks available. CLO can be developed through problem solving. Several previous studies have reported that there is a positive relevance between problem solving and CLO (Ashman et al., 2020; Banawi et al., 2024; Hasan et al., 2019). Through problem solving, students are initiated to analyze causes and find solutions. Problem solving has the advantage of providing contextual and comprehensive problems. This is very much in line with the characteristics of Plant Ecology. Thus, the consequences obtained if not using problem solving are feared that students will have difficulty analyzing a problem and finding the right solution. The Plant Ecology textbook that was developed contains contextual problems and local

potentials in the Kalimantan region. So that it gives a different impression from existing Plant Ecology textbooks. Therefore, this study aims to develop a problem-solving-based textbook to improve cognitive learning outcomes (CLO) in the Plant Ecology course.

METHODS

Research Design

The research method used is research and development, which refers to the 4D model (define, design, development, and disseminate) developed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel in 1974. This research was conducted in the even semester of 2023-2024. The subjects in the study were students who programmed the Plant Ecology course.

Population and Samples

The population in this study were all biology education students of the Faculty of Teacher Training and Education, Borneo Tarakan University, totaling 312 students. Sampling was done purposively. The sample in this study was students taking the Plant Ecology course in the 2023-2024 academic year, totaling 56 students.

Instrument

The instruments used in this study were questionnaires, validation sheets, and problem-solving-based test instruments in the form of essay questions. The questionnaire used was a student response questionnaire to the problem-solving-based Plant Ecology textbook. The questionnaire consists of context, process, and content (Samsu et al., 2020). The validation sheet consists of validation by material/content experts, learning media experts, and practitioners. The aspects of material validity consist of the systematic presentation of the material, the relevance of the material to learning outcomes, the suitability of the material to the level of student ability, the clarity of the material description, the suitability of the presentation of problems to the material, and the accuracy of the language structure used (modification from Lutfauziah et al., 2023). The aspects of the validity of learning media consist of the clarity of the division of material in the textbook, the clarity of the numbering system, the arrangement of space/layout, the selection of the appropriate font type and font size, the suitability of the physical size of the book to the user, and the suitability of the images used to the problems presented (modification from Sabri et al., 2023). The test instrument used was 10 essay question items covering the cognitive abilities of remembering, understanding, applying, analyzing, evaluating, and creating (Anderson & Krathwohl, 2001). The test instrument used has been tested for validity of Pearson Product Moment with a value of 0.451. The results of the Cronbach's Alpha reliability test were 0.342.

Procedure

The procedures in this research and development consist of definition, design, development, and dissemination (Figure 1). Define stage, a front-end analysis is carried out. An initial diagnosis is carried out to improve the efficiency and effectiveness of learning. Student character analysis is also carried out to determine the initial abilities of students. Analysis of concepts and learning objectives is carried out for the preparation of materials. In the design stage, the preparation of test standards is carried out by creating a grid for understanding concepts in the plant ecology course. The preparation of the grid is adjusted to the results of the analysis of students' academic abilities. In addition, designing teaching materials based on problem-solving that are in accordance with the Plant Ecology sub-CPMK. In the development stage, the development of teaching materials is then carried out through expert appraisal and developmental testing. Expert assessment is conducted to assess teaching materials in terms of construction and content of the material. Valid teaching materials will be tested with a total of 9 students with different academic abilities. The dissemination stage is conducted to promote the product resulting from the development of problem-solving-based test instruments on real targets or objectives. In addition, this stage is carried out to determine the effectiveness of the product being developed. At the disseminate stage, an effectiveness test was conducted using a quasi-experimental design. Two classes were used in this study. The experimental class used the PBL model, while the control class used discussion-lecture.

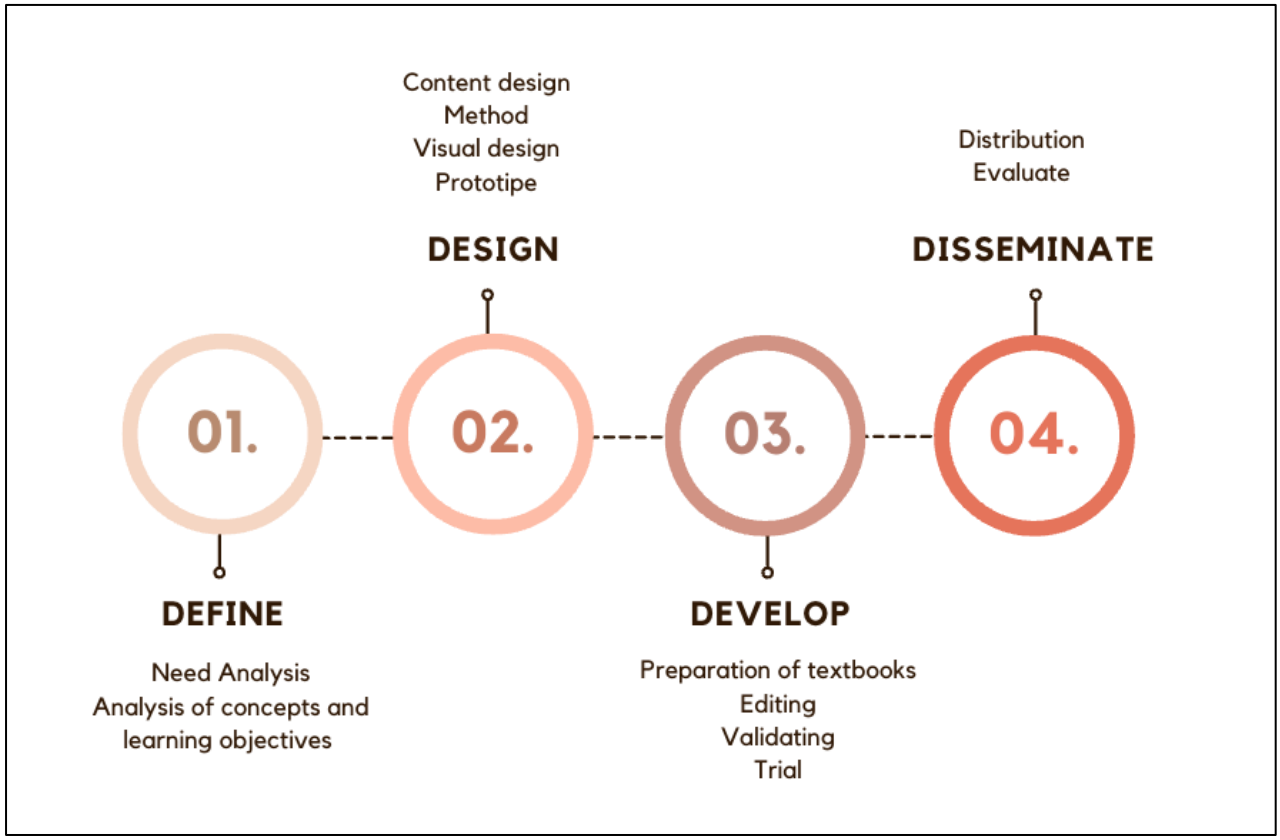

Figure 1. Flowchart for developing a problem-solving-based plant ecology textbook

Data Analysis Techniques

The data collection techniques used were questionnaires and tests. To determine the feasibility of problem-solving-based test instruments, the data analyzed were the results of validation by material experts and media experts. To determine the practicality of problem-solving-based test instruments, the data analyzed were the results of lecturer validation and student responses referring to the criteria of feasibility and practicality (Alwi et al., 2020). The effectiveness of problem-solving-based textbooks was analyzed using ANCOVA to determine the effect of problem-solving-based textbooks on CLO. Levene's homogeneity test and Kolmogorov-Smirnov normality test are conducted before the hypothesis test.

RESULTS AND DISCUSSION

The results of the research and development of problem-solving-based textbooks in plant ecology courses are effective in improving students' mastery of concepts. The following presents the results of the research and development of problem-solving-based textbooks.

1) Define

The following presents the results of the analysis at the define stage (Table 1). The define stage is carried out to know the basic needs for carrying out development. At the define stage, front-end analysis, learner analysis, task analysis, concept analysis, and specifying instructional objectives.

Table 1
Results of needs analysis at the define stage

No	Define Stage	Analyze result
1	Front-end Analysis	- There are no problem-solving-based textbooks for plant ecology courses - Students expect learning media that support learning about plant ecology
2	Learner Analysis	- Students want real/contextual learning - Students' CLO is not yet optimal. 73% are not yet able to analyze and evaluate concepts in plant ecology. - Students are not yet able to identify the causes and solutions to environmental problems around them
3	Task Analysis	- Students will be directed to carry out problem-solving based learning - Students will be trained with high-level thinking questions to facilitate problem-solving and CLO skills
4	Concept Analysis	- The concept of plant ecology that will be taught is the principle of plant ecology; characteristics of plant populations and communities; community structure and community dynamics; vegetation parameters and analysis; the concept of adaptation and indicator plants.
5	Specifying Instructional Objectives	- Formulation of learning objectives through problem-solving based learning in plant ecology courses enables students to improve their analytical, evaluation and creative abilities.

Table 1 shows that the need for problem-solving-based textbooks is an important thing that needs to be developed in Plant Ecology lectures. The results of the needs analysis show that there are no problem-solving-based textbooks in plant ecology courses. whereas problem-solving has an important role in everyday life, especially in environmental problems (Lutfauziah et al., 2023). In addition, through problem-solving, students can think more critically (Topsakal et al., 2022).

Students also expect books that help them learn by presenting contextual things. Contextual in learning makes it easier for students to remember and understand a concept (Sarip et al., 2022). Students' cognitive abilities also need to be improved in high-order thinking (levels of analysis, evaluation, and creation). High-order thinking is the main thing that students must have to face the challenges of the world of work (Dewi et al., 2020). After conducting a needs analysis, the next stage is the design stage.

2) Design

After defining, the next step is to design a textbook and a grid for the student's conceptual understanding test. Conceptual understanding consists of remembering, understanding, applying, analyzing, evaluating, and creating. The conceptual understanding test consists of 10 essay questions. The design of the textbook is adjusted to the stages in problem solving. The following is the design of a problem-based textbook (Figure 2).

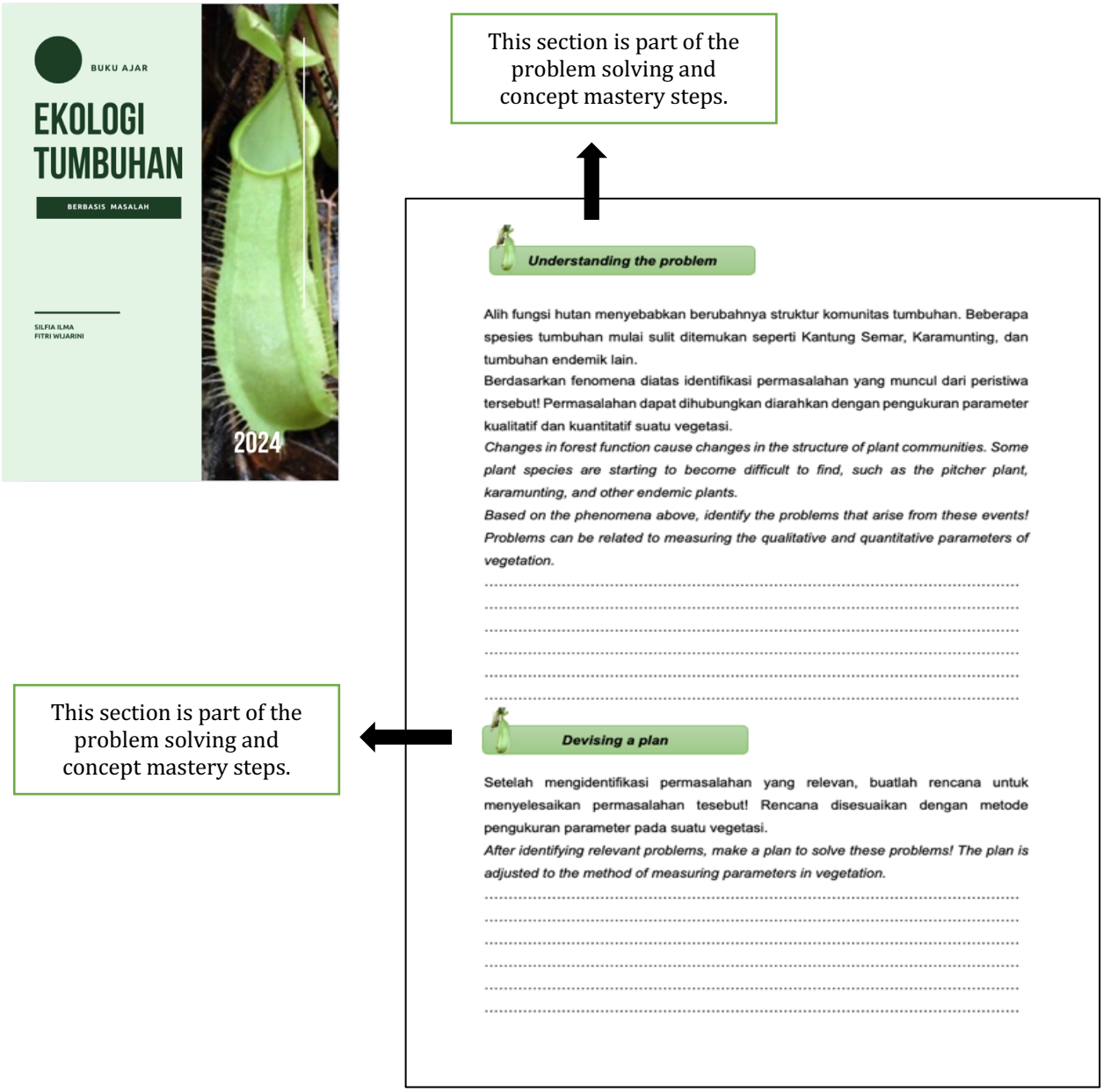

Figure 2. Design of problem-solving based textbooks in Plant Ecology

Figure 2 shows that the developed Plant Ecology textbook integrates problem-solving aspects to help students improve CLO. The plant icons used on the cover and in the sub-chapters use endemic plants from Kalimantan. This aims to add interesting and contextual elements to the textbook. The use of contextual images helps in understanding concepts (Ani et al., 2017). In addition, the structure of this textbook is made as consistent as possible from the basics of problem-solving skills (Magdalena et al., 2020).

3) Develop

The developed teaching materials were then validated by material experts, media and practitioners. Categorization follows (Alwi et al., 2020). The validation results are in Table 3.

Table 3
Validity Results of Material and Practitioners

No	Validity	Percentage (%)	Criteria
1	Contents	88.00	Feasible
2	Media	85.00	Feasible
3	Practitioner	90.00	Very Feasible

Table 3 shows that problem-solving-based textbooks have met the eligibility criteria of experts in terms of learning materials and media. After expert validation, the next trial was conducted with 9 student subjects who had taken plant ecology courses. The results of the trial are in Figure 3.

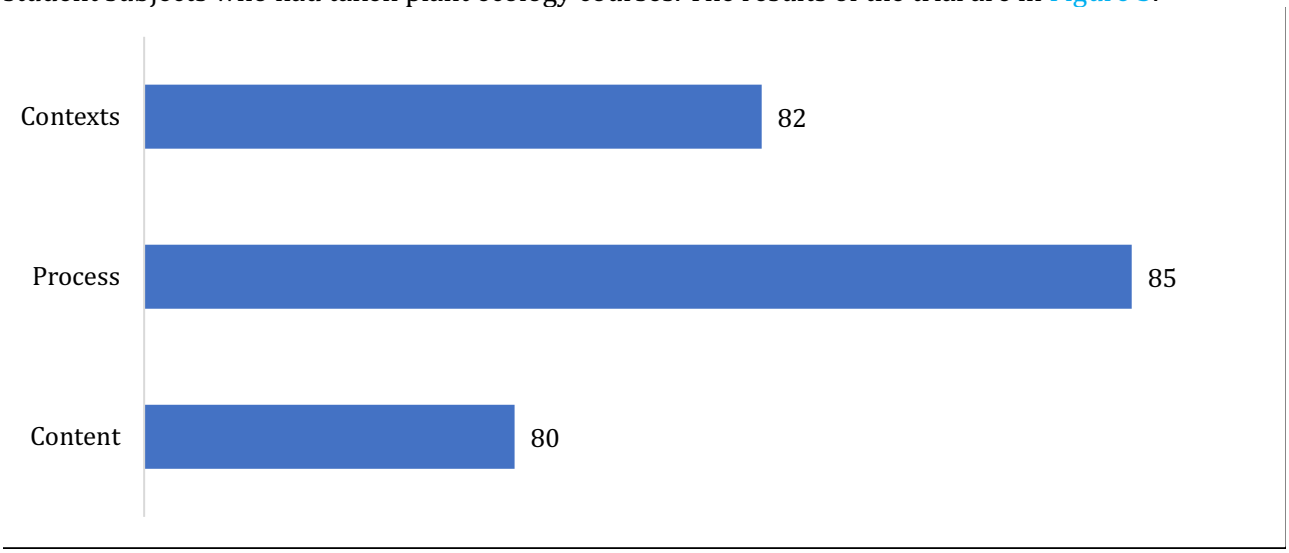

Figure 3. Results of the trial of the problem-solving-based Plant Ecology Textbook

Figure 3 shows the results of the practicality trial of problem-solving-based textbooks in the Plant Ecology course from the context aspect of 82% practical criteria, the process aspect of 85% practical criteria, and the content of 80% practical criteria. Valid and practical textbooks can then be continued for effectiveness testing (Nursamsu et al., 2020).

4) Disseminate

This stage is conducted to test the effectiveness of problem-solving-based textbooks on students' conceptual understanding. The effectiveness of problem-solving-based textbooks is carried out using a pretest-posttest non-equivalent control group design. The results of descriptive statistics are in Table 4.

Tabel 4
Descriptive statistics

Cognitive Learning Outcome (CLO)	N	Minimum	Maximum	Mean	SD
Pretest PBL	27.00	22.00	46.00	37.00	6.51
Postest PBL	27.00	80.00	87.00	83.00	2.74
Pretest konvensional	25.00	32.00	56.00	42.00	5.74
Postest konvensional	25.00	80.00	88.00	82.00	3.56

Table 4. Explains the results of descriptive statistics from the pretest and posttest of the PBL class and the Conventional class. The standard deviation in the PBL class post-test 2.74 is smaller than the average value, meaning that the data is well distributed. This also occurs in the Conventional class. Hypothesis test results Table 5.

Table 5
ANCOVA Results of Concept Mastery

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	F Table
Corrected Model	1321.81[a]	2	1321.81	5.24	.00	2.38
Intercept	26158.22	1	26158.22	450.21	.00	
Xcognitive learning	1283.62	1	1283.62	6.21	.00	2.38
outcome	11904.25	1	117.20			
Class	13621.11	52				
Error	241698.00	50				
Total	24712.00	49				
Corrected Total						

a.R Squared = .233 (Adjusted R Square = .152)

The results of the study showed that the post-test scores of students in conventional learning classes and PBL classes were different. This means that there is an influence of problem-solving-based textbooks on students' mastery of concepts in the Plant Ecology course. This is in accordance with the results of research, which explain that problem-based learning can increase CLO (Trihastuti et al., 2019; Zaidah & Hidayatulloh, 2023).

The development of problem-based textbooks is an appropriate learning medium to improve students' CLO. This is in accordance with the results of research, which state that to solve problems, students need to explain in detail and make plans (Miller-Cotto et al., 2022; Riyadi et al., 2021). The textbooks developed contain worksheets that serve as guides for the learning process and improve concept mastery. Good worksheets will help students master concepts (Maharani & Marhamah, 2024).

The difference in CLO in the control class and the experimental class occurs because in learning in the experimental class, students are fully facilitated to solve a problem. In solving problems, students think systematically from the most basic things. Students are asked to recognize the problem. The process of recognizing problems starts with recognizing a concept. After recognizing the problem, students are directed to plan activities to solve the problem. The preparation of a problem-solving plan is closely related to cognitive components from the lowest to the highest cognitive levels (Gunawan et al., 2020; Pradestya et al., 2019).

Problem-solving-based textbooks in the Plant Ecology course consist of problem-based learning steps. The problems contained in this textbook are environmental problems that occur around. Contextual problems contribute greatly to students' success in understanding concepts (Hasan et al., 2019). In addition, problem-solving-based textbooks provide additional knowledge content, which increases students' interest in reading. The images presented in the textbook are also images that are around. Another advantage provided by problem-solving-based textbooks is that these books gradually accompany students to practice high-level thinking. The high-level thinking process in question starts from the cognitive level of analyzing to evaluating (Banawi et al., 2024). Problem-solving-based textbooks contain a systematic presentation of material and have an attractive visual design.

Problem-based learning helps students learn to be sensitive to problems that occur (Bariyyah, 2021; Kartini et al., 2021). Through this sensitivity, students are challenged to explore their curiosity. Then, learn to identify the cause of a problem. Identification is an activity in learning that can help students explore and apply a concept (Afnan et al., 2023). After identifying the problem, students are directed to prepare a problem-solving plan. In preparing a problem-solving plan, students collect data, supporting theories, and relevant facts to solve the problem (Aslan, 2021; Roosyanti & Suryarini, 2024). The next problem-solving process is to carry out the plan that has been prepared. In formulating a solution, students are asked to note down things that are obstacles. In this case, obstacles can be technical and financial. Obstacles in implementing the next activity will be reflected in the evaluation activity. In the final activity, students are asked to present the results of the problem-solving activity. Each group is required to provide suggestions, questions, or responses. In providing responses or suggestions to other groups, students have evaluated or formulated a new idea to overcome the problems faced (Ebrahim & Brown, 2022). This research is limited to the Plant Ecology course, so for further research, it is necessary to develop problem-solving-based textbooks in other similar courses. Other similar courses are Conservation, Environmental Education, and Environmental Ecology.

CONCLUSION

This study concludes that the development of problem-solving-based teaching materials for Plant Ecology courses is valid and practical, as well as effective in improving students' conceptual understanding.

ACKNOWLEDGMENT

The author expresses his deepest gratitude to the Institute of Research and Community Service of the Faculty of Teacher Training and Education Universitas Borneo Tarakan, which has become the main sponsor in this research by decree number 047/UN51.7/KONTRAK-RKD/2024.

REFERENCES

Afnan, R., Munasir, M., Budiyanto, M., & Aulia, M. I. R. (2023). The Role of Scientific Literacy Instruments For Measuring Science Problem Solving Ability. *IJORER : International Journal of Recent Educational Research*, *4*(1), 45–58. https://doi.org/10.46245/ijorer.v4i1.271

Alwi, Z., Ernalida, & Lidyawati, Y. (2020). Kepraktisan Bahan Ajar Perencanaan Pembelajaran berbasis Pendidikan Karakter dan Saintifik. *Jurnal Pendidikan Bahasa Dan Sastra Indonesia*, *16*(1). https://doi.org/10.25134/fjpbsi.v16i1.2312

Anderson, L. , W., & Krathwohl, D. , R. (2001). *A Taxonomy for Learning, Teaching, and Assesing: A Revision of Bloom's Taxonomy of Educational Objectives*. Addison Wesley Longman, Inc.

Ani, A., Maulana, M., & Suaneningsih, C. (2017). Pengaruh Pendekatan Kontekstual berbasis kecerdasan visual-spasial terhadap kemampuan pemahaman matematis siswa sekolah dasar. Jurnal Pena Ilmiah. *Jurnal Pena Ilmiah*, *2*(1), 971–980. https://doi.org/10.17509/jpi.v2i1.11234

Antonio, R. , P., & Prudente, M. , S. (2024). Effects of Inquiry-based Approaches on Students Higher-Order Thinking in Science: A Meta Analysis. *International Journal of Education in Mathematics, Science and Technology*, *12*(1), 251–281. https://files.eric.ed.gov/fulltext/EJ1408841.pdf

Ashman, G., Kalyuga, S., & Sweller, J. (2020). Problem-solving or Explicit Instruction: Which Should Go First When Element Interactivity Is High? *Educational Psychology Review*, *32*(1), 229–247. https://doi.org/10.1007/s10648-019-09500-5

Aslan, A. (2021). Problem- based learning in live online classes: Learning achievement, problem-solving skill, communication skill, and interaction. *Computers & Education*, *171*, 104237. https://doi.org/10.1016/j.compedu.2021.104237

Aydoğan, Y., & Özyürek, A. (2020). The Relationship between Problem-Solving Skills and Memory Development in Preschool Children. *Journal of History Culture and Art Research*, *9*(3), 43. https://doi.org/10.7596/taksad.v9i3.1988

Banawi, A., Rumasoreng, M. , I., Hasanah, N., & Basta, I. (2024). The Relationship between Problem-Solving Skills and Student Academic Achievement: A Meta-Analysis in Education. *Journal of Ecohumanism*, *3*(3), 1287–1299. https://doi.org/10.62754/joe.v3i3.3413

Bariyyah, K. (2021). Problem solving skills: esssential skills challenges for the 21st century graduates. *Jurnal EDUCATIO: Jurnal Pendidikan Indonesia*, *7*(1), 71. https://doi.org/10.29210/120212843

Costley, J., Gorbunova, A., Courtney, M., Chen, O., & Lange, C. (2024). Problem-solving support and instructional sequence: impact on cognitive load and student performance. *European Journal of Psychology of Education*, *39*(3), 1817–1840. https://doi.org/10.1007/s10212-023-00757-7

Destiansari, E., Salsabilla, F. W., & Meilinda. (2024). Development of electronic students' worksheets based on problem-based learning on air pollution material. *Biosfer*, *17*(2), 337–349. https://doi.org/10.21009/biosferjpb.34117

Dewi, R. M., Sholikhah, N., & Fitrayati, D. (2020). High Order Thinking Skills Instrument on Microeconomics Course: A Development Research. *International Journal of Instruction*, *13*(4), 283–294. https://doi.org/10.29333/iji.2020.13418a

Dulger, Z., & Ogan-Bekiroglu, F. (2024). Examination of the Relationship between Metacognitive Awareness and Problem Solving Strategies. *International Journal of Research in Education and Science*, *10*(3), 595–611. https://doi.org/10.46328/ijres.3454

Ebrahim, K., & Brown, L. (2022). Enhancing Students Problem-Solving Skills through Project-based Learning. *Journal of Problem Based Learning in Higher Education*, *10*(1), 74–87. https://doi.org/10.54337/ojs.jpblhe.v10i1.6887

Greenstein, L. (2012). *Assessing 21st Century Skills: A Guide to. Evaluating Mastery and Authentic Learnin*. Corwin.

Gunawan, G., Harjono, A., Nisyah, M., Kusdiastuti, M., & Herayanti, L. (2020). Improving Students' Problem-Solving Skills Using Inquiry Learning Model Combined with Advance Organizer. *International Journal of Instruction*, *13*(4), 427–442. https://doi.org/10.29333/iji.2020.13427a

Hasan, R., Lukitasari, M., Juniarti, V., & Irwandi, I. (2019). Improving student problem-solving skill and cognitive learning outcome through the implementation of problem-based learning. *JURNAL BIOEDUKATIKA*, *7*(1), 18. https://doi.org/10.26555/bioedukatika.v7i1.12323

Jannah, N., & Saifuddin, M. F. (2024). Problem-based blended learning: The student's critical thinking skills in the respiratory system material. *Biosfer*, *17*(2), 350–360. https://doi.org/10.21009/biosferjpb.36522

Kartini, F. S., Widodo, A., Winarno, N., & Astuti, L. (2021). Promoting Student's Problem-Solving Skills through STEM Project-Based Learning in Earth Layer and Disasters Topic. *Journal of Science Learning*, *4*(3), 257–266. https://doi.org/10.17509/jsl.v4i3.27555

Leasa, M., & Pelamonia, J. (2024). Emotional literacy and problem-solving skills with pbl model and hpc strategy: Circulatory system concept. *Biosfer*, *17*(2), 421–433. https://doi.org/10.21009/biosferjpb.42521

Lutfauziah, A., Handriyan, A., & Fitriyah, F. K. (2023). Assessment of Problem-Solving Skills in The Topic Of Environment: Its Validity And Reliability. *Jurnal Pena Sains*, *10*(1), 20–27. https://doi.org/10.21107/jps.v10i1.14142

Magdalena, I., Sundari, T., Nurkamilah, S., Nasrullah, & Amalia, D. , A. (2020). Analisis bahan ajar. *Nusantara: Jurnal Pendidikan Dan Ilmu Sosial*, *2*(2), 311–326. https://doi.org/10.36088/nusantara.v2i2.805

Maharani, P., & Marhamah. (2024). Development of E-Student Worksheet Based Task-Based Learning Through LiveWorksheets.com for High School Students. *Al-Ishlah: Jurnal Pendidikan*, *16*(2), 1205–1217. https://doi.org/10.35445/alishlah.v16i2.5183

Miller-Cotto, D., Booth, J. L., & Newcombe, N. S. (2022). Sketching and verbal self-explanation: Do they help middle school children solve science problems? *Applied Cognitive Psychology*, *36*(4), 919–935. https://doi.org/10.1002/acp.3980

Nursamsu, Mustika, D., Nafaida, R., & Manurung, N. (2020). Analisis Kelayakan dan Kepraktisan Modul Praktikum berbasis Literasi Sains untuk Pembelajaran IPA. *JIPI: Jurnal IPA Dan Pembelajaran IPA*, *4*(1), 29–40. https://doi.org/10.24815/jipi.v4i1.15546

Pradestya, R., Imswatama, A., & Balkist, P. , S. (2019). Langkah-langkah Pemecahan Masalah dan Kemampuan Kognitif. *Jurnal Pendidikan Matematika*, *2*(2), 34–40. https://doi.org/10.37150/jp.v2i2.1113

Rini, D. S., Azrai, E. P., & Inayah, S. S. (2024). The effect of using ar sinaps learning supplements on high school students' concept understanding of respiratory system topics. *Biosfer*, *17*(2), 361–370. https://doi.org/10.21009/biosferjpb.37579

Riyadi, R., Syarifah, T. J., & Nikmaturrohmah, P. (2021). Profile of Students' Problem-Solving Skills Viewed from Polya's Four-Steps Approach and Elementary School Students. *European Journal of Educational Research*, *volume-10-2021*(volume-10-issue-4-october-2021), 1625–1638. https://doi.org/10.12973/eu-jer.10.4.1625

Roosyanti, A., & Suryarini, D. Y. (2024). Science problem solving in elementary schools through the application of project-based learning. *Journal of Research in Instructional*, *4*(1), 27–38. https://doi.org/10.30862/jri.v4i1.278

Sabri, S., Umar Kholil, & Marzuki Ahmad. (2023). Validitas Buku Ajar dengan Pendekatan Kontekstual dalam Membelajarkan Kemampuan Berpikir Kreatif Siswa Sekolah Dasar. *Jurnal Elementaria Edukasia*, *6*(3), 1043–1056. https://doi.org/10.31949/jee.v6i3.6629

Samsu, N., Mustika, D., Nafaida, R., & Manurung, N. (2020). Analisis Kelayakan dan Kepraktisan Modul Praktikum Berbasis Literasi Sains untuk Pembelajaran IPA. *Jurnal IPA & Pembelajaran IPA*, *4*(1), 29–40. https://doi.org/10.24815/jipi.v4i1.15546

Sarip, M., Amintarti, S., & Utami, N. H. (2022). Validitas Dan Keterbacaan Media Ajar E-Booklet Untuk Siswa SMA/MA Materi Keanekaragaman Hayati. *JUPEIS : Jurnal Pendidikan Dan Ilmu Sosial*, *1*(1), 43–59. https://doi.org/10.57218/jupeis.Vol1.Iss1.30

Schäfer, J., Reuter, T., Karbach, J., & Leuchter, M. (2024). Domain-specific knowledge and domain-general abilities in children's science problem-solving. *British Journal of Educational Psychology*, *94*(2), 346–366. https://doi.org/10.1111/bjep.12649

Schäfer, J., Reuter, T., Leuchter, M., & Karbach, J. (2024). Executive functions and problem-solving—The contribution of inhibition, working memory, and cognitive flexibility to science problem-solving performance in elementary school students. *Journal of Experimental Child Psychology*, *244*, 105962. https://doi.org/10.1016/j.jecp.2024.105962

Surur, M., Hasanah, M., Sholeha, F., Laillaturrahma, S., & Saputra, F. D. (2022). Analisis Keterampilan Pemecahan Masalah Peserta Didik Kelas XI dengan Model Pembelajaran Kontekstual di MA Sarji Ar-Rasyid Situbondo. *Sustainable Jurnal Kajian Mutu Pendidikan*, *5*(2), 308–319. https://doi.org/10.32923/kjmp.v5i2.2907

Susanti, V. D. (2018). Analisis Kemampuan Kognitif dalam Pemecahan Masalah Berdasarkan

Kecerdasan Logis-Matematis. *JMPM: Jurnal Matematika Dan Pendidikan Matematika*, *3*(1), 71–83. https://doi.org/10.26594/jmpm.v3i1.998

Topsakal, İ., Yalçın, S. A., & Çakır, Z. (2022). The Effect of Problem-based STEM Education on the Students' Critical Thinking Tendencies and Their Perceptions for Problem Solving Skills. *Science Education International*, *33*(2), 136–145. https://doi.org/10.33828/sei.v33.i2.1

Trihastuti, I., Pratiwi, Y. , T., & Sudaygara, C. (2019). Dampak penerapan model problem-based learning (PBL) terhadap penguasaan konsep dan kerja ilmiah siswa SMP pada materi tekanan zat cair. *Rainstek: Jurnal Terapan Sains & Teknologi*, *1*(2), 73–82. https://ejournal.unikama.ac.id/index.php/jtst/article/view/3550/2243

Wang, L., Zeng, J., Ran, X., Cui, Z., & Zhou, X. (2022). Different cognitive mechanisms for process-open and process-constrained problem solving. *ZDM – Mathematics Education*, *54*(3), 529–541. https://doi.org/10.1007/s11858-022-01373-3

Widyaningtyas, F. , S., Mundilarto, Kuswanto, H., Aththibby, A. , R., & Muskina, R. , T. (2024). Creative Physics Problem Solving Based on Local Culture to Improve Creative Thinking and Problem-Solving Skills. . *Pegem Journal of Education and Instruction*, *14*(1), 234–243. https://doi.org/10.47750/pegegog.14.01.26

Zaidah, A., & Hidayatulloh, A. (2023). Model pembelajaran problem-based learning (PBL) terhadap penguasaan konsep sains siswa. *Jurnal Ilmiah Wahana Pendidikan*, *9*(2), 40–44. https://doi.org/10.5281/zenodo.7563562