RESEARCH ARTICLE

The effectiveness of environment-oriented e-books based on problem-based learning for problem-solving skills

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Abstract: This study aims to test the effectiveness of using environment-oriented e-books based on Problem-Based Learning (PBL) to empower problem-solving skills. The research design used is a Nonrandomized Control Group, Pretest-Posttest Design. The study used a quasi-experimental method with a 2 x 2 factorial design. The research sample was 70, grade X students of Colomadu State High School. The sample was divided into two groups: the control group using powerpoint media and conventional learning models and the treatment group using PBL-based environment-oriented e-books. The material used in the research is ecosystems in biology subjects. The instrument used to obtain data on problem-solving skills is an essay test. Data analysis using ANCOVA (p = 0.05%) with pretest value as a covariate. The results showed that PBL-based environment-oriented e-books had the most significant increase in problem-solving skills scores compared to the control class.

Keywords: electronic book; environment-oriented; problem-based learning; problem-solving skills

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Introduction

One of the challenges of education today is building 21st-century skills, including collaborating, communicating, creative thinking, critical thinking, and problem-solving (Azrai et al., 2022). Problem-solving is a life skill that involves analyzing, interpreting, reasoning, predicting, evaluating, and reflecting (Karatas & Baki, 2013). So, problem-solving skills are the skills to apply pre-existing knowledge to new situations involving higher-order thought processes (Heong et al., 2016). The fulfillment of problem-solving indicators characterizes the achievement of problem-solving skills: identifying problems, formulating and analyzing problems, finding alternative solutions, choosing the best alternative solutions, smoothness in solving problems, and quality of problem-solving results (Paidi, 2010).

The fact that exists about problem-solving skills based on previous research states that learning to train problem-solving skills is not considered (Huebner et al., 2018; Khotimah & Masduki, 2016; Yu et al., 2015). Learning in schools does not train students to solve problems by providing solutions. This is because learning is teacher-oriented (Dole et al., 2015). The teacher acts as a material giver, while students only receive the material. Learning that can train students' problem-solving skills must be active learning (Bozdağ et al., 2021).

The results of initial observations with teachers stated that learning tools were prepared based on agreement with biology teachers, learning strategies used in the form of discussions, teachers have not used environment-oriented learning, teachers have not trained students' problem-solving skills, learning media used in the form of powerpoints contain core materials, and student learning outcomes are assessed without regard to the abilities to be measured. From these initial observations, teachers have not applied a learning model that can train problem-solving skills. The results of observations with students stated that students consider biology lessons rote lessons, the teaching materials provided are less motivating, students are unfamiliar with environment-oriented learning, and teachers rarely use learning models that demand student activeness. The analysis results of the material listed in the teaching material book still have shortcomings and are not following the material reference according to the Independent Curriculum. Analysis of concepts related to empowering students' problem-solving

abilities did not meet all six indicators. The textbooks used do not accommodate students to carry out problem-solving activities.

Biology lessons are fun and exciting lessons related to everyday life. Learning biology is one way to improve some aspects of students in terms of knowledge, attitude, skills, and responsibility toward the environment (Azrai et al., 2022). Learning biology is not just theories and concepts but must do something, knowing and solving biology-related problems (Afcariono, 2008). Problem-solving skills are essential in learning biology because students are not enough to receive material from the teacher but require the correct analysis of concepts and principles in solving problems related to the surrounding life. Learning about ecosystems requires students to learn directly in the field to correctly know the concepts of ecosystems (Giannakos et al., 2016).

The problem of lack of training in students' problem-solving skills on ecosystem material can be done by designing models and learning media. One learning model that includes active learning is problem-based (Kundariati et al., 2022). Problem-Based Learning (PBL) is a meaningful learning model derived from experience. PBL is included in constructivist learning theory or promotes an active learning process in research to build knowledge (Simone, 2008). PBL in solving problems requires basic investigation and knowledge. PBL uses real problems as a start to start learning (Tan, 2003). The problem used as the starting point for learning PBL should be ill-structured. Ill-structured problems allow many solutions to solve them (Noer, 2011). PBL can provide exploration space for students to fulfill active learning activities (Drăghicescu et al., 2014).

Collaborative student activities to analyze problems are indispensable in PBL learning (Hmelo-silver, 2004). The PBL learning process involves students actively working independently first to analyze problems, then the information obtained is brought into the group; teachers in PBL learning as student facilitators are to think, reflect, and investigate (Simone, 2014). The PBL-based learning process includes five stages: (1) meeting the problem, (2) problem analysis and learning issues, (3) discovery and reporting, (4) solution presentation and reflection, dan (5) overview, integration, and evaluation (Tan, 2003). The PBL learning process begins with individual analysis. Students work in groups to identify each individual's analysis and devise possible solutions based on the results of student discussions in groups. The formulation of problem-solving is prepared by students in groups (Hmelo-silver, 2004). The teacher acts as a facilitator; there is no teacher's answer in formulating the solution (Mishan, 2011). The role of the teacher as a student facilitator is to assist students in thinking, reflecting, and directing group discussions in conducting investigations (Simone, 2014).

PBL will be more meaningful if combined with learning methods in the surrounding environment with local wisdom so that students can learn realistically and acquire their concepts (Dewi et al., 2021). The local potential around Surakarta, Central Java, Indonesia, has many natural attractions that are part of local wisdom that can be used as a source of learning. However, teachers have not fully utilized this potential as a learning resource. As a creative teacher, providing real examples to students is very important in understanding students related to the material taught.

Based on the background and preliminary observations, it is necessary to conduct research to test the effectiveness of using environment-oriented e-books based on Problem-Based Learning (PBL) to empower problem-solving skills.

Method

Research Design

This study used a quasi-experimental method with two research groups. The control class uses conventional learning models. The conventional model used is the lecture methode by displaying Power Point teaching media (PPT) and the theacher as the center of student's learning only listen to what the teacher explain , and the treatment class uses the application of PBL-based environment-oriented e-books. The research design used is a Nonrandomized Control Group, Pretest-Posttest Design. The research design used a factorial design of 2×2. Factorial design research can be seen in Table 1, information (1) Problem-solving skills before treatment (Y1), (2) PBL-based environment-oriented e-book treatment (X1), (3) Control group problem-solving skills (Y2), and (4) Experiment group problem-solving skills (X1Y2)

Table 1. Research Factorial Design

Group	Pretest	Independent variable	Posttest
Control	Y1	-	Y2
Experiment	Y1	X1	X1Y2

Sample and Sampling Technique

The target population is 210 students divided into six randomly grouped classes, including Mathematics and Natural Sciences X1, Mathematics and Natural Sciences X2, Mathematics and Natural Sciences

X3, Mathematics and Natural Sciences X4, Mathematics and Natural Sciences X5, and Mathematics and Natural Sciences X6. The sampling technique uses cluster random sampling, which refers to groups. The class used as a sample has been pretested using an equivalence test. The equivalence test results showed that the population classes were not significantly different, so that each class group could be used as a research sample. The research samples used are class Mathematics and Natural Sciences X5 and Mathematics and Natural Sciences X6. The sample used was 70 students, with each group comprising 35 students.

The instrument for Data Collection

This study used two instruments: an initial observation questionnaire and problem-solving skills test. The questionnaire is an open-ended question given to biology subject teachers and students at Colomadu State High School to obtain learning information in class and alleged perceptions of teachers and students regarding problem-solving abilities. Concept analysis in the form of lesson plan analysis on ecosystem material commonly used by biology subject teachers at Colomadu State High School.

The research instrument to obtain data uses an open-ended questions test of six cognitive questions with a maximum score of 4. The questions given are used to determine students' problem-solving abilities. The problem of problem-solving skills was developed and adapted from Paidi (2010), which has six indicators: identifying problems, formulating and analyzing problems, finding alternative solutions, choosing the best alternative solutions, fluency in solving problems, and quality of problem-solving results.

Validation and Reliability Instrument

Research instruments to measure the problem-solving skills developed have been tested through trials on students and analyzed for feasibility using RASCH analysis. The validity of the questions shows that the analysis results of the six question items meet three conditions. It can be stated that each question item has good quality and can be used to measure students' problem-solving abilities. The results of the validity test can be seen in Table 2. The questions have been tested for reliability and declared feasible and reliable by meeting the Cronbach alpha value. The reliability test results can be seen in Table 3.

Table 2. Validity Result

Question Number	MNSQ	ZSTD	CORR
1	0.68	-1.19	0.85
2	0.80	-0.83	0.84
3	1.47	1.77	0.29
4	1.38	1.37	0.68
5	0.79	-0.80	0.58
6	1.04	0.24	0.71
7	1.15	0.63	0.57

Table 3. Reliability Result

	Mean Logit (SD)	Separation	Reliskills	Alpha Cronbach
Person	0.42 (0.27)	1.70	0.76	0.78
Item	0.00 (0.34)	2.62	0.93	

Method and Data Analyses

The data analysis technique used is an inferential statistical analysis using the help of SPSS version 16.0. The results of the description of inferential statistical analysis were used to test the effectiveness of using PBL-based environment-oriented e-books to empower problem-solving skills. The effectiveness test is carried out through a covariate analysis (ANCOVA) test using the pretest value as a covariate with a significance level of 5%. The purpose of using the pretest as a covariate is to obtain initial competency parameters, namely how far students know about the learning material. The prerequisite test of parametric statistical analysis was conducted before analyzing the data using the students' pretest and posttest scores of problem-solving skills. The prerequisite tests used in this study are normality and homogeneity tests.

Results and Discussion

The Development Result of Environment Oriented E-Books Based on Problem-Based Learning (PBL)

PBL-based environment-oriented e-book on ecosystem material is an e-book that contains ecosystem learning materials for grade mathematics and natural sciences X senior high school, which refer to Tan's (2003) PBL learning steps and utilize the surrounding environment as a place for student observation. The e-book includes an introduction, a core, and a concluding part. The introduction of the E-book consists of 1) a Description of the E-book, in this section, an explanation is given about the brief characteristics of ecosystem materials, how to prepare the E-book, and the advantages of E-books oriented to the surrounding environment; 2) Table of Contents, which contains the order of pages in each section of the E-book to make it easier for users to get to the page they are looking for; 3) Learning outcomes, containing phase E biology learning outcomes, namely: 10.12. Identify ecosystem components by presenting reports on ecosystem observations in the surrounding environment; 10.13. Compile food webs or food chains from the results of observations of ecosystems in the environment.

The core part of the e-book consists of two parts: learning with PBL syntax and learning materials. Learning according to PBL syntax is described: (1) Meeting the problem, is the initial stage where students are required to find problems as a stimulus for the following learning process (Nurhidayati et al., 2018). Stimuli can be videos, real stories, field observations, and others that can lead students to learning materials; (2) Problem analysis & learning issues, self-conducted analysis process (Yew & Goh, 2016); (3) Discovery & reporting, meet in groups to exchange information from previous issue sharing and summarize solutions related to issues made by the group (Tan, 2021); (4) Solution, presentation, & reflection, Students demonstrate new knowledge that has been acquired; at this stage, allowing many questions from other students as listeners, the role of the teacher in this stage is to clarify missed steps and misconceptions or provide limits to information that is too far away (Florea & Hurjui, 2015); and (5) Overview, integration, & evaluation, Students assisted by teachers summarize and interpret principles and concepts and review and evaluate the results or solutions obtained (Tan, 2003).

Learning materials consist of sub-material ecosystem components, interactions between biotic components in various ecosystems; energy flows in ecosystems and ecological pyramids. Learning in the E-book is arranged according to the orientation of the surrounding environment. The selected neighborhoods are Sekartaji Park Surakarta, Tirtonadi Dam, and Cengklik Reservoir. A surrounding environment is a place for students to make direct observations in PBL learning; students are asked to observe and provide solutions to problems related to ecosystem materials. The e-book has a summary section containing each material presented's conclusion. In addition, evaluation questions are presented to measure students' understanding of ecosystem material.

PBL-based environment-oriented E-book products on ecosystem materials have the potential to empower problem-solving skills PBL-based environment-oriented E-books have advantages over textbooks used in schools. The complete PBL-based environment-oriented e-book can be accessed at the link: https://online.flipbuilder.com/asldh/romu/

The Result of Application Environment Oriented E-Books Based on Problem-Based Learning (PBL) on Problem Solving Ability

The normality test in the study used the Shapiro-Wilk test because the study sample was less than 100 (González-Estrada & Cosmes, 2019). The results of the normality test with SPSS 16 on the pretest and posttest values of problem-solving skills showed that both groups used in the study had a significance value of >0.05, which means H0 was accepted, so the samples used in the study were declared normally distributed (Erick Suryadi et al., 2019). The normality test results of the three groups can be seen in Table 4.

Table 4. Normality Test Result

Group		Shapiro-Wilk		
		Statistic	df	Sig.
Pretest	Media Control Books & PPT	0.947	35	0.094
	Media Treatment of PBL-Based Environment-Oriented E-Books	0.950	35	0.117
Posttest	Media Control Books & PPT	0.961	35	0.253
	Media Treatment of PBL-Based Environment-Oriented E-Books	0.954	35	0.146

Based on the analysis of the homogeneity test using Levene's Test of Equality of Error Variance with SPSS 16 on the pretest and posttest values of problem-solving skills, it was found that the significance value >0.05, which means H0 was accepted, so that the sample used in the study had homogeneous variance (Erick Suryadi et al., 2019). The homogeneity test results can be seen in Table 5.

Table 5. Homogeneity Test Result

F	df1	df2	Sig.
1.064	1	68	0.306

Based on the ANCOVA prerequisite test, the samples used in the study were declared normally distributed and had homogeneous variances. So that it can be further tested using ANCOVA's parametric statistical test. The ANCOVA test results showed a significance value of <0.05, so H0 was rejected (Hidayat, 2018). ANCOVA test results can be seen in Table 6.

Table 6. ANCOVA Test Result

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	159.582a	2	79.791	21.565	0.000
Intercept	616.388	1	616.388	166.589	0.000
Pretest (covariat)	10.954	1	10.954	2.960	0.090
Treatment	127.357	1	127.357	34.420	0.000
Error	247.903	67	3.700		
Total	10344.000	70			
Corrected Total	407.486	69			

Based on the results of the ANCOVA Test, there are differences in students' problem-solving skills scores on using learning media. The conclusion is that there is a significant influence on the use of PBL-based environment-oriented E-books compared to PPT media on students' problem-solving abilities. The results of the ANCOVA test are then further test analysis of differences in the use of learning media. Further test results can be seen in Table 7 and Table 8. Based on the results of BNT further tests, it can be seen that each treatment has a significance value of <0.05, so each treatment is significantly different.

Tabel 7. Advanced Test Results

(I) Class	(J) Class	Average difference (I-J)	Sig.a
Control	Experiment	-2.753*	0.000
Experiment	Control	2.753*	0.000

Table 8. Estimated Value Limit

Kelas	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control	10.538a	.328	9.882	11.193
Experiment	13.291a	.328	12.635	13.947

PBL-based environment-oriented E-book media is the most significant combination of media, methods, and learning models to empower students' problem-solving abilities. This is evidenced by the value of students' problem-solving skills in the PBL-based environment-oriented E-book treatment class has the highest average score of 13,291 compared to the control class of 11,193.

These results align with the research of Restiana, Suhendi, Yudiyanto, & Hakim (2022) which states that the characteristics of E-books can enhance students' understanding and skills of ecosystem materials. The selection of teaching materials and the way of delivering material affect students' understanding of ecosystem materials (Hung et al., 2017). The teaching materials used must be able to meet the characteristics of the ecosystem system material. One characteristic closely related to ecosystem material teaching materials is the ability to visualize the state of the ecosystem around (Afriza, 2022; Nyoman et al., 2021). Visualization can be in the form of images or videos in teaching materials which is one way to make it easier for students to understand complex ecosystem materials (Eilam, 2012).

Teaching materials on ecosystem materials can be embedded in learning media. Learning media can be arranged in such a way that it can meet learning objectives (Williamson et al., 2020), mainly on

ecosystem materials. The learning media developed must increase students' understanding of ecosystem materials. Up-to-date learning media can be developed by utilizing technology. For one, we can use technology to illustrate the complexity of ecosystems (Giannakos et al., 2016b). The learning media developed in the research is E-book. The E-book can utilize technology in ecosystem material used as a combination of the conceptual framework of the ecosystem with the contextual framework through construction so that students can explore the surrounding environment.

Learning orientation about the surrounding environment can empower students' problem-solving abilities on ecosystem materials. The surrounding environment is used as a model in the exploration of ecosystems. In addition, using the surrounding environment is one of the learning methods for problem-based situations. Activities that use problem-based situations in the surrounding environment encourage students to solve a problem with analysis and evaluation to achieve problem-solving (Shek et al., 2016; Wolf et al., 2015). The sequence of steps used to solve a problem can empower problem-solving capabilities.

Environment-oriented learning is supported by an active learning approach, where students actively carry out activities to obtain information about the material studied. Students are given teaching responsibilities to master learning objectives, namely problem-solving abilities. One learning model that includes active learning is problem-based learning (PBL) (Giannakos et al., 2016a). Active learning in ecosystem learning involves students in the learning process through discussion activities, group work, and activities in practice (Giannakos et al., 2016b). PBL is one of the active learning that can empower students' understanding by solving problems in ecosystem materials (Fauzia et al., 2021).

The ill-structured PBL learning model can provide opportunities for students to think through simple observations of the surrounding ecosystem problems (Tan, 2003). PBL can provide exploration space for students to fulfill active learning activities (Drăghicescu et al., 2014). PBL is a learning model that requires the scientific method. The scientific method involves analysis and evaluation to achieve problem-solving (Shek et al., 2016; Wolf et al., 2015). Problem-solving through the scientific method begins with observation, compiling problem formulations, finding problems, and analyzing (Prince & Felder, 2006). The sequence of steps of the scientific method used to solve problems can empower problem-solving abilities. The PBL model consists of 5 stages: meeting the problem, problem analysis and learning issues, discovery and reporting, solutions presentations and reflection, and overview, integration, and evaluation.

The meeting the problem stage begins with raising the problem presented through video and news viewing. The videos and news presented accommodate students to conduct investigations in the neighborhood. The video and news asked students to observe three locations: Taman Sekartaji Surakarta, Tirtonadi Dam, and Cengklik Reservoir, so students could more easily formulate problems. Formulating the issues made by students requires the initial step of problem identification so that students can reach initial questions about the observations made (Savery, 2015). So that with observation activities of the surrounding environment at the meeting stage, the problem can empower indicators to identify problems in problem-solving abilities. The presentation of the problem at the meeting stage problem in the E-book can be seen in Figure 1.

Figure 1. Meeting the Problem Oriented to the Environment

The second stage is problem analysis and learning issues, which begins with individual problem analysis. Students can use various sources of information from books and internet sources that can be accessed with their respective gadgets. The teacher directs students to be able to sit in groups. Each group gets a worksheet, and the teacher directs students to discuss issues. At this stage, students must be able to discuss to determine the formulation of the problem along with the variables relevant to the problem to find the correct hypothesis. To achieve this, students must analyze the problem. This stage accommodates students to develop statements to solve problems through problem analysis (Kumala et al., 2017). The problem analysis and learning issues stage can empower indicators to formulate and analyze problems on problem-solving abilities. The presentation of group discussions, problem analysis, and learning issues in the E-book can be seen in Figure 2.

The discovery and reporting stage is carried out in groups. Students are directed to divide the tasks of each group member so that each individual can play an active role in observation activities. At this stage, students discuss how to find solutions to existing problems. Each member's assignment is written into a worksheet, and then students do source tracing activities or go to the field. The results of the discussion that have been written are then formulated into a solution to the problem. Direct observation and discussion activities can accommodate students' skills to find alternative solutions to problem-solving skills (Weiss et al., 2016). The presentation of discovery and reporting group worksheets in the E-book can be seen in Figure 2.

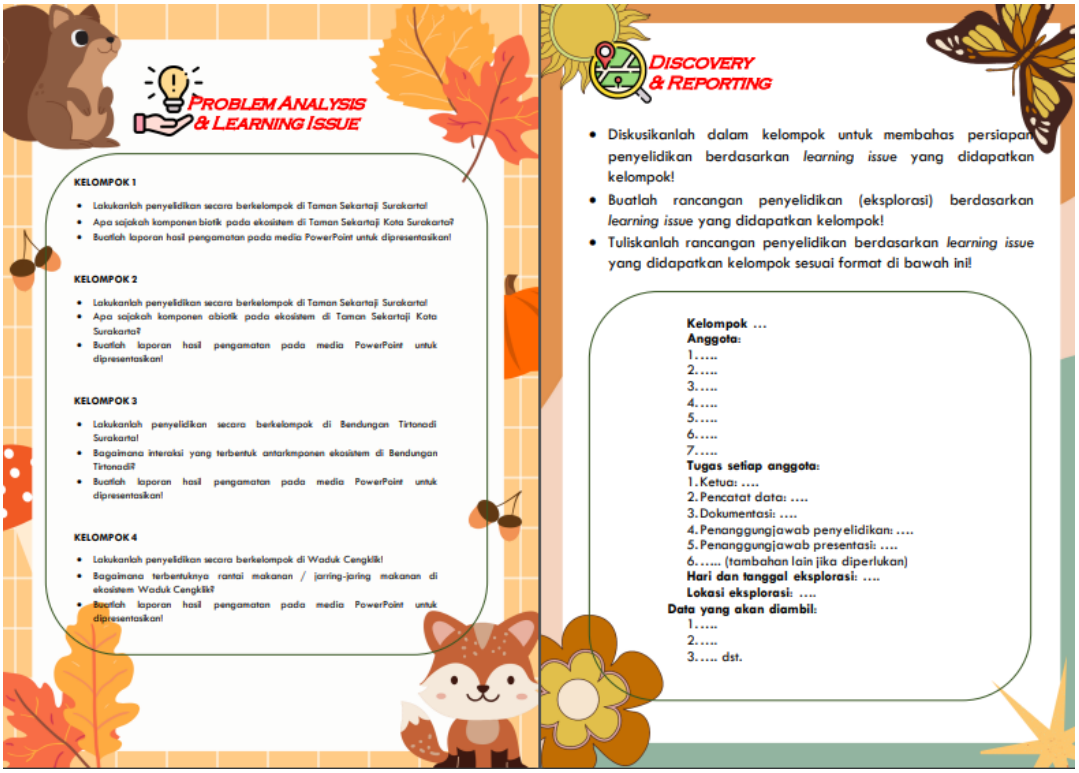

Figure 2. Problem Analysis and Learning Issues dan Discovery and Reporting

The solution presentation and reflection stage is the stage where students make presentations about the solutions that students have made and reflect. The solution to the problem obtained by the group must meet the facts and information available. At this stage, students play a role in connecting the information data that has been obtained to the best solution (Drăghicescu et al., 2014). The solution presentation and reflection stage can accommodate students to choose the best solution from various alternative solutions obtained previously. In addition, reflection at this stage can determine fluency in solving with special attention from the teacher and whether what each group does is absolute without cheating (Paidi, 2010).

The last stage is overview, integration, and evaluation. At this stage, students are assisted by the teacher to review the material as a whole. The results of each group's discussion are connected to become a complete series of learning materials. Reviews by teachers and other groups determine the quality of problem-solving results and whether they are appropriate, rational, and scientific (Paidi, 2010).

Conclusion

This study concludes that the development of environment-oriented e-books based on Problem-Based Learning (PBL) can potentially empower students' problem-solving skills. Problem-Based Learning (PBL)-based environment-oriented e-books are more effective in empowering problem-solving skills than PowerPoint media with conventional learning models because the combination of learning in real environments and PBL learning models can train the six indicators of problem-solving skills.

Conflicts of Interest

We have no conflicts of interest to disclose. All authors declare that they have no conflicts of interest.

Author Contributions

W. Ningsih: methodology, analysis, writing original draft preparation. **B. A. Prayitno:** review and editing. **S. Santosa:** review and editing.

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