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Development of a Science e-Book by Exploring Traditional Food Within a PBL-ESD Framework to Foster Students' Problem-Solving Skills

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Abstract: This study aims to determine the effect of science e-books, with a focus on the topic of mixture separation, delivered through the Problem-Based Learning (PBL) model integrated with the local potential of Petis as a traditional food, to improve students' problem-solving skills. The research was conducted at SMPN Yogyakarta in the second semester of the 2023/2024 academic year, involving 24 students in class VIII as a randomly selected research sample. The research was a quasi-experiment with a non-equivalent control group design. The instrument used was a problem-solving skills test consisting of 10 questions. The paired t-test results show a significance level of 0.001 which is smaller than the value of $\alpha = 0.05$ so it can be concluded that there is a significant difference between the pretest and posttest results of students' problem-solving skills. The N-gain of the pretest posttest of problem-solving skills is 0.46 with the acquisition per indicator as follows: understanding the problem (0.8), analyzing the problem (0.7), planning the solution (0.6), implementing the solution (0.6), and evaluating (0.5). The effect size analysis shows a value of 0.94 which is included in the large category. Thus, this study shows that the science e-Book by exploring traditional food within a PBL-ESD has a substantial positive influence on students' problem-solving skills.

Keywords: e-Book, PBL-ESD, problem solving skills, traditional food.

▪ INTRODUCTION

In the 21st century, education is increasingly focused on actively engaging students in the learning process. This paradigm shift demands a transformative approach to developing excellent human resources, as everyone strives to improve their potential and personal qualities through education. The need for high-quality resources is paramount, as developing inherent capabilities enables students to effectively address emerging challenges. The right education system can produce outstanding and competent individuals. One important strategy to develop students' potential is the development of innovative teaching materials.

Teaching materials are designed to actively involve students in the learning process by stimulating their self-development, especially in problem solving skills and plays an important role in creating a meaningful learning process (Abdala, 2024). Problem solving ability is a basic ability that involves critical, logical, and systematic thinking by understanding the problem thoroughly and generating creative ideas collaboratively to solve it effectively (Gao et al., 2022; Van Hooijdonk et al., 2023). This skill can also be understood as an essential cognitive ability that includes the process of systematic observation and critical thinking through various real-life phenomena (He et al., 2023).

By integrating innovative teaching resources, such as e-books, into the curriculum, educators can enhance students' problem-solving abilities, preparing them to face complex challenges in an ever-evolving world. This approach not only encourages academic growth, but also equips students with the necessary skills to thrive in their future endeavors. However, looking at the current profile of education, it is apparent that

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students' problem-solving abilities are still inadequate. Particularly in science, 35% of Indonesian students are still at competency level 1a, indicating that their abilities are limited to basic identification based on knowledge and have not progressed to the level of application or implementation (OECD, 2023).

The Partnership for 21st Century Learning has developed a global framework for 21st century skills, which includes learning and innovation skills that include critical thinking and problem solving (Partnership for 21st Century Skills, 2015) . This concern is further emphasized by the results of the PISA 2022 assessment which indicates that Indonesian students' problem-solving skills are still at level 1c. This means that students are only able to answer simple questions with the help of tables and pictures. (OECD, 2023). These findings highlight the urgent need for educational reform and the development of effective teaching materials that can improve students' problem-solving skills, particularly in the science curriculum. By addressing this gap, educators can better prepare students for the complexities of the 21st century.

The low level of problem-solving skills among students is further strengthened by initial observations made at SMPN Yogyakarta. It was noted that teachers play a more active role in delivering subject matter, while students tend to be passive listeners and participate less in the learning process. In addition, the utilization of technology is still not optimal, with reliance on printed textbooks. This scenario indicates that educators are not fully utilizing opportunities to enhance problem-solving skills during the learning process. Supporting this observation, research highlights that lack of interest in learning and lack of understanding of problem-solving concepts are significant contributors to students' inadequate problem-solving abilities (Darmasrura et al., 2021).

To address this issue, it is imperative to implement teaching strategies that not only actively engage students, but also integrate innovative technologies and materials. By fostering a more interactive and supportive learning environment, educators can significantly improve students' problem-solving abilities, preparing them to face challenges in the real world. Problem solving skills are a component of Higher Order Thinking Skills (HOTS) (Putra et al., 2023) . Mastery of these skills is critical to navigating the complexity of global knowledge while driving innovation. To empower problem-solving ability, innovative teaching materials are essential to improve the quality of learning. Challenges related to students' low problem-solving ability require innovative learning media and approaches that support skill development. This is because skill development requires an in-depth learning approach that trains and improves competencies to create quality human resources (Daryanes et al., 2023).

In response to these issues, an innovative medium that can help visualize science concepts and natural phenomena is the "Science e-book with PBL-ESD Integrated with Local Potential Petis as A Traditional Food." (Efendi et al., 2022; Selamat et al., 2023; Wardani et al., 2021)This digital textbook facilitates independent learning through interactive multimedia, including images, audio, and video, making the content more accessible (Efendi et al., 2022; Selamat et al., 2023; Wardani et al., 2021). E-books are systematically organized electronic books that connect learning concepts with everyday life (Wibisari & Mulyani, 2023) . E-books also allow teachers to present varied materials by integrating components such as images and videos, which can greatly motivate students to be actively involved in their learning . (Selamat et al., 2023; Wardani et al., 2021) . Research by Jannah et al. (2017) shows that e-books increase students' motivation

and academic achievement compared to traditional textbooks. Thus, the use of e-books in the learning process can foster the desire to gain knowledge and contribute to successful educational outcomes.

To effectively improve students' problem-solving skills, appropriate models and approaches are needed, such as PBL-ESD. PBL (Project-Based Learning) facilitates students in analyzing real-life problems systematically, making the learning process more interesting and meaningful (Kayati et al., 2023). According to Wicaksana (2023), the PBL model allows students to develop problem-solving skills through real-world issues, foster self-confidence and high-level skills. In addition, PBL trains students to achieve meaningful learning through the stimuli provided by its syntax (Makiyah et al., 2021).

PBL-ESD combines project-based learning with Education for Sustainable Development (ESD), which encourages critical thinking and problem-solving skills in a relevant context. PBL-ESD is an integrated model and approach that facilitates student learning. Education for Sustainable Development (ESD) emphasizes sustainability, aligning with goal 4 of the 2030 SDGs for quality and sustainable education (UNESCO, 2017) . Hallmarks of ESD include a focus on local environmental issues (Trott & Weinberg, 2020) , encouraging critical thinking, student-centered learning, lifelong learning, and participatory education (Eilks, 2015) . PBL-ESD encourages active student engagement, critical thinking, and practical application of knowledge (Eilks, 2015; Trott & Weinberg, 2020).

Integrating local potential into the learning process significantly improves students' problem-solving ability. Research by Ningrum et al. (2023) showed that local integration provides hands-on experience, helping students understand the material through their environment. Similarly, Siti et al. (2020) found that incorporating local potential in science education improved cognitive learning outcomes, as it matched the context of students' environment. Science e-books with PBL-ESD integrated with local potential allow students to develop the skills necessary to achieve learning objectives through continuous contextual problem-based learning. (Arani et al., 2023).

This e-book framework enhances students' understanding and engagement with local sustainability issues (Bastida, 2023). PBL focuses on solving complex and contextualized problems through collaborative learning (Kelly et al., 2016) . When combined with ESD and local potential, PBL significantly contributes to developing sustainability literacy and skills to address real-world challenges, making learning more relevant to students' lives. ESD encourages students to consider sustainability in their solutions, thus enabling them to understand real issues related to the production or use of local resources while applying scientific concepts to find solutions.

The urgency of this research lies in the pressing need to improve problem-solving skills among students, which is critical to navigating the complexities of today's world. As education evolves, innovative digital teaching materials become essential for developing effective learning environments. This research addresses a significant gap in existing educational resources by developing a high-quality e-book focusing on mixture separation. By integrating PBL-ESD with local potential, this research not only aims to improve students' understanding of scientific concepts but also to promote active engagement and critical thinking. The application of such innovative materials is crucial to equip students with the necessary skills to address real-world challenges, thus ensuring a more relevant and impactful educational experience. The findings from this study will

contribute to the broader goal of achieving quality education and preparing students to deal with future complexities in their academic and professional lives.

▪ METHOD

Participants

The research was conducted at SMPN Yogyakarta in the second semester of the 2023/2024 academic year, involving 24 students of class VIII as the research sample. The technique used to select the research sample was simple random sampling, where classes were randomly selected to obtain representative and valid data regarding the effectiveness of Science e-Book by Exploring Traditional Food Within a PBL-ESD Framework to Foster Students' Problem-Solving Skills.

Research Design and Procedures

The type of research is research and development (R&D) with the development carried out is "Science e-Book by Exploring Traditional Foods in the PBL-ESD Framework to Foster Students' Problem Solving Ability. The development of learning tools adapts 4D development research from Thiagarajan including: Define, Design, Develop, and Disseminate (Thiagarajan et al., 1974).

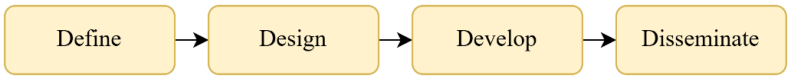

Figure 1. 4D research flow

Define

In the define stage, analysis or definition is carried out to determine and define the requirements needed before the product development process (Thiagarajan et al., 1974). The define stage includes initial analysis by collecting descriptive data through theoretical studies such as literature reviews, observations, and interviews with both teachers and students.

Design

At the design stage, alternative solutions are determined to overcome the problems that have been identified at the define stage (Thiagarajan et al., 1974). So that the design obtained can be used as the basis for preparing the initial draft of the product and validation sheet.

Develop

At the develop or development stage, the realization and implementation of media products that have been designed previously at the design stage are carried out with the aim of producing valid and effective e-Book teaching materials.

Disseminate

The last stage is disseminate or spread, this stage is carried out to disseminate the product. E-books that have been analyzed and revised will then become the final product which will then be disseminated as a feasible and effective media to support the science learning process.

Instrument

The instrument used was a test of problem-solving ability, consisting of 10 multiple-choice questions focusing on the topic of mixture separation. These questions were designed to measure five key indicators of problem solving (Bradshaw & Hazel, 2017; Dewey, 1910; Heller & Heller, 2010, Carson, 2007; Kuang Chou-You, 2015; (Polya, 1985); Wankat & Oreovicz, 2015; (Yuriev et al., 2017)) include: (1) understanding the problem; (2) analyzing the problem; (3) planning the solution; (4) implementing the solution; and (5) evaluating or reviewing the developed solution. The indicator questions are presented in the following table.

Table 1. Problem-solving skill question indicator

Aspect	Indicator	Items
Understanding the problem	Students are able to explain and identify various problems in everyday life	1.6
Analyzing the problem	Students are able to relate some problems to the impacts in everyday life.	2.7
Planning the solution	Students are able to design solutions / plans that will be carried out on the problems faced	3.8
Implementing the solution	Students are able to implement relevant solutions based on the ideas that have been put forward	4.9
Evaluating or reviewing	Students are given the opportunity to evaluate the results in order to understand the effectiveness, relevance or otherwise of the solutions implemented.	5.10

Data Analysis

The data were then analyzed using descriptive statistics, including mean, mode, median, standard deviation, N-Gain and effect size, as well as inferential statistics through t-test to assess the improvement of problem-solving skills after treatment. Then the results of the N-Gain calculation into three categories based on the general interpretation used in education which consists of three categories namely high, medium, and low. Furthermore, an effect size analysis was also carried out to determine how much influence the e-book developed on students' problem-solving skills with the following categories. (Xuebao, 2021).

Table 2. Effect size category

Effect Size	Category
$0.0 \leq d < 0.20$	Weak effect
$0.21 \leq d < 0.50$	Modest effect
$0.51 \leq d < 0.8$	Moderate effect
$d \geq 0.8$	Strong effect

Before conducting a paired t-test, it is important to verify the assumptions of normality and homogeneity of variance. Data normality can be assessed using statistical tests such as the Shapiro-Wilk test or Kolmogorov-Smirnov test. If the p-value of these tests is greater than the significance level ($\alpha \geq = 0.05$), it can be concluded that the data is normally distributed. In addition, visual inspection of the Q-Q plot or histogram can provide insight into the normality of the data. The assumption of homogeneity of variance

can be evaluated using Levene's test. This test checks whether the variances of the two groups being compared are equal. If the p-value is greater than 0.05, this indicates that the variances are homogeneous, which is an important requirement for a paired t-test. Once the assumptions of normality and homogeneity are validated, the paired t-test can be performed. This test is designed to compare the means of two related groups such as pre-test and post-test scores by determining whether there is a statistically significant difference between them. The following is the flow of research that has been conducted.

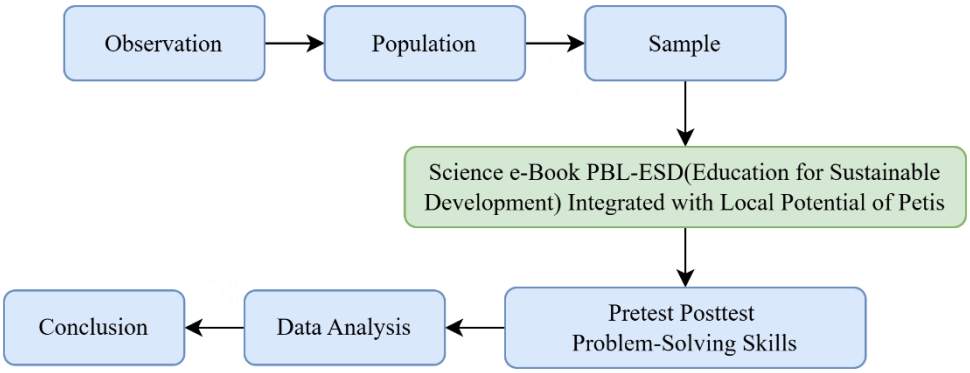

Figure 2. Flow of research

▪ RESULT AND DISSCUSSION

The results in this study, the teaching material used was an e-book designed based on the PBL-ESD (Education for Sustainable Development) model integrated with local potential in Petis production, especially on the topic of mixture separation. The following is a description of the e-book development that has been carried out.

Define

At this stage, an initial analysis was carried out through a series of observation and interview activities, which obtained the following information.

1. Already implementing Merdeka Curriculum, the utilization of technology is quite maximum as seen from learning activities that often utilize electronic devices as learning media.
2. Learning models that are often used are learning models such as guided inquiry, discovery learning. Meanwhile, the use of the PBL model has not been maximized enough.
3. Learning methods are still mostly lectures emphasizing the concept of memorization.
4. Learning activities are still passive with the teacher as the center of learning and learning methods are still mostly lectures.
5. Students' understanding of science subjects is also still lacking, because most of the learning is still stuck in the textbook.
6. Grade VIII students are aged between 12-14 years old.

Design

The design stage is the realization of define, namely the selection of media for the learning process. So that e-books were chosen as learning media to improve problem

solving skills on the topic of mixture separation by producing an initial draft of the product, namely science e-Book PBL-ESD. The e-book was chosen on the basis of its practicality during learning activities that are able to connect students with learning activities based on real experiences. In line with the statement that media selection is expected to make the learning process more practical and effective (Riani Johan et al., 2023).

Figure 3. View of e-book

Develop

At this stage, the realization and implementation of media products that have been designed previously at the design stage are carried out with the aim of producing a valid e-book. As for this stage, expert validation is carried out in the form of assessments, comments, and suggestions both from a technical point of view as well as instructions for product improvement by two experts appointed based on their expertise. The assessment and evaluation carried out by learning experts relates to the content and construct aspects of the e-book developed. The following presents details of the assessment of each aspect of the e-book that has been developed.

Table 3. Results of e-book assessment by experts

Aspect	Calculation result CR (%)	CR Standart (%)	Calculation result CS (%)	CR Standart (%)	Description
Display	100	90	100	60	Valid
Content	100	90	100	60	Valid
Construction	100	90	100	60	Valid
Language	100	90	100	60	Valid
Presentation	100	90	100	60	Valid
Graphics	100	90	100	60	Valid

Based on the results of the e-book validation contained in Table 3, it can be concluded that the average calculated value of CR is 100% and the average calculated

value of CS is 100%, which means that the e-book is declared valid and suitable for use in learning.

Disseminate

The e-Book that has been developed will be carried out an initial dissemination process through the distribution of products to science subject teachers and students. Problem solving skills are measured using a 10-item multiple choice question instrument given before and after learning activities. Developed based on indicators such as understanding the problem, analyzing the problem, planning a solution, applying the proposed solution, and evaluating/reviewing the results. Before conducting statistical tests, a normality test was conducted on the pretest and posttest results to determine whether the data obtained followed a normal distribution. The normality test was conducted using the Kolmogorov-Smirnov analysis method with the help of the SPSS 25 for Windows program. The following is a table that presents the results of the normality test of pretest and posttest results.

Table 4. Normality test results

Aspect		Statistic	df	Sig.
Problem Solving Skills	Pretest	0.175	24	0.054
	Posttest	0.197	24	0.016

The normality test results for the pretest and posttest, as illustrated in Table 3, show that the significance level for the pretest is 0.054, which exceeds α (0.05). In contrast, the significance level for the posttest is 0.016, which is also greater than α (0.05). Therefore, it can be concluded that the pretest and posttest scores came from normally distributed data sets.

Next, a paired sample t-test was conducted to assess whether there was a significant difference in students' problem-solving ability between the pretest and posttest, before and after the intervention. This analysis was conducted using SPSS 25 for Windows software.

Table 5. Paired samples statistics results

Aspect	Mean	N	Std.Dev	Std. Error Mean
Pretest	55.00	24	21.468	4.382
Posttest	75.83	24	22.826	4.659

Based on the output of the t-test conducted using SPSS 25, as shown in Table 5, the mean value for the pretest was 55, with a standard deviation of 21.468, while the mean value for the posttest was 75.83, with a standard deviation of 22.826. This shows a significant difference between the students' pretest and posttest scores. The average value shows that after being given treatment with science e-books, there is a real increase. In addition, the results of the paired sample t-test are presented in Table 6 below.

The t-test results showed a significance level of 0.001 which is smaller than α = 0.05. This finding confirms a significant difference between the pretest and posttest scores of students' problem-solving skills after using the e-book integrated with local potential in Petis, based on the PBL-ESD model. This shows that learning through integrated

Table 6. Paired samples test results

Aspect	Mean	Std.Dev	Std. Error Mean	df	Sig. (2-tailed)
Pretest Posttest	20.833	27.333	5.579	24	0.001

science e-books effectively improves students' problem-solving skills on the topic of separation methods.

These results are in line with Agusti's (2019) research, which illustrates that problem-based learning models within the framework of Education for Sustainable Development (ESD) can be an effective alternative to improve students' critical thinking skills which are closely related to problem-solving skills. In addition, Ajri & Diyana (2023) found that the development of e-modules based on problem-based learning, supported by hands-on worksheets, significantly improved problem-solving skills, from identifying problems to drawing conclusions from problem-solving efforts.

Next, we will look at the N-Gain results of the pretest and posttest of problem-solving ability, along with the N-Gain to presents the results of the calculation the gain score on the pretest-posttest results of problem-solving skills presented in the following table.

Table 7. Pretest posttest of problem-solving skills

Aspect	Pretest	Posttest	Gain Score	Category
Problem Solving Skills	55.00	75.83	0.46	Medium

Analysis of N-Gain scores showed that the average pretest score was 55.00 while the posttest score increased to 75.83 resulting in an N-Gain score of 0.46 indicating a moderate level of improvement. This shows that the use of integrated science e-books that utilize local potential in petis and follow the PBL-ESD model effectively improves students' problem-solving skills in the context of the separation method.

Furthermore, the N-Gain value for each indicator of problem-solving ability was examined to draw a comparison between the pretest and posttest results. This analysis helps measure the extent of improvement in students' problem-solving skills after intervention with science e-book within PBL-ESD model.

Table 8. N-Gain score indicator of problem solving skills

Aspect	Gain Score	Category
Understand the Problem	0.8	High
Analyzing the Problem	0.7	High
Planning a Solution	0.8	High
Implementing the Solution	0.8	High
Evaluation/Review	0.6	Medium

Based on Table 8, the results of the N-Gain test conducted on the pretest and posttest show performance in various indicators of problem-solving skills. The diagram shows that the “understanding the problem” indicator achieved the highest N-Gain score of 0.8 followed by “analyzing the problem” at 0.7, “planning the solution” at 0.8, “applying the

solution" also at 0.8 and "evaluation or review" at 0.6. These results show that although students excel in understanding the problem, they have more difficulty in evaluation.

The low score on the evaluation indicator may be due to the limited involvement of students in providing feedback on the solutions presented by their peers, coupled with time constraints during classroom learning. This N-Gain value indicates that the PBL-ESD-based e-book integrated with the local potential of petis as a traditional food can improve problem solving skills. This finding is in line with Taufiqurrahman and Wijaya's research (2022) which shows that the development of electronic teaching materials using PBL models integrated with local culture can improve junior high school students' problem-solving skills.

However, this situation highlights a significant challenge: when applying the PBL-ESD model, students often struggle to effectively apply the indicators during actual activities. A deeper analysis revealed that the evaluation indicators involved more than just assessing the results of discussion or analysis. When linked to the evaluation syntax in the PBL-ESD model, this indicator plays an important role in the problem-solving process. According to Hixson, Ravitz, and Whisman, reviewing is a skill that empowers students to take responsibility for their learning by re-evaluating learning topics (Siahaan & Meilani, 2019).

Therefore, it is important for students to realize that they cannot ignore small details during the learning process. Thoroughness and attention should be instilled in them, to ensure that they truly understand the given learning topic, especially when formulating solutions to problems. Although the indicator of revisiting is fundamentally important, students seem to overlook important aspects that should be prioritized for effective completion.

Furthermore, an effect size analysis was conducted to determine how much the effectiveness of the PBL-ESD (Education for Sustainable Development) modeled science e-book integrated with the local potential of petis as a traditional food on students' problem-solving skills presented in the following table.

Table 9. Effect size pretest posttest of problem-solving skills

Aspect		Std. Dev	Mean	Effect Size	Category
Problem Solving Skills	Pretest	21.468	20.833	0.94	Strong effect
	Posttest	22.826			

Based on the results of the effect size calculation above, it is known that the effect size value is 0.94 which is included in the strong influence category. So, from this statement it can be concluded that the science e-book with the PBL-ESD model has a big influence on students' problem-solving skills. This is also in line with research conducted by Widyastuti (2021) which states that the effect size of 1.009 shows that the PBL model has a very large effect on improving students' problem-solving skills. In addition, Putri's research (2022) states that the application of the PBL learning model to students' problem solving in science learning produces a high influence and impact with an average effect size of 1.16.

Another study was also conducted by Sutisna (2023) which also stated that the effect size value was 0.930 which indicated that the application of the PBL model had a high influence on students' problem-solving skills. The statement can be concluded that

the application of the Problem-Based Learning (PBL) with ESD model that utilizes media such as e-Books is proven to significantly improve students' problem-solving skills. Various studies have shown that PBL is an effective strategy for improving learning outcomes at various levels of education, especially in developing problem-solving skills.

▪ CONCLUSION

Based on the results of the research and discussion, it can be concluded that the use of PBL-ESD model science e-books integrated with local potential in petis production effectively improves students' problem-solving skills. The paired t-test results show a significance level of 0.001 which is smaller than $\alpha = 0.05$ which confirms a significant difference between the pretest and posttest scores of students' problem-solving skills. The results of the N-Gain test conducted on the pretest and posttest showed an increase in various indicators of problem-solving ability. The indicator "understanding the problem" achieved the highest N-Gain score of 0.8 followed by the indicator "analyzing the problem" of 0.7, "planning the solution" of 0.8, "implementing the solution" also of 0.8, and "evaluation or review" of 0.6. Furthermore, the results of the effect size analysis also show a value of 0.94 which is included in the strong influence category. So, from this statement it can be concluded that the science e-book modeled PBL-ESD has a great influence on students' problem-solving skills.

Future research should focus on integrating PBL-ESD model e-books that incorporate local cultural elements into the school curriculum, providing targeted training for educators on effective implementation, developing activities to improve students' evaluation skills through peer review, and exploring the impact of various local potentials across different contexts to assess the broader applicability of this model in improving problem-solving ability.

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