

The Influence of Use of Problem-Based Learning E-Book Materials of Optical Equipment on Improving Students' Critical Thinking Ability

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Abstract: This study intends to ascertain whether problem-based learning e-books for optical devices can improve students' critical thinking skills. *Quasy experiment* approach *one group pretest* and *posttest* used in this research. A total of 45 students of class XI MIPA MAN 1 Yogyakarta were used as research subjects. *Pretest* and *posttest* values of critical thinking in the material of optical instruments were used to collect research data. N-gain and Wilcoxon test were used for data analysis. The N-gain value obtained was 0.45 which met the medium criteria. The results showed that electronic books with problem-based learning on optical devices increased students' critical thinking skills.

Keywords: Critical thinking skills; E-book; Optical devices

Introduction

The era of the industrial revolution 4.0 was marked by the emergence of new technologies such as information technology, communication networks, big data, artificial intelligence and virtualization. The emergence of digital technology and its increasingly rapid developments have an impact on all disciplines, the economy, and existing industries (Cynthia et al., 2023). The impact of the industrial revolution 4.0 is a big challenge for the world. Science and technology are developing at a rapid pace in the twenty-first century. Consequently, in the twenty-first century, talent is required. The abilities that students need to have in the 21st century include learning and innovation, which includes problem solving, communication, collaboration, creative, innovative and critical thinking skills (Nofianti, 2021).

Critical thinking is included in high order thinking which involves the ability to draw valid conclusions,

identify relationships, analyze probabilities, make predictions, and solve complex problems (Tanti et al., 2020). Students' skills in critical thinking are very necessary in learning to solve problems (Samadun & Dwikoranto, 2022). Critical thinking encourages students to solve a problem using previously held understanding, process it and then prove its truth with existing knowledge (Rauf et al., 2022). This ability exists in all students, it's just that it hasn't been honed and directed properly. According to Ariyati (2012) based on observations in learning activities, students must memorize and hoard information so they are less motivated to develop their thinking skills. Therefore, students are capable theoretically but lacking in terms of application. This resulted in critical thinking skills difficult to develop.

According to a study by Benyamin et al. (2021) students still show little critical thinking during assessments. Only physical calculations can be performed by students but not interpreting the answers.

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According to research Susilawati et al. (2020) , 64% of high school students have very low critical thinking skills and 21% of students are included in the medium group, and 15% of students have very low critical thinking skills. Rizky Anisa et al. (2021) argues that an ineffective learning process, which hinders the interests, abilities and potential of other students from developing, is the lack of critical thinking skills. Given the above, it is very important to intensify the learning process to improve critical thinking (Syafitri & Syafriani, 2023). A critical thinker always questions sources of knowledge information, tests the validity of information, analyzes the reliability of information, in order to be able to provide appropriate explanations for certain situations (Astriani et al., 2023). A person can be said to have a critical thinking style if he is able to be consistent, think logically and accurately, have reasoning skills, argue, analyze, predict, and anticipate. Meanwhile, someone with a creative thinking style has characteristics such as being able to produce unique, imaginative ideas, interpret, recognize different ideas or objects, and be a little emotional (Syahfitri, 2023).

In order for students' critical thinking skills to be optimal, there are several learning models that can be used by educators. Applying a learning model that gives students direct experience is one way to improve critical thinking. There are various types of learning models that support increasing students' critical thinking, including discovery learning models, PjBl, PjBl-STEM, and guided inquiry (Nilyani et al., 2023). Problem-based learning models allows students to be actively involved in learning to provide students with practical learning experiences through a series of problem-solving activities (Madroji et al., 2019). Real-world learning situations are used as a setting to teach students how to think critically and gather useful knowledge and concepts in the context of problem-based learning. Students are encouraged to apply critical thinking skills while embracing classroom information in problem-based learning (Bego et al., 2019) . The problem-based learning approach can be used to help students improve their critical thinking skills. Students are taught to solve problems critically using *Problem Based Learning e-books*, which require them to voice their perspectives on how to solve problems and find answers (Putri, 2017; Widianingtiyas et al., 2015). *Problem Based Learning* requires students to critically analyze each argument.

The application of learning models can also be combined with the teaching materials used. Interesting and fun learning requires stimulation from educators. Stimuli or stimuli such as audio, visual, and current issues can potentially increase curiosity. Curiosity followed by the number of questions asked by students will increase learning motivation and academic abilities.

Therefore it is very important to apply learning through media that can invite attention so that students become proactive.

Learning media can be books, print and electronic media, the natural environment or other relevant learning resources. Along with the rapid development of technology, teachers are required to develop practical and flexible learning media. Interesting and varied learning media can eliminate students' boredom in learning (Widiyono, 2020). One solution to overcome this is by utilizing digital learning resources in the form of e-books (Lestari et al., 2021). Interactive e-books with animations and videos make students more motivated and can improve students' academic achievement (Aftiani et al., 2021). *E-book* is one of the media that contains a network of digital content data which includes all of the following: text, images, videos, animations, and questions collected in one program, integrated in the form of visualization and complemented by color, sound and music (Restiyowati et al., 2012) . These networks are all collected in one application. With animations and videos to complement the text, which is related to everyday life, this media will be more developed. Because they can be saved to e-mail, cellphones, and laptops, e-books are easier for students to use because they can be accessed at any time.

The application of learning using electronics in fact still has many pros and cons, there are deficiencies in its effective utilization, less attractive appearance and usage procedures so that it can cause students to be less enthusiastic (Saputri et al., 2023). In addition, another weakness of the electronic book is that not all students can use this electronic book due to limited facilities, but the electronic book also has advantages. The first advantage of *the e-book* is without the use of paper. This is in accordance with PP No. 66 of 2014 concerning Environmental Health and Law no. 32 of 2009 concerning Protection and Maintenance of the Environment to reduce paper use and switch to digital media. Second, it can be an interactive medium that provides action and reaction to students. Third, accessing *e-books* can be via smartphones owned by students or PCs provided at schools. Fourth, there is a menu that is linked with a hyperlink so that students can go directly to the page they want. To convey learning material, the various media created must be used with the right tactics, methodologies and models.

Based on the premise above, the purpose of this study was to determine the effectiveness of problem-based learning using optical devices in the form of e-books in improving students' critical thinking skills.

Method

A quasi-experimental design with *pretest* and *posttest* in the same group was carried out in this study. A total of 45 students of class XI MIPA MAN 1 Yogyakarta became research participants. Study participants were involved in problem-based learning activities while utilizing electronic books on optical instruments. Students' critical thinking skills were measured using critical thinking instruments in the form of essay questions developed by researchers. The developed instrument must have passed the expert validation stage.

Pretest and posttest results data are used to improve students' critical thinking skills. N-Gain analysis is calculated using the following equation to determine the acquisition of critical thinking skills that are measured:

$$g = \frac{S_{post} - S_{pre}}{S_{m_ideal} - S_{pre}} \quad (1)$$

The N-gain value obtained on the critical thinking ability data is then interpreted in the range of categories listed in table 1.

Table 1. Interpretation of the Average N-gain Score

Gain score	Interpretation
$g \leq 0.30$	Low
$0.30 \leq g \leq 0.70$	Currently
$g \geq 0.70$	Tall

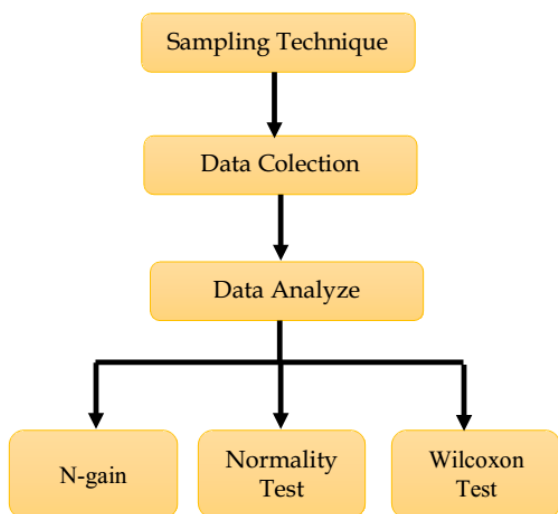


Figure 1. Research design

After the research data was collected, the *pretest*, *posttest*, and N-gain values were tested statistically. The IBM SPSS Statistics 26 application program is used to carry out tests in the form of normality tests and Wilcoxon tests on data that are not normally distributed. This hypothesis was tested at the significance level (α)

which is 0.05 or 5%. The decision to test the hypothesis is made based on the following criteria: If the *Asymp.Sig* value < 0.05 , the hypothesis is accepted. The hypothesis in this study is "There are differences in students' critical thinking abilities between the *pretest* and *posttest*, this indicates that the use of optical devices *Problem Based Learning e-books* has an effect on student's critical thinking abilities. The research design can be seen in Figure 1.

Result and Discussion

E-books are digital books that can contain writing, pictures, videos and even audio that can be used on computers, smartphones and similar media. The images in the *e-book* have been adapted to the material being delivered by the teacher, where in research material optical instruments will display pictures of optical instruments such as eyes, telescopes, microscopes and so on. According to Kasmir (2021) visual media can help students describe or visualize examples of material that is difficult to explain if only in the form of written explanations. In addition, there are also videos to help students understand the explanation of the material visually and audio. The use of videos in *e-books* is also adapted to the material discussed. These videos can be in the form of explanatory videos or tutorial videos that you can make yourself or videos made by other people from video *platforms* such as YouTube. The purpose of using images, videos and text together in *e-book media* is to achieve a unity that supports each other in the learning process, so that interactive learning occurs and student learning outcomes can be higher.

Skills that should be prepared by learners to face the demands of the 21st century, one of which is the 4C skills consisting of critical thinking, creativity, cooperation, and communication skills. 4C skills are needed by learners to face 21st century learning challenges. Based on the journal review, it is found that the 4C skills, one of which is the critical thinking skills of students, are low (Pramita, 2023).

This study examines whether problem-based learning *e-books* on optical devices can help develop students' critical thinking skills. Students' critical thinking was assessed in this study using their performance on the *pretest* and *posttest*. Before starting the learning activity, students do a *pretest* to measure their level of familiarity with the optical instrument subject. On optical devices, problem-based learning *e-books* are also used to accelerate learning. After utilizing the *e-book*, students' critical thinking skills are assessed at the end of class.

The data that has been obtained was analyzed using SPSS Statistics 26. The analysis was carried out to

determine the maximum value, minimum value, mean and standard deviation, while the N-gain value was searched using the Microsoft Excel *formula*. Descriptive

statistical analysis and the N-gain value from *the pretest* and *posttest* can be seen in table 2.

Table 2. Descriptive Statistical Results and N-gain

	N	Min	Max	Means	Std. Dev	N-gain	Category
Pretest	45	20.00	60.00	31.55	12.42	0.45	Currently
Posttest	45	40.00	80.00	63.11	11.24		
Valid N(listwise)	45						

The results of *the pretest* and *posttest* about critical thinking are shown in table 2. A total of 45 students attended the *pretest* and *posttest*. From the data from the test results, the maximum score for critical thinking *pretest* is 60 and the minimum score is 20 and there is an increase in the maximum score of 80 while the minimum score becomes 40 in the *posttest*. In addition, the average *pretest* score was 31.55, while the *posttest* average score was 63.11. As shown by the accumulation of N-Gain points, students' critical thinking skills increased after

being exposed to learning activities in the form of problem-based learning electronic books. Students' capacity to think critically grew by 45%, which is in the average range. The statistical test results give credence to the idea that problem-based learning e-books on optical equipment can help students to hone their critical thinking skills.

The normality test is carried out to find out whether the data is normally distributed or not. The normality test results are shown in Table 3.

Table 3. Normality Test Results

	Statistics	df	Sig.	Category
Pretest	.31	45	.000	Not Normal Distribution
Posttest	.37	45	.000	Not Normal Distribution

Because the results of the normality test indicate that the data from *the pretest* and *posttest* are not normally distributed, the Wilcoxon test will be used to determine

whether the use of Problem Based Learning-based e-books has an effect on students' critical thinking skills. Wilcoxon test results are shown in table 4.

Table 4. Wilcoxon Test Results

	N	Mean rank	Sum of ranks	Z	Asymp. Sig.(2-tailed)
Negative ranks	0	.00	.00		
Positive ranks	41	21.00	861.00	-5.87	
Ties	4				.000
Total	45				

The pretest and *posttest* optical devices, so that the negative difference between critical thinking between *the pretest* and *posttest* is zero, this indicates that there is no decrease or reduction from *pretest* to *posttest* scores. An increase in critical thinking skills from *pretest* to *posttest* with an average of 29.50 is indicated by a positive score or positive difference between *the pretest* and *posttest* of critical thinking in optical instruments material with 41 students. *Ties* is an example where there is a parallel between *the pretest* and *posttest* results, and the data shows that four students have that similarity. Based on the table of values for *Asymp.Sig. (2-tailed)* hypothesis is accepted because students' critical thinking skills differ between *pretest* and *posttest* obtained $0.000 < 0.05$ which means that the use of e-books based on PBL content on optical instrument material has an impact on students' critical thinking abilities.

Critical thinking is a student's ability to recognize, describe, evaluate, and arrive at conclusions about a subject. Using e-books on optical instruments can help students learn more and improve their critical thinking skills. Students' critical thinking skills were evaluated using the four critical thinking marks identified by Ennis: presenting and analyzing arguments, observing and evaluating observations, drawing and evaluating conclusions, and understanding terminology and meaning. The thinking abilities possessed by the students are used as a process of concepts mastering, with the intention that the more critical thinking ability of the students will be able to increase their understanding that could give concrete benefits in influencing the learning outcomes (Khairinaa et al., 2023). This is reinforced by research conducted by Fristadi et al. (2015) which states that critical thinking is a level of thinking ability that allows us to analyze and

synthesize the information obtained to solve problems within a certain scope. This is in line with research conducted which states that only individuals who have the ability to think critically and creatively will be able to survive productively in the midst of intense competition and increasingly open opportunities and challenges (Mulatsih & Yamtinah, 2023).

One of the learning approaches that has gained attention is problem-based learning (PBL). PBL encourages students to learn through exploring realworld problems that are relevant to their daily lives. In the context of science education, PBL encourages students to identify problems, design and conduct experiments, and find solutions based on the scientific knowledge they have learned (Anbiya & Khaldun, 2023).

The learning process using *e-books* means using visualization to facilitate the delivery of material (Andini & Qomariyah, 2022). If students can understand the material through text, audio, video and audio-video media, it is hoped that learning will take place interactively and students will understand the material well. Several researchers have looked at the impact of e-books on students' capacity to think critically. This includes Ristanti et al. (2021) which provides that teaching materials used in education in schools, such as e-books, may have an impact on students' critical thinking abilities. The results of research by Aprilia (2021) the use of interactive media in class, such as e-books and flipbooks, are simple and have a positive impact on students' critical thinking abilities.

From the point of view of the teacher or instructor, the use of *e-books* can facilitate the delivery of knowledge for teachers. Its concise form on electronic devices such as smartphones, can display writing or readings, pictures and videos, of course, makes it easier for teachers to convey material to students when direct communication is difficult. As written by Aprilia (2021) in his research, the use of *e-books* or flipbooks for science learning has a positive impact on students' critical thinking skills and makes it easier for teachers to deliver science material. Therefore, it is possible that in the future the use of printed books will be replaced by more practical *e-books*. It is assumed that the ease with which the teacher conveys material to students creates good learning.

Conclusion

Based on the results of data analysis, the N-gain value obtained was 0.45, which meets the medium criteria. The research results show that electronic books with problem-based learning on optical devices can improve students' critical thinking skills but are still

moderate. Therefore, there is a need for further innovation in the form of learning media, learning models and learning methods to maximize learning, especially in developing students' critical thinking.

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Author Contribution

The research team contributed to the writing of this scientific work, namely: idea, conception, data collection, analysis and interpretation of results, drafting of manuscript, D. P.; Guidance in writing articles, Z. K. P., and J. J.; funding acquisition, D. P., and A. N. S.

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Conflicts of Interest

The authors declare that there is no conflict of interest in the publication of this article

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