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## Designing an E-Module on the Solar System to Develop Critical Thinking Skills

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This study aimed to develop learners' critical thinking abilities through concentrated application in related learning activities. A quasi-experimental design of the Pretest-Posttest Non-Equivalent Control Group type was employed. The study was done between January and February 2023 with a sample of 60 junior high school students in grade VII, divided evenly into an experimental group and a control group, each with 30 participants, focused on the solar system. The experimental group utilized problem based learning (PBL) e-modules, while the control group followed conventional teaching methods. The instrument used in this study included a critical thinking variable with four components in the form of a multiple-choice exam with a reliability value of 0.183, allowing it to evaluate students' critical thinking skills. The data were collected during the pretest and after treatments by administering the posttest. After the SPSS analysis, the data was shown descriptively and inferentially. The results revealed a notable difference in critical thinking capabilities between students involved in PBL-based e-modules and those taught using conventional approaches ( $P < 0.01$ ). Therefore, the study shows that including PBL-based e-modules into the curriculum could improve students' critical thinking ability quite successfully.

**Keywords:** critical thinking skills, e-module, PBL, solar system

### INTRODUCTION

The shift to Industry 4.0 is marked by incorporating digital technologies, including intelligent services, cloud computing, and digital networks, reshaping contemporary society's economic and social frameworks (Ulyana, 2019). As we enter the era of Industrial Revolution 4.0, Indonesia aims to develop a workforce that is efficient, straightforward, and rewarding to enhance job creation and employment opportunities (Lane et al., 2020). In summation, the 21st century has engendered substantial transformations in human existence, demanding the demand for skilled labor across all sectors of endeavor and productivity. This transitional time is undeniable. Unitasari et al., 2021. The educational environment of the 21st century is replete with challenges. The significance of education is increasing for students' development of media literacy, information technology, and learning and innovation competencies, along with job and life skills (Ardelia, 2021).

The concept of education is commonly referred to as 21st-century learning, and the array of competencies demanded of students in the current period of globalization is often recognized as 21st-century skills (Sharma, 2019). Indonesians face challenges in attaining a comprehensive understanding of their society in the twenty-first century. This objective may be achieved if every Indonesian have robust ambitions and ethical integrity to impact the civilization of their nation (Iriany, 2017). The rapid progression of science and technology (IPTEK) (Ginting et al., 2021) signifies transformative transformations in the 21st century. This induces a transformation in the learning paradigm, marked by modifications to the media, curriculum, and technology. Comprehensible elucidations of abstract subjects are offered in an appropriate educational setting. The integration of technology in enhancing learning capabilities is a fundamental requirement for education in the twenty-first century (Rahayu et al., 2022; Bakri et al., 2023).

The education system is encountering unparalleled problems, especially in its capacity to counter deception and advocate for truth in a post-truth world (Patrinos, 2021). Twenty-first century education must prepare Indonesians for transformations in media and communication in everyday life. As we enter a competitive era, every individual necessitates 21st-century skills. The capabilities include raising questions, participating in critical and creative thinking, making assessments, and solving issues to identify, analyze, and produce new ideas (Gaur, 2017; Mardhiyah, 2021). Strategic planning is vital while instructing these talents to an individual. Systematic implementation of student skill development through study programs is essential to ensure it is targeted and adapted to contemporary needs and challenges (Garcia-Villar, 2021).

Education is integral to enhancing human welfare. Moreover, education constitutes an integral component of national development (Suryana, 2020). The curriculum must include a clear vision and strategy to address all transformations associated with the Industrial Reform 4.0 period of the 21st century. Actualizing this goal and strategy necessitates comprehension of the diverse obstacles presently arising as a manifestation of 21st-century growth (Khasanah, 2019). Competent and high-caliber resources equip individuals to engage in the competitive landscape. Consequently, all educational institutions must develop efficient and practical curriculum that equip students with the requisite skills and competencies for the future, prioritizing rigorous learning as the primary objective of academic instruction.

To be able to think critically, you need to be able to carefully consider all of your options, work through problems, evaluate and criticize points, and complete tasks with accuracy and clarity (Santika et al., 2017). Critical thinking is an important skill for today's world because it helps people understand themselves, make decisions based on facts, and solve problems by using knowledge disorders well (Bubnys et al., 2023-5). Critical thinking is an important part of being able to solve problems. The idea of critical thinking can be broken down into three parts: parts that focus on reasoning skills and abilities, parts that question social norms and ethics, and parts that limit people's freedoms (Sato, 2022). To help people learn how to think critically, they need enough tools and teaching materials.

E-modules in the area of education feature a variety of learning resources to help students comprehend the subject being taught more quickly and become more engaged in the process of learning since they employ engaging teaching strategies (Chu et al., 2018; Pasaribu, 2020). Studying with the e-module would enhance student learning results and help educators identify more engaging teaching strategies. The relationship between e-module media and critical thinking abilities has yet to be studied. Under the problem-based learning paradigm, students are given tasks to complete on their own, which helps them hone their critical and creative thinking abilities (Fidan & Tuncel, 2019; Hsu et al., 2018). In order to help students develop critical and creative thinking abilities, this learning strategy often employs real-world situations for them to examine and find answers (Jabarullah & Hussain, 2019; Theobald et al., 2020). According to this paradigm, the teacher's primary responsibility is to assist students in developing critical and creative thinking abilities to advance in their academic journey (Dearnley et al., 2018; Kim et al., 2018). This is the first time anyone has employed problem-based learning incorporated into e-modules in earlier research. The solar system is covered in scientific classes that include celestial bodies, such as the sun, moon, stars, earth, natural satellites on these planets, and other celestial bodies (Ahmed, 2021).

## METHOD

### Research Design

The method used in this research was a quasi-experiment with a non-equivalent control group design. This research method has a sample of 2 groups, namely control and experiment (Finch, 2017). This quasi-experimental procedure is that a pre-test is first carried out to determine the control and experimental classes, then both sample groups are given the research product to understand the material contained in the product, but in the control class this is not necessary. To explain the material on the product further, while in class, the opposite experiment was carried out, and finally, a post-test was carried out on both samples (Brackmann, 2017). The research design is as showed by FIGURE 1.

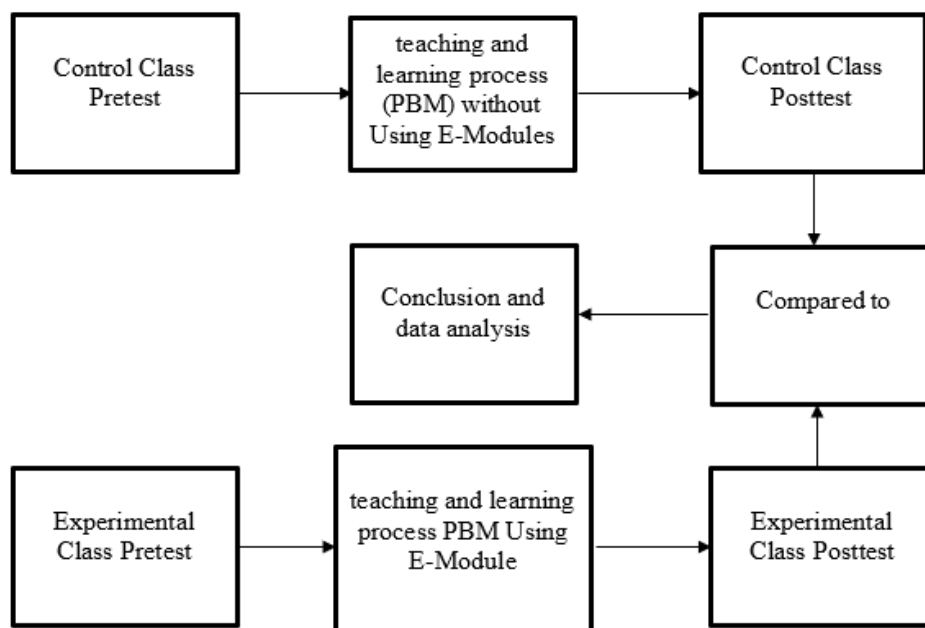


FIGURE 1. Research Method Scheme

### Population and Sample

This research was conducted with a sample of 60 people consisting of 30 people in the control class and 30 people in the experimental class. Most of the observed samples were intact and considered representative of the population and samples were partial from the original study population (Arikunto, 2010). This research was conducted for a week and the research participants were class VIII students of junior high school. The sample was selected by random method and purposive sampling because class VIII students had studied global warming material, so it was easier to collect research data on class VIII students.

### Critical Thinking Test Instruments

The researcher uses a test instrument made in previous research because the test instrument has gone through the validation and practicality stages. The critical thinking test instrument is already in the valid category, as evidenced by  $t_{table} > t_{count}$ . The thinking test instrument is in the reliable category, as evidenced by the results of the practicality test  $> 0.80$ .

### PBL Based E- Module Development

The material used in the product is Solar System material. This material is used in this research because this material is an issue that is currently being discussed all over the world. Researchers hope that by choosing this material students can gain an in-depth understanding of the solar system through

increasing critical thinking skills. The description regarding the development of the prototype e-module can be seen in FIGURE 2 and FIGURE 3.

The cover is made as attractive as possible to attract students' interest. The e-module is then equipped with a foreword, table of contents, introduction, and learning activities. The introduction consists of the module identity, basic competencies, a brief description of the material, instructions for using the module, and learning materials in the module.

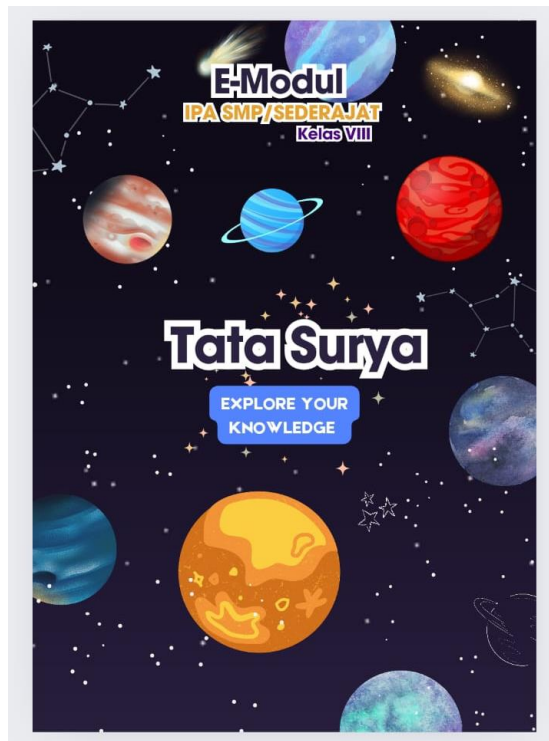


FIGURE 2. Cover E-Module of the solar system.

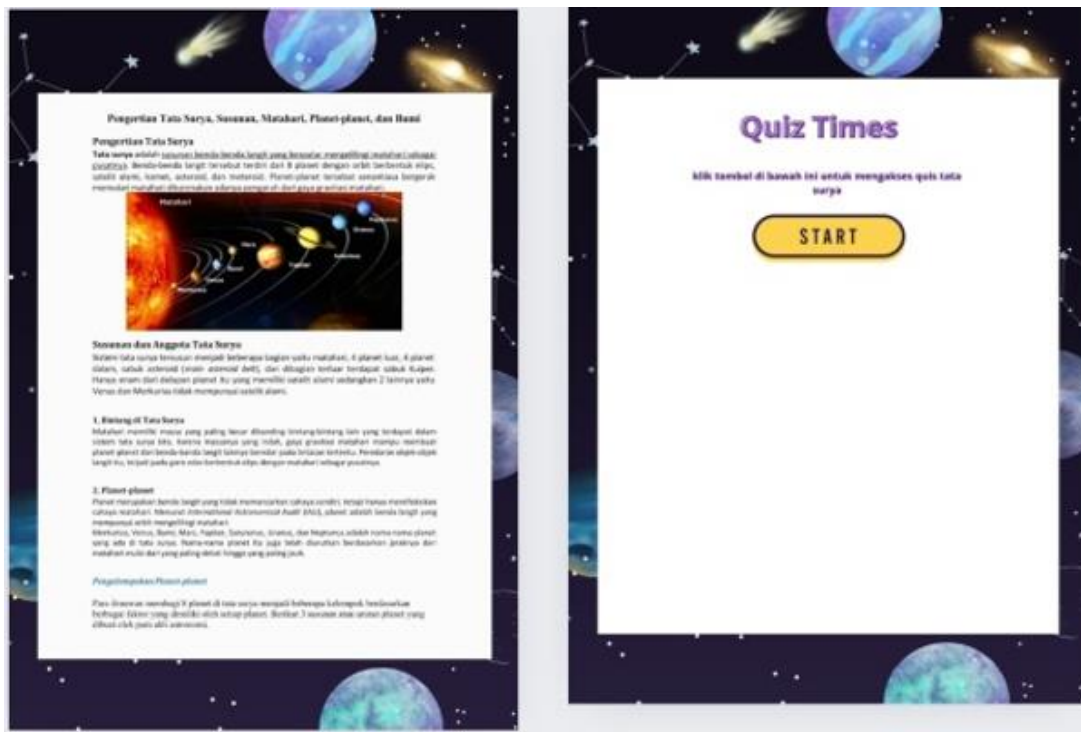


FIGURE 3. Learning activities in the form of materials and exercises (Quiz).

### Data collection

In this study, the media created was E-Module media, which was made by adjusting the science material for junior high schools, namely the Solar System material. Then the media assessment data is taken by using a questionnaire that can be opened with *Google Form*. The type of data that the researchers collected were pre-test and post-test data. The data is necessary because, from the data, it can be seen how much the ability to think student credit. The technique used in data collection is the mean score technique. The stages of data collection are first by conducting a pre-test and post-test from the two tests to produce research data. Overall data in this study were collected for two months, from January to February. The amount of data generated is very adequate because the total data generated is as many as 60 people. The quality of the data collected is quite good with the test results in the two classes only slightly different.



FIGURE 4. Data Collection Process

### Data analysis

Researchers analyzed the data using SPSS with the mean score theory. Researchers use the mean score technique because the technique is easier to use in research that uses quasi-experimental models. In data processing, researchers analyzed descriptive data and tested the N-Gain using SPSS. The stage begins with processing the pretest and posttest data to get an overview of the existing problems. Furthermore, the researcher conducted the N-Gain test so that he could see the difference before and after being given treatment using the E-Module media. After that, he could see whether there was an increase in post-test scores after treatment. The evaluation criteria for the N-Gain test by Meltzer & David, 2002 can be seen in TABLE 1.

**TABLE 1. N-Gain Test Criteria**

Mark	Category
$> 0.7$	High
$0.3 \leq G \leq 0.7$	Medium
$< 0.3$	Low

## RESULTS

The implementation of the research conducted by the researchers was carried out in stages in coordination with the teachers at the schools where the research was carried out. First, the researcher conducted a pretest; after that, the scores from the pretest were grouped into two classes, namely the control and experimental classes. For the control class, the teacher showed the PBL-based e-module to the students, while for the experimental class, the researcher explained the material in the e-module again. After the two classes saw the e-module, a post-test was carried out in both classes, and the results were outlined in this study. Data in the form of scores was used to determine the increase in critical thinking.

**TABLE 2. Critical Thinking Pretest and Posttest Results**

No	Parameter	Experiment Class		Control Class	
		Pretest	Posttest	Pretest	Posttest
1.	The number of students	30	30	32	32
2.	Average	39.7	66.7	37.11	55.8
3.	Standard Deviation	7.82	10.63	6.34	8.76
4.	The highest score	65	80	55	70
5.	Lowest Value	30	50	25	40

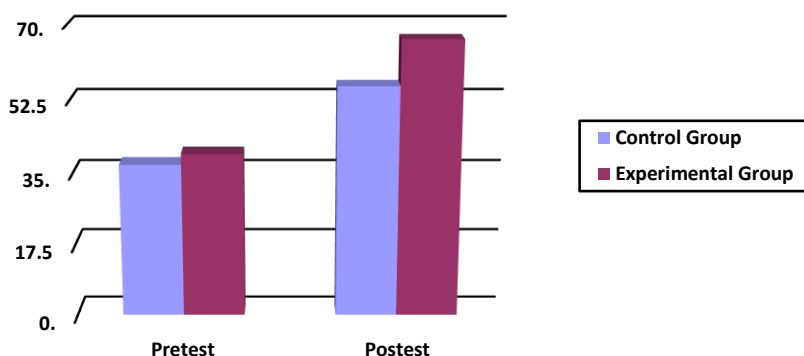
**TABLE 3. Average N-Gain Score**

No	Score Acquisition	Experiment Class	Control Class
1.	Highest N-Gain	0.66	0.56
2.	Lowest N-Gain	0	0
3.	Average N-Gain Value	0.467	0.253
4.	Percentage (%)	46.72	25.33
5.	Category	Medium	Low

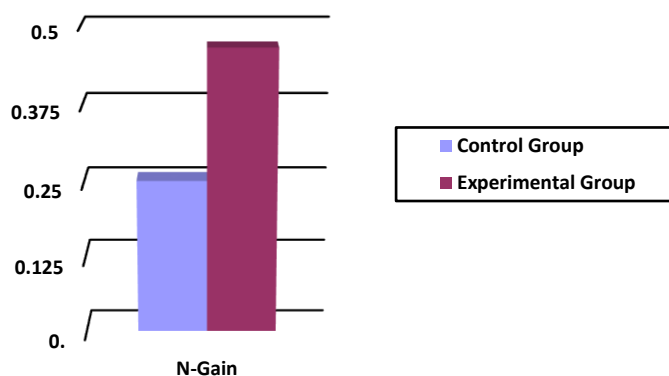
TABLE 2 shows that there are 60 students. Based on the research profile data above. They obtained the average number of pretest and posttest experimental classes of 39.7 for the pretest and 66.7 for the posttest. Then, the highest score in the experimental class was 65. The lowest score was 30 in the pretest and 80 for the high category, 50 for the low category in the posttest, while in the control class, the highest score was 55 and the lowest score was 25 in the pretest and 70 for the highest score, 55 for the lowest score on the posttest. There was an increase after being given treatment in the experimental class using the E-Module learning media. Suitable device quality is essential to ensure that the data obtained is consistent and relevant (Suvarna, 2016). After knowing the average scores and the highest and lowest scores on the pretest and posttest, the researcher then conducted the N-gain test to determine

the effectiveness of the e-module media in evaluating the knowledge of students on the material of the Solar System. The results of the N-gain calculation can be seen in TABLE 3.

Based on TABLE 3 shows the average value of the N-gain Score. The highest n-gain score was obtained from the posttest results. A score of 0.66 was obtained for the experimental and control classes, 0.56. Furthermore, the lowest n-gain is obtained from the pretest value and the lowest average value for the experimental and control classes is obtained with a value of 0.



**FIGURE 3.** Diagram of students' pretest and posttest and the results of the N-Gain test.



**FIGURE 4.** Diagram of results of the N-Gain test

## DISCUSSION

Before carrying out a survey on the use of media in learning, it was found that the results of the data showed that the competency results related to the solar system material were not optimal. From this problem the researcher analyzed and found that the factors causing the learning outcomes were not achieved were in the learning process. In dealing with the problem of academic success, there are many methods and means of testing teachers and education professionals, but it is not uncommon for the methods applied to confuse students and have an impact on learning outcomes (Fazli et al., 2022). One strategy that can be used is the use of interesting learning media. Media plays an important role in learning, educators are required to be more creative and innovative in this regard.

Therefore, researchers used E-Module media as learning media which was applied in this study. By using PBL-based E-Modules as learning media, students are expected to be able to think critically (Budiarti et al., 2016) and understand material related to the solar system. In addition, with the E-Module it is hoped that the learning process will run effectively and efficiently (Wulandari et al., 2021) and support communication between teachers and students so that students understand the concept of learning and experience better results in learning (Imansari & Sunaryantiningsih, 2017). This research is a quantitative study which consists of two variables, namely the use of the E-Module (X) and the knowledge evaluation variable (Y) (Lestari & Parmiti, 2020) and the data in this study were obtained



from questionnaires and questions. The use of a questionnaire is to measure the E- Module media, scores obtained using a Likert Scale (Devi et al., 2018) which consists of five options, namely Strongly Agree (S), Agree (S), Agree Moderately (CS), Less Agree (KS), Strongly Disagree (SKS). The questions that the researchers used to measure the evaluation of students' knowledge, the scores obtained used the Guttman scale.

The results of the above study with the number of students as a sample of 62, namely the experimental class obtained an N-Gain score of 0.66 and the control class 0.56 The pre-test results of both classes and both variables show that the value is quite good with the mean value > 60. The results of the post test of both classes and also of the two variables show that the scores of both classes are good as evidenced by the mean value >70. The pre-test results with an average value of > 60 are included in the pretty good category, the post-test results with an average > 70 are included in the good category. Overall the results of the pre-test and post-test that have been carried out are quite good and if related to the research objectives it has been quite successful where the use of learning media through Problem Based Learning-based E-Modules can improve students' critical thinking skills.

## CONCLUSION

In this study, it can be concluded that the results of the pre-test and post-test conducted in the quasi-experimental method showed that the pre-test results were in a pretty good category with an average value for critical thinking variables of 70. The post-test results in this study included in the good category, this is evidenced by the post-test average value for critical thinking variables > 70. This has implications for improving students' critical thinking skills . So this study recommends teachers to be able to use this PBL-based e- module in the teaching and learning process.

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