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Enhancing students' science outcomes through problem-based interactive flipbook e-module

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Abstract: The challenges of finding interesting and interactive teaching materials is one of the causes of low science learning outcomes. Accordingly, this study formulates valid, practical, and effective flipbook-based e-modules for improving junior high school students' science learning outcomes. The Research and Development (R&D) method with the ADDIE development model was adopted. Then, the effectiveness of proposed e-modules in improving cognitive learning outcomes through pretest and posttest questions was measured. The garnered data was analyzed using the t-test and N-Gain. The material aspect was declared valid with 87% accuracy, while the media aspect yielded 84% accuracy, falling under the valid category. The practicality test for the e-module conducted by involving the teacher resulted in a 97% score in the practical category. Similarly, the readability test conducted by involving the students resulted in a 93% score in the practical category. The analysis of the test results indicated a significant difference in cognitive learning outcomes before and after using flipbook-based e-modules, with a sig value of 0.000 < a = 0.05. The N-Gain test yielded a value of 0.70 in the medium criteria, placing the level of effectiveness in the moderately effective category. These results suggest that the implementation of the Problem-Based Learning (PBL) model, facilitated by flipbook-based interactive e-modules in learning activities, can enhance the science learning outcomes of junior high school students.

Keywords: digestive system; e-module; flipbook; learning outcomes; problem-based learning

1. Introduction

During learning activities, teaching materials present a crucial role as they train students' independence in learning (Setiyadi et al., 2017). Although many teaching materials have been developed, discovering effective, interesting, interactive, and engaging teaching materials for the learning process remains a challenge (Sepriana et al., 2019). Fikri and Rahmaniyyah (2023) suggest that interesting teaching materials aid students in developing knowledge and understanding information more easily. Meanwhile, the quality of teaching materials can enhance the learning experience by providing diverse resources beyond textbooks. Besides, interactive modules have been identified as an effective solution for creating such materials (Wijaya & Sefriani, 2017). In the current digital era, it is crucial to create effective and engaging e-modules for teaching (Phandini et al., 2023; Serevina et al., 2018; Sulisetijono et al., 2023). This will motivate students to learn and provide them with practical and interesting learning resources (Hamid & Alberida, 2021).

Science learning is essentially carried out based on research (Affriyenni et al., 2022). However, student learning outcomes in science have been a persistent issue. According to research conducted by Widianti (2023) and Jufrida et al (2019), students' learning

achievement in science falls below the minimum completion criteria (75%). Similarly, students at one of Malang Junior High School, Indonesia, also face similar conditions. The science teacher reports that only 60% of students meet the minimum completion criteria during daily science tests. The low academic achievement of junior high school students may be attributed to the lack of available teaching materials (Lela et al., 2023). Furthermore, the learning models also play a significant role in academic achievement in science. Similarly, low academic achievement is observed in the area of food and the digestive system. The study conducted by Ekasari (2021) revealed that students have a low comprehension of the abstract and complex nature of the human digestive system material. It is due to their inability to directly observe the digestive process and organs, which suggests suboptimal learning outcomes. The use of many technical terms in material related to the digestive system can also hinder students' understanding (Ekasari, 2021), leading to challenges in learning the digestive system.

In response to these issues, the Indonesian government has attempted to enhance students' science learning outcomes by improving teaching materials (Suparya et al., 2022). An example of teaching materials is e-modules. E-modules are highly beneficial to learning activities as they enable teachers to present subject matter effectively (Phandini et al., 2023; Serevina et al., 2018). Digital learning materials, such as flipbook-based e-modules, have the added advantage of being highly accessible, as they can be accessed anytime and anywhere (Marsuki et al., 2021). This e-module is presented as a flipbook that can be accessed on each student's cellphone screen, allowing for easy reading (Munzil et al., 2022). While there have been numerous efforts to improve academic achievement through the development of e-modules (Agung et al., 2022; Wahab et al., 2023; Wibisana et al., 2022), the currently available e-module lacks interactive features and does not allow for direct student engagement. Interactive features in teaching materials can improve students' academic achievement by providing immediate feedback, which encourages students to continue learning. Feedback helps students understand which material they have not yet mastered and motivates them to relearn it (Wulandari et al., 2020). Therefore, it is essential to develop interactive e-modules that facilitate two-way communication between the module and students.

In addition to teaching materials, the learning model also has a significant impact on student academic achievement. Problem-based learning (PBL) is an alternative learning model for improving learning outcomes. By focusing on contextual problem-solving, PBL requires analytical, evaluative, and solution-oriented thinking (Ananda & Mulhamah, 2023; Scholkmann et al., 2023). This teaching model connects science with students' everyday life and society (Uluçinar, 2023). This approach can be used to teach science by relating science materials to real-life materials, such as food and its digestive system (Istiqah et al., 2021). Therefore, it provides students with authentic problems and promotes meaningful learning (Arends, 2012). The PBL model places students at the center of the learning process, allowing them to take an active role in learning activities while the teacher serves as a guide (Munawaroh & Setyani, 2020). Previous research has been conducted on the use of the PBL model to improve learning outcomes (Fitrida et al., 2022; Mangngi et al., 2022; Weja & Bano, 2023), reporting that the PBL model can enhance student academic achievement. However, these studies have not applied interactive e-modules.

Following the aforementioned explanation, this study developed flipbook-based interactive e-modules using the PBL model to enhance science learning outcomes for junior high school students. Additionally, the feasibility of flipbook-based interactive e-modules using the PBL model was assessed, and their effectiveness in improving science learning outcomes for junior high school students was analyzed.

2. Materials and Methods

This study employed the ADDIE model for research and development (R&D), which consists of analyzing, designing, developing, implementing, and evaluating stages. The ADDIE learning system concentrates on content management, learning technique design, and media selection and development (Branch, 2010). The research was conducted at one of Malang State Junior High School, Indonesia, from October to November 2023. The study population consisted of eighth-grade students in the odd semester of the 2023/2024 school year. A sample of 32 students from the class was selected using random sampling.

The analysis stage involved examining issues related to science education, specifically the material on food and the digestive system, through a needs analysis and interviews with science teachers. The resulting product was an interactive e-module. During the design stage, flipbook-based e-module specifications and storyboards were created, while material content and learning tools were compiled, and instruments were developed to test the validity and practicality of teaching materials. Additionally, student readability questionnaires and pretest and posttest questions were used to measure academic achievement. In the development stage, the previously designed e-module was completed. Canva and Heyzine were used to create the e-module. Then, the validity and practicality tests were conducted on the developed e-modules by involving teachers and students. The validation test instrument was adjusted to national standard (Kemendikbud, 2017). Validation and readability tests were carried out to ensure that teaching materials were appropriate for students' characteristics and needs (Taherdoost, 2018). Meanwhile, the practicality test was carried out after the individual, small groups, and field trials.

During the implementation stage, activities were conducted involving eighth-grade junior high school students who are learning about food and the human digestive system. The first activity was a pretest, followed by learning activities on food and the digestive system materials using flipbook-based e-modules in three meetings. Finally, students were given a posttest to determine the effectiveness of the e-modules on their cognitive learning outcomes. Evaluation was conducted at every stage of development based on assessment scores and feedback from validators and students.

This study utilized various instruments, such as a questionnaire for analyzing student needs, a validation sheet for teaching materials, a practicality sheet for teachers, a readability sheet for students, question grids, and pretest and posttest questions to measure learning outcomes. The pretest-posttest questions were validated through empirical tests. This study collected quantitative and qualitative data. Quantitative data was collected from validation test scores of teaching and learning materials, teacher practicality, and student readability. These data were garnered through validation and practicality questionnaires. Additionally, quantitative data was obtained from the pretest and posttest results of students. The study collected qualitative data through interviews, suggestions, and comments on the needs analysis questionnaire, teaching materials, and materials validation questionnaire, as well as a practicality questionnaire for teachers and students (Taherdoost, 2018).

The module's validity and practicality scores were obtained through a questionnaire using a Likert scale (Aka et al., 2018). The obtained validity percentage was categorized following the criteria presented in Table 1.

Table 1. Criteria for e-modules validity and practicality

Percentage (%)	Criteria
$X = 100$	Very valid/practical, can be used without revision
$80 \geq X < 100$	Valid/practical, can be used with minor revisions
$60 \geq X < 80$	Not valid/practical, moderate revision
$40 \geq X < 60$	Not valid/practical, major revision
$20 \geq X < 60$	Not very valid/practical, not used

Qualitative data included needs analysis results, suggestions, and comments from the validation of teaching materials and materials, as well as results from teacher and student practicality questionnaires. Qualitative descriptive analysis was used to analyze this data. The study analyzed both qualitative and quantitative data. Quantitative data included empirical test results and pretest-posttest learning outcomes data from students. Statistical analysis was conducted using the SPSS 16.0 program.

The validity of the pretest and posttest questions was analyzed using product moment. Once the questions were proven valid, a reliability test was carried out using Cronbach's alpha. The pretest and posttest value data were analyzed using the normality test. If the distribution was normal, another analysis using the paired sample t-test was performed. This research evaluated the effectiveness of flipbook-based e-modules in improving learning outcomes using a normalized gain test. The normalized gain formula (Formula 1) was used to determine the difference in scores between pre-learning and post-learning. The results were classified based on the criteria for normalized gain values presented in Table 2. The effectiveness criteria for N-gain are presented in Table 3.

$$\text{Normalized Gain} = \frac{\text{posttest score} - \text{score pretest}}{\text{ideal score} - \text{pretest score}} \quad \text{..... (1)}$$

Table 1. Criteria for normalized gain values

N-Gain	Criteria
0,70 ≤ g ≤ 1,00	High
0,30 ≤ g ≤ 0,70	Moderate
0,00 ≤ g ≤ 0,30	Low
g = 0,00	Constant
-1,00≤ g < 0,00	Decline

Table 2. Criteria of N-gain effectiveness

Percentage (%)	Criteria
< 40	Ineffective
40-55	Less effective
56-75	Relatively effective
> 76	Effective

3. Results

During the analysis stage, a needs analysis was conducted on data from the questionnaire for students and interviews with teachers at one of Malang State Junior High School. The preliminary study revealed that 83% of students showed enthusiasm for learning science, particularly when discussing real-life problems. Additionally, 97% of students reported that their teachers had never used flipbook-based e-modules during the learning process. Meanwhile, 90% of students prefer science learning resources that include attractive images, suggesting their great interest in using flipbook-based e-modules to learn. Additionally, all students express their need for teaching materials to ease the learning of science concepts, such as food and the digestive system, resulting in more engaging learning.

The interviews with science teachers suggest low learning outcomes in science lessons, with only 60% of students having met the learning minimum completeness criteria, particularly in the food and digestive system material. Further, the teachers face obstacles when teaching this material, as students struggle to memorize the enzymes of the digestive organs and often lack learning enthusiasm. Consequently, teachers should aim to facilitate learning through innovative, interactive, and interesting teaching materials (Fung, 2020; Karunanayaka et al., 2016). Therefore, the development of flipbook-based interactive e-modules with PBL models in food and digestive system material is necessary. Several researchers reported that using innovative media such as flipbooks has a positive impact

on student learning outcomes, especially in science (Andini et al., 2018; Aprilia, 2021; Hardiansyah & Mulyadi, 2022; Tsai et al., 2018). Flipbooks are widely used because of several advantages and their relevance to Zoomers as users (Hardiansyah & Mulyadi, 2022; Prasetyono & Hariyono, 2020; Sulistianingsih & Carina, 2019). As a generation born and raised in technology and digital, enriching learning media with technology is one effective effort to increase engagement (Fisher & Baird, 2021; Pescadero & Cabahug, 2023).

In the design stage, various materials were produced, including a needs analysis instrument, teaching modules, pretest and posttest questions, teaching material, material validation questionnaires, and e-module content. Meanwhile, a flipbook-based interactive e-module prototype was created in the development stage using the PBL model for food and digestive system material. The prototype can be accessed via the QR code as a shortcut. The e-module component comprises general information, problem-based learning activities, video to deliver problems during learning (Figure 1), and evaluation of learning at the end of each sections. The module's learning activities follow the syntax of the PBL (Birgili, 2015; Sada et al., 2016), comprising problem orientation (presenting the problem), organizing students to learn (providing material), guiding investigations (using student worksheets), presenting results and solutions, and evaluation.

Figure 1. Learning video as part of interactive e-module

At this stage, increasing student interaction with the material is facilitated by adding student worksheet features using the LiveWorksheet application (Figure 2) and virtual practice using Virtual Lab (Figure 3). The module's interactive features are presented during the problem investigation activity, which utilizes the Virtual Lab. Through Virtual Lab, students can conduct various simulation experiments to learn about the nutrient content in various types of food and receive direct feedback (Cindikia et al., 2020; Narulita et al., 2019). Through this process, students can increase their interaction and understanding of concepts independently (Caño De Las Heras et al., 2021; Lewis, 2014; Sari et al., 2022).

Virtual Lab is a breakthrough in online learning (Errabo et al., 2024; Hermansyah et al., 2015). This is done as an effort to continue to provide high-level learning and thinking experiences to students (Serdyukov, 2017). On the other hand, it is also intended to make it easier for students to learn more about the concepts learned through direct practice activities (Quigley, 2014). Many researchers believe that virtual lab learning can improve student learning levels (Angreani et al., 2022; Sari et al., 2022; Serdyukov, 2017).

Figure 2. LiveWorksheet to engage students' understanding comprehensively

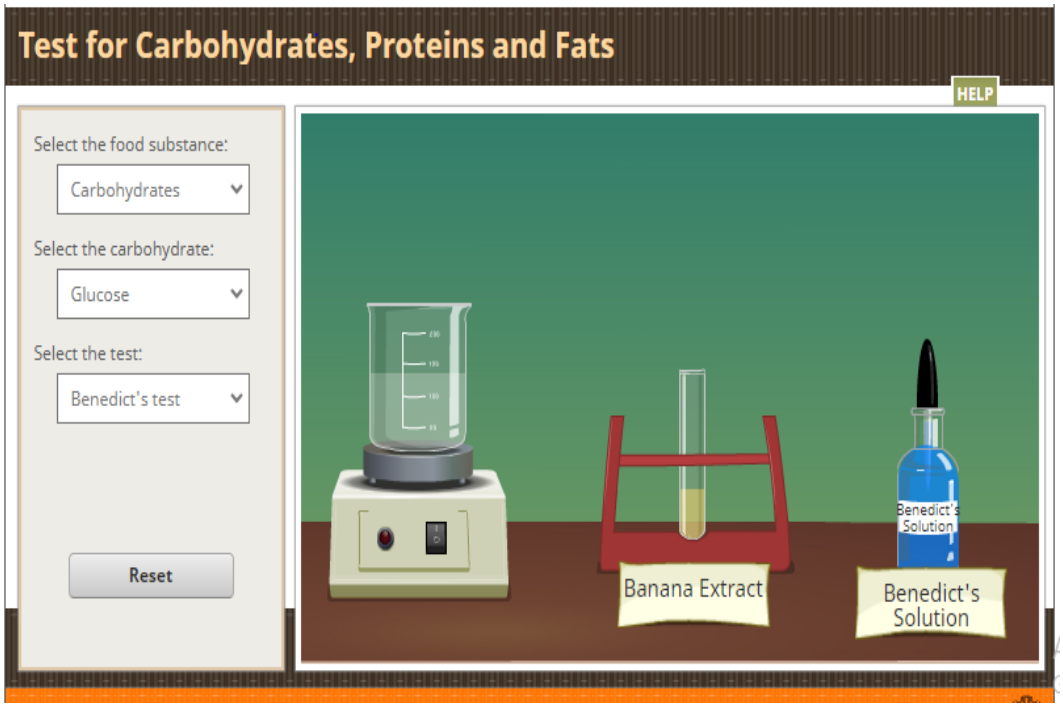


Figure 3. Virtual Lab to facilitate students' investigation

Additionally, interactive exercise questions are provided through Google Forms, with immediate scoring available upon completion, provides quick feedback that motivates

students to learn better. Further, the e-module is divided into three meetings, each of which contains one PBL cycle, thereby, the module contains a total of three PBL cycles, as exhibited in Table 4. LiveWorksheet is used to facilitate every student activity, from the first syntax to the last syntax in the PBL cycle, which allows students to work on worksheets digitally and interactively. To support understanding of the material, the e-module is also equipped with learning videos and relevant images. This makes the material easier to understand and enhances students' learning experience visually and interactively

Table 3. Detail of learning activities in PBL-based e-module

Syntax	Meeting 1	Meeting 2	Meeting 3
Problem orientation	Presentation of problems of obesity	Presentation of problems related to toddlers with obesity	Presentation of problems related to unhealthy eating patterns in Indonesian society
Organizing student learning	Collect information by reading material about nutrition and food	Collect information by reading material about additives	Collect information by reading material about the digestive system
Investigation	Conduct food testing practicum through the virtual lab in the LiveWorksheet.	Investigate the additive content from packaged foods and beverages. Then, the data are analyzed based on the rules for additives consumption from the Ministry of Health	Investigate the digestive organs and enzymes, as well as the types of digestive diseases associated with food consumption or diet
Presenting results & solution	Present the results of the investigation that leads to the problem orientation at the beginning, then come up with solutions for the presented problems	Present the results of the investigation that leads to the problem orientation at the beginning, then come up with solutions for the presented problems	Present the results of the investigation that leads to the problem orientation at the beginning, then come up with solutions for the presented problems
Evaluation	Evaluate the appropriateness of the proposed solution for obesity	Evaluate the appropriateness of the proposed solution for diabetes	Evaluate the appropriateness of the proposed solution for an unhealthy eating pattern

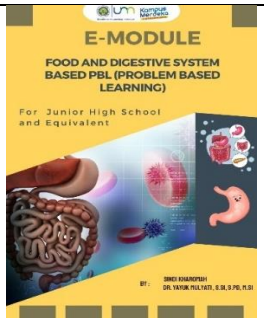
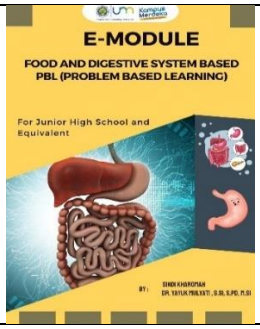
The validity test results for the e-module, presented in Table 5, indicate a final score of 84.6%, it means that the developed teaching materials is valid and suitable for use as a learning resources. Additionally, the validator provided notes for product improvement, as shown in Table 6.

Table 4. Results of e-module validation

No	Aspects of Assessment	Score (%)	Category
1	Display	85	Valid
2	Additional feature	93	Valid
3	Conformity with the PBL model	64	Moderate
4	Usage	88	Valid
5	Consistency	93	Valid
6	Benefit	85	Valid

Final Score	**84.6**	**Valid**

Table 5. Revision from validator

Suggestion	Before	After
The cover should be representative of the content of the e-module		
Repair the non-functional link	There is a non-functional link	The non-functional link has been repaired
Customize the E-module with the PBL model	The problem orientation section includes a command to formulate a problem, and four columns are provided to list the problem formulations provided by students. However, the problem formulation leads to a general definition or concept, which is less in accordance with the Problem-Based Learning model.	It has been revised, resulting in two available columns directly related to the presented problem.

Following the results of the material validity test presented in Table 7, the final score for the material is 87.3%. Meanwhile, the final score for question validation is 92%, as shown in Table 8. These results indicate that the material in the e-module is valid and suitable for use. Additionally, the validator provides notes for product improvement, as exhibited in Table 9.

Table 6. Results of materials validity test

No	Aspects of assessment	Score (%)	Category
1	Conformity of materials	87.5	Valid
2	Language	85.7	Valid
3	Presentation	93	Valid
4	Conformity of e-*module* with PBL syntax	64	Moderate
5	Learning module	96	Valid
6	Accuracy of concepts	98	Valid
	Final Score	**87.3**	**Valid**

Table 7. Validity of pretest and posttest items

No	Aspects of assessment	Score (%)	Category
1	Suitability of learning objectives with learning outcomes	100	Very Valid
2	Conformity of problem indicators with learning objectives	81	Valid
3	Suitability of problems with problem indicators	81	Valid
4	Suitability of questions with the cognitive domain	80	Valid
5	Only one correct answer for every item	100	Very Valid
6	Easily understood and non-ambiguous language	100	Very Valid
7	Conformity of concept	100	Very Valid
8	There is distractor	100	Very Valid
	Final Score	**92**	**Valid**

Table 8. Revision from materials experts

Suggestion	Before	After
It is important that e-modules adhere to the PBL learning model. This requires a clear connection between the problems presented and the investigation conducted in order to provide effective solutions and present accurate results, particularly in the second meeting.	The problem concerns a 7-year-old child who has developed diabetes due to frequent consumption of packaged drinks. The investigation conducted in the student worksheet is focused solely on examining the additives present in various brands of packaged food and beverages.	The issue concerns a 7-year-old child with diabetes due to frequent consumption of packaged drinks. During the investigation activities in the worksheet, students were tasked with examining the content of additives in various brands of packaged food and beverages. The students were then asked to investigate the levels of additives in these products and compare them with the recommended consumption rates set by the Ministry of Health. This process allowed for the identification of brands of food and beverages that potentially cause diabetes.
Revise questions that do not align with the learning objectives or the indicators of the questions and their cognitive levels.	There are several question indicators that do not align with the learning objectives, while some questions do not align with the question indicators and cognitive level.	The unsuitable questions have been revised to align with the learning objectives, question indicators, question narratives, and cognitive level.

Table 9. Results of practicality test

No	User	Score (%)	Category
1	Teacher	97	Valid
2	Student	96	Valid
	Final score	**96.5**	**Valid**

According to Table 10, the results of the flipbook-based e-module practicality test conducted by teachers and students indicate a practicality score of 96.5%, suggesting its feasibility for usage. The implementation stage involves the application of PBL-based learning facilitated by e-modules. The learning process consists of a pretest, learning implementation, and posttest. The validity and reliability of the questions used in the pretest and posttest have been ensured, with 15 out of 21 questions tested being valid and highly reliable. Further, statistical analysis was conducted to evaluate the effectiveness of flipbook-based e-modules in enhancing cognitive learning outcomes.

Table 10. Results of normality test ($\alpha = 0.05$)

Category	Sig	α	Conclusion
Pre-test	0.072	0.05	Normal distribution
Posttest	0.078	0.05	Normal distribution

According to the results of the normality test presented in Table 11, the data from the pretest and posttest results are normally distributed, as indicated by the pretest value of (sig 0.072 > 0.05) and the posttest value of (sig 0.078 > 0.05). This finding meets the criteria for normality described by Sundayana (2018), suggesting that if the sig value is more significant than α, then the data is normally distributed.

Table 11. Results of t-test (α = 0.05)

Learning Outcomes	Sig	α	Conclusion
Pretest - Posttest	0.00	0.05	Ha is accepted

According to the results of the T-test shown in Table 12, the sig (2-tailed) value is 0.000. This meets the criteria for acceptance of the hypothesis, which states that if sig (2-tailed) < α = 0.05, then H_0 is rejected, and Ha is accepted (Sundayana, 2018). Therefore, there are significant differences in student learning outcomes for the food and digestive system material before and after using flipbook-based e-modules.

Table 12. Results of n-gain analysis

N	N-Gain	N-Gain (%)	Conclusion
32	*0.70*	70%	Sufficiently effective

The N-gain analysis revealed a moderate value of 0.70, placing it in the moderately effective category. The e-modules have been proven to be successful in improving student learning outcomes, with an effectiveness percentage of 70%. A formative evaluation was employed to monitor and improve the product's development at each stage, including the analysis, design, development, and implementation stages.

4. Discussion

Preliminary observations indicate that the learning outcomes of the majority of the participants, particularly in food and digestive system material, have not met the minimum completeness criteria. Several factors contribute to these students' low academic achievement in this subject. One of these factors is students' lack of enthusiasm for learning. As reported by Ngadiwon (2020), students' enthusiasm for learning is still low. The results of observations indicate students' lack of focus and interaction during learning. For instance, during the observation it was observed that students sitting in the back row were engaged in conversations with their peers. Some students in the middle rows were daydreaming with vacant stares, and when given the opportunity to use their gadgets, they accessed content unrelated to the lesson.

The teacher at this middle school also reported that this issue occurs in subjects perceived as difficult, such as Science and Mathematics. Besides, the academic achievement of students can be influenced by the availability of quality and adequate teaching materials (Prabowo et al., 2019). In this case, adequate refers to teaching materials that are interesting and interactive, which can help to build students' enthusiasm for learning (Lela et al., 2023; Parmin et al., 2016). E-modules are an example of engaging and interactive teaching materials (Budiarti et al., 2016; Munzil et al., 2022; Nurandari & Triatmanto, 2023). The limited availability of such materials restricts students to a single learning resource. Even in this self-directed curriculum, the material in the accompanying book is presented briefly, which can make it challenging for students to comprehend independently. This condition provides the basis for developing teaching materials in the form of engaging and interactive e-modules. It aims to motivate students to learn and provide them with diverse learning resources to enhance their learning outcomes (Budiarti et al., 2016; Serrat et al., 2014).

A module is considered to be of high quality if it satisfies the following criteria, clear instructions, self-contained, stand-alone, adaptive, and user-friendly (Nisa et al., 2022). The developed module meets the criteria for a good e-module by having clear instructions that make it easy for students to use. It is self-contained and complete, making it easier for students to understand the material without the need for additional teaching materials. This e-module is presented in electronic form and contains updated materials, thereby, it is adaptive to development and technology. Besides, its use of clear and simple language

makes it easier for students to understand the material, resulting in a user-friendly experience.

In addition, the results of the practicality test conducted by involving the teachers and students indicate that the e-module can be categorized as practical. This suggests that the e-module has user-friendly features for both students and teachers, and the content is easy to comprehend. This is understood because the e-module includes clear instructions, contains images and videos that clarify the material, is accessible via both laptops and mobile phones, and features exercises that assess students' understanding. Additionally, the learning design utilizes the PBL model, enabling students to study independently. These findings align with previous research (Sugihartini & Jayanta, 2017), highlighting that PBL e-modules are designed to enhance students' independent learning abilities. Electronic-based learning resources offer various benefits, including increased flexibility in terms of time and location for students to utilize these resources (Nurandari & Triatmanto, 2023). The interactive nature of the developed e-module also makes it to be more engaging than the manual module. This module includes interactive features in the Virtual Lab and Google Form. Besides, it also provides direct feedback to students after they complete the practicum in the Virtual Lab. Additionally, exercise questions are available through Google Forms, and students can receive an immediate score upon completion. This e-module includes images and YouTube videos to aid students in comprehending the material. Interactive features are also present.

The statistical analysis confirmed that the pretest and posttest data are normally distributed. The t-test results indicate significant differences in learning outcomes before and after using the e-module. The N-gain score results are in the medium category, with the effectiveness level in the moderately effective category. These results suggest that flipbook-based e-modules can improve student academic achievement. The integration of interactive e-modules with teaching and learning activities has been shown to increase learning outcomes (Wahab et al., 2023). The study also highlights the importance of active student learning. Meanwhile, Sidiq and Najuah (2020) suggest that interactive e-modules can enhance students' motivation to become more self-sufficient in their learning, leading to more effective learning activities and improved learning outcomes. Another influencing factor aiding the e-module to enhance students' learning outcomes is the PBL activities. The module's PBL activities can improve learning as it requires students to be actively involved in the learning process, with the teacher serving as a guide. This model has been shown to contribute to improved learning outcomes (Syarifudin et al., 2021). Also, Ayaz and Söylemez (2015) clarifies that the problem-based approach is more effective in improving students' academic achievement in science classes compared to traditional teaching methods. Meanwhile, a study from (Pramana et al., 2020) suggests that collaboration between e-modules and PBL models can be used to present innovative and effective learning, which encourages students' desire to learn and has a positive impact on their learning outcomes.

Several factors contribute to the relative effectiveness of e-module implementation. Several obstacles faced by students require them to access e-modules collaboratively with their peers, which results in less than optimal use and impacts their learning outcomes. Meanwhile, for students who are less experienced in learning using digital teaching materials, their learning outcomes are lower than optimal. To improve the quality of learning comprehensively, students need to be exposed to problem-based e-modules more often so that they feel comfortable and accustomed to them. This will result in a more comfortable and optimal learning experience. This study is limited to improving learning outcomes. Future research can use it to measure 21st century skills.

5. Conclusion

This research presents a flipbook-based e-module that utilizes a PBL model to teach about food and the digestive system. The validation results from teaching materials and material experts indicate that the e-module is valid and appropriate. The practicality test for teachers and students also shows that the e-module is practical. The results of the implementation of the e-module in junior high school classrooms demonstrate its effectiveness in improving students' science learning outcomes.

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References

Affriyenni, Y., Mardiana, M., Marsuki, M. F., & Mulyati, Y. (2022). Pengembangan instrumen penilaian literasiagu sains berbasis PISA pada materi IPA kelas VII dan VIII. *Jurnal Pendidikan IPA*, *6*(1), 17–27. https://doi.org/10.31331/jipva.v6i1.2378

Agung, I. D. G., Suardana, I. N., & Rapi, N. K. (2022). E-modul IPA dengan model STEM-PjBL berorientasi pendidikan karakter untuk meningkatkan hasil belajar siswa. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *6*(1), 120. https://doi.org/10.23887/jipp.v6i1.42657

Aka, K. A., Akbar, S., & Sahertian, J. (2018). *Development of validation instrument for interactive multimedia learning implementation plan*. *244*(Ecpe), 118–123. https://doi.org/10.2991/ecpe-18.2018.25

Ananda, S., & Mulhamah, M. (2023). Penerapan pendekatan pembelajaran berbasis masalah dalam meningkatkan keterampilan pemecahan masalah siswa sekolah menengah. *Ulul Albab: Majalah Universitas Muhammadiyah Mataram*, *27*(1), 1–15. https:/ /doi.org/10.31764/jua.v27i1.23323

Andini, S., Budiyono, & Fitriana, L. (2018). Developing flipbook multimedia: The achievement of informal deductive thinking level. *Journal on Mathematics Education*, *9*(2), 227–238. https://doi.org/10.22342/jme.9.2.5396.227-238

Angreani, A., Saefudin, S., & Solihat, R. (2022). Virtual laboratory based online learning: Improving environmental literacy in high school students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *8*(1), 10–21. https://doi.org/10.22219/jpbi.v8i1.18120

Aprilia, T. (2021). Efektivitas penggunaan media sains flipbook berbasis kontekstual untuk meningkatkan kemampuan berfikir kritis siswa. *Jurnal Penelitian Ilmu Pendidikan*, *14*(1), 10–21. https://doi.org/10.21831/jpipfip.v14i1.32059

Arends, R. I. (2012). *Learning to teach (9th ed)*. McGraw-Hill. https://www.academia.edu/34403357/_Richard_Arends_Learning_to_Teach_BookFi_org_

Ayaz, M. F., & Söylemez, M. (2015). The effect of the project-based learning approach on the academic achievements of the students in science classes in Turkey: A meta-analysis study. *Egitim ve Bilim*, *40*(178), 255–283. https://doi.org/10.15390/EB.2015.4000

Birgili, B. (2015). Creative and critical thinking skills in problem-based learning environments. *Journal of Gifted Education and Creativity*, *2*(2), 71–80. https://doi.org/10.18200/JGEDC.2015214253

Branch, R. M. (2010). Instructional design: The ADDIE approach. In *Instructional Design:*

The ADDIE Approach. https://doi.org/10.1007/978-0-387-09506-6

Budiarti, S., Nuswowati, M., & Cahyono, E. (2016). Guided inquiry berbantuan e-modul untuk meningkatkan keterampilan berpikir kritis. *Journal of Innovative Science Education*, *1*(1), 1–9. http://journal.unnes.ac.id/sju/index.php/jise

Caño De Las Heras, S., Kensington-Miller, B., Young, B., Gonzalez, V., Krühne, U., Mansouri, S. S., & Baroutian, S. (2021). Benefits and challenges of a virtual laboratory in chemical and biochemical engineering: Students' experiences in fermentation. *Journal of Chemical Education*, *98*(3), 866–875. https://doi.org/10.1021/acs.jchemed.0c01 227

Cindikia, M., Achmadi, H. R., Prahani, B. K., & Mahtari, S. (2020). Profile of students' problem solving skills and the implementation of assisted guided inquiry model in senior high school. *Studies in Learning and Teaching*, *1*(1), 52–62. https://doi.org/10.46627/silet.v1i1.22

Ekasari, N. (2021). Penerapan metode circuit learning untuk meningkatkan hasil belajar siswa. *Jurnal Pendidikan Indonesia*, *2*(2), 282–293. https://doi.org/10.36418/japendi.v2i2.69

Errabo, D. D., Paguio, A. J., & Enriquez, P. A. (2024). Epistemic fluency in virtual laboratories as flipped classroom's innovative learning delivery. *Journal of Research in Innovative Teaching and Learning*, *17*(2), 256–281. https://doi.org/10.1108/JRIT-03-2024-0052

Fikri, A. A., & Rahmaniyyah, A. (2023). Development of e-modules based on science literacy and Islamic values in ecosystem materials. *Research and Development in Education (RaDEn)*, *3*(2), 58–67. https://doi.org/10.22219/raden.v3i2.23326

Fisher, M. M., & Baird, D. E. (2021). Humanizing user experience design strategies with new technologies: AR, VR, MR, ZOOM, ALLY and AI to support student engagement and retention in higher education. In *Innovations in Higher Education Teaching and Learning* (Vol. 33, pp. 105–129). https://doi.org/10.1108/s2055-364120200000033007

Fitrida, E., Sutamrin, & Rusdianto. (2022). Peningkatan hasil belajar siswa melalui model problem based learning pada materi sistem pencernaan pada siswa kelas 8A SMPN 4 Lembah Gumanti tahun pelajaran 2020/2021. *Global Journal Pendidikan IPA*, *1*(3), 153–157. https://doi.org/10.35458/jpi.v1i1.237

Fung, C. H. (2020). How Does Flipping Classroom Foster the STEM Education: A Case Study of the FPD Model. *Technology, Knowledge and Learning*, *25*(3), 479–507. https://doi.org/10.1007/s10758-020-09443-9

Hamid, A., & Alberida, H. (2021). Pentingnya mengembangkan e-modul interaktif berbasis flipbook di sekolah menengah atas. *Edukatif : Jurnal Ilmu Pendidikan*, *3*(3), 911–918. https://doi.org/10.31004/edukatif.v3i3.452

Hardiansyah, F., & Mulyadi, M. (2022). Improve science learning outcomes for elementary school students through the development of flipbook media. *Jurnal Penelitian Pendidikan IPA*, *8*(6), 3069–3077. https://doi.org/10.29303/jppipa.v8i6.2413

Hermansyah, H., Gunawan, G., & Herayanti, L. (2015). Pengaruh penggunaan laboratorium virtual terhadap penguasaan konsep dan kemampuan berpikir kreatif siswa pada materi getaran dan gelombang. *Jurnal Pendidikan Fisika Dan Teknologi*, *I*(2), 97–102. https://media.neliti.com/media/publications/119881-ID-pengaruh-penggunaan-laboratorium-virtual.pdf

Istiqah, W., Agustini, R., & Budijastuti, W. (2021). Pengembangan perangkat pembelajaran IPA menggunakan model PBL (problem based learning) pada materi sistem pencernaan manusia untuk meningkatkan keterampilan berpikir kritis peserta didik di SMPN 02 Suboh. *Jurnal Education and Development*, *9*(2), 237–243. https://journa l.ipts.ac.id/index.php/ED/article/view/2560/1484

Jufrida, J., Basuki, F. R., Pangestu, M. D., & Djati Prasetya, N. A. (2019). Analisis faktor yang mempengaruhi hasil belajar IPA dan literasi sains di SMP Negeri 1 Muaro

Jambi. *EduFisika*, *4*(02), 31–38. https://doi.org/10.22437/edufisika.v4i02.6188

Karunanayaka, S. P., Rajendra, J. C. N., Ratnayake, H. U. W., & Naidu, S. (2016). Peer-facilitated discussions to enhance OER-based e-learning. *Asian Association of Open Universities Journal*, *11*(1), 90–104. https://doi.org/10.1108/AAOUJ-07-2016-0022

Kemendikbud, K. (2017). *Pemenuhan standar nasional pendidikan sebagai prediktor mutu sekolah*. Pusat Penelitian Kebijakan Pendidikan dan Kebudayaan, Balitbang, Kemendikbud. https://pskp.kemdikbud.go.id/assets_front/images/produk/1-gtk/buku/Pemenuhan_Standar_Nasional_Pendidikan_sebagai_Prediktor_Mutu_Sekolah.pdf%0A

Lela, M., Amilda, A., & Jayanti, E. (2023). Efektivitas penggunaan modul pembelajaran kimia berbasis POE materi larutan elektrolit dan non elektrolit terhadap hasil belajar. *Orbital: Jurnal Pendidikan Kimia*, *7*(1), 11–24. https://doi.org/10.19109/ojpk.v7i1.17202

Lewis, D. I. (2014). The pedagogical benefits and pitfalls of virtual tools for teaching and learning laboratory practices in the Biological Sciences. In *The Higher Education Academy: STEM* (Issue November). http://www.fbs.leeds.ac.uk/staff/profile.php?un=bmsdil

Mangngi, S. E., Lalupanda, E. M., & Enda, R. R. H. (2022). Penerapan model pembelajaran problem based learning (PBL) untuk meningkatkan hasil belajar peserta didik pada materi sistem pencernaan manusia kelas VIII A SMP N 6 Wewewa Timur. *Diklabio: Jurnal Pendidikan dan Pembelajaran Biologi*, *6*(2), 154–159. https://doi.org/10.33369/ diklabio.6.2.154-159

Marsuki, M. F., Munzil, & Setiawan, A. M. (2021). Development of learning materials based on interactive multimedia for elements and compound course in Universitas Negeri Malang. *AIP Conference Proceedings*, *2330*(June 2022). https://doi.org/10.1063/5.0043462

Munawaroh, M., & Setyani, N. S. (2020). The effect of problem based learning (PBL) model on student learning motivation inproducts, creative and entrepreneurship subject in Eleventh Grade of SMK PGRI 1 Jombang. *Journal of Physics: Conference Series*, *1464*(1). https://doi.org/10.1088/1742-6596/1464/1/012021

Munzil, M., Affriyenni, Y., Mualifah, S., Fardhani, I., Fitriyah, I. J., & Muntholib, M. (2022). Development of problem based learning based e-modules in the form of flipbooks on environmentally friendly technology materials as an independent learning material for students' especially online learning. *Jurnal Pendidikan Sains Indonesia*, *10*(1), 37–46. https://doi.org/10.24815/jpsi.v10i1.21807

Narulita, E., Hariyadi, S., Utomo, A. P., & Fauziah, L. F. (2019). Research-based biotechnology book with virtual laboratory for elevating TPACK of biology pre-service teacher. *International Journal of Learning, Teaching and Educational Research*, *18*(11), 297–310. https://doi.org/10.26803/ijlter.18.11.18

Ngadiwon, N. (2020). Peningkatan hasil belajar IPA Melalui model pembelajaran discovery learning pada peserta didik di SMPN 2 Kota Bekasi. *Research and Development Journal of Education*, *1*(1), 117. https://doi.org/10.30998/rdje.v1i1.7577

Nisa, A. F., Rezkita, S., Khosiyono, B. H. C., Wijayanti, A., Murniningsih, M., Utaminingsih, R., Trisniawati, T., & Sumiyati, S. (2022). Basic science module as a resource for independent learning for elementary teacher education students in the pandemic Covid-19. *International Journal of Elementary Education*, *6*(2), 213–222. https://doi.org/10.23887/ijee.v6i2.44444

Nurandari, B. D. N., & Triatmanto, T. (2023). Development of biodiversity enrichment e-module fauna Gembira Loka Zoo for high school students. *Research and Development in Education (RaDEn)*, *3*(1), 37–50. https://doi.org/10.22219/raden.v3i1.23456

Parmin, P., Sajidan, S., Ashadi, A., Sutikno, S., & Maretta, Y. (2016). Preparing prospective teachers in integrating science and local wisdom through practicing open inquiry. *Journal of Turkish Science Education*, *13*(2), 3–14.

https://doi.org/10.12973/tused.10163a

Pescadero, R. J., & Cabahug, M. M. (2023). Social media engagement in relation to psychosocial well-being among Generation Z. *… Education: A Multidisciplinary Journal*, 802–812. https://doi.org/10.5281/zenodo.10032354

Phandini, I., Fauzi, A., Nuryady, M. M., Husamah, H., & Miharja, F. J. (2023). STEM-PBL integrative electronic module: Is that effective in improving students' critical thinking skills? *Jurnal Inovasi Pendidikan IPA*, *9*(2), 118–126. https://doi.org/10.21831/jipi. v9i2.60871

Prabowo, A., Rahmawati, U., & Anggoro, R. P. (2019). Android-based teaching material for statistics integrated with social media Whatsapp. *International Journal on Emerging Mathematics Education*, *3*(1), 93. https://doi.org/10.12928/ijeme.v3i1.11961

Pramana, M. W. A., Jampel, I. N., & Pudjawan, K. (2020). Meningkatkan hasil belajar biologi melalui e-modul berbasis problem based learning. *Jurnal Edutech Undiksha*, *8*(2), 17. https://doi.org/10.23887/jeu.v8i2.28921

Prasetyono, R. N., & Hariyono, R. C. S. (2020). Development of flipbook using web learning to improve logical thinking ability in logic gate. *International Journal of Advanced Computer Science and Applications*, *11*(1), 342–348. https://doi.org/10.14569/ijacsa.2020. 0110143

Quigley, C. (2014). Expanding our view of authentic learning: Bridging in and out-of-school experiences. *Cultural Studies of Science Education*, *9*(1), 115–122. https://doi.org/10.1007/s11422-013-9535-2

Sada, A. M., Mohd, Z. A., Adnan, A., & Yusri, K. (2016). Prospects of problem-based learning in building critical thinking skills among technical college students in Nigeria. *Mediterranean Journal of Social Sciences*, *7*(3), 356–365. https://doi.org/10.5901/mjss.2016.v7n3p356

Sari, R. T., Angreni, S., & Salsa, F. J. (2022). Pengembangan virtual-lab berbasis STEM untuk meningkatkan keterampilan berpikir kritis mahasiswa. *Jurnal Pendidikan Sains Indonesia*, *10*(2), 391–402. https://doi.org/10.24815/jpsi.v10i2.23833

Scholkmann, A., Stegeager, N., & Miller, R. K. (2023). Integrating the integration: The role and challenges of problem-based learning in bringing together social science and humanities (SSH) and science, technology, engineering and mathematics (STEM). *Journal of Problem Based Learning in Higher Education*, *11*(1), 98–123. https://doi.org/10.54337/ojs.jpblhe.v11i1.7371

Sepriana, R., Sefriani, R., Wijaya, I., & Lestari, P. (2019). Pengujian validitas modul interaktif simulasi dan komunikasi digital berbasis Macromedia Director Mx. *Edukatif : Jurnal Ilmu Pendidikan*, *1*(3), 120–126. https://doi.org/10.31004/edukatif.v1i3.25

Serdyukov, P. (2017). Innovation in education: what works, what doesn't, and what to do about it? *Journal of Research in Innovative Teaching & Learning*, *10*(1), 4–33. https://doi.org/10.1108/jrit-10-2016-0007

Serevina, V., Sunaryo, S., Raihanati, R., Astra, I. M., & Sari, I. J. (2018). Development of e-module based on Problem Based Learning (PBL) on heat and temperature to improve student's science process skill. *The Turkish Online Journal of Educational Technology*, *17*(3), 26–37. https://files.eric.ed.gov/fulltext/EJ1184205.pdf

Serrat, M. A., Dom, A. M., Buchanan, J. T., Williams, A. R., Efaw, M. L., & Richardson, L. L. (2014). Independent learning modules enhance student performance and understanding of anatomy. *Anatomical Sciences Education*, *7*(5), 406–416. https://doi.org/10.1002/ase.1438

Setiyadi, M. W., Ismail, I., & Gani, H. A. (2017). Pengembangan modul pembelajaran biologi berbasis pendekatan saintifik untuk meningkatkan hasil belajar siswa. *Journal of Educational Science and Technology*, *3*(2), 102–112. https://doi.org/10.26858/est.v3i2.3468

Sidiq, R., & Najuah. (2020). Pengembangan e-modul interaktif berbasis android pada

mata kuliah strategi belajar mengajar. *Jurnal Pendidikan Sejarah*, *9*(1), 1–14. https://doi.org/10.21009/jps.091.01

Sugihartini, N., & Jayanta, N. L. (2017). Pengembangan e-modul mata kuliah strategi pembelajaran. *Jurnal Pendidikan Teknologi Dan Kejuruan*, *14*(2), 221–230. https://doi.org/10.23887/jptk-undiksha.v14i2.11830

Sulisetijono, S., Sunarmi, S., & Rochmah, A. N. (2023). The effectiveness of AR e-module of flower structure material on biology students' science literacy. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(2), 217–224. https://doi.org/10.22219/jpbi.v9i2.25747

Sulistianingsih, A., & Carina, A. (2019). Developing interactive e-book as material technology coursebook by flipbook maker software. *Journal of Education and Practice*, *1735*, 11–17. https://doi.org/10.7176/jep/10-24-03

Sundayana, R. (2018). *Statistika Penelitian Pendidikan*. Alfabeta.

Suparya, I. K., I Wayan Suastra, & Putu Arnyana, I. B. (2022). Rendahnya literasi sains: Faktor penyebab dan alternatif solusinya. *Jurnal Ilmiah Pendidikan Citra Bakti*, *9*(1), 153–166. https://doi.org/10.38048/jipcb.v9i1.580

Syarifudin, A., Dhewy, R. C., & Agustina, E. N. S. (2021). Pengaruh model brain based learning terhadap hasil belajar siswa. *JEDMA Jurnal Edukasi Matematika*, *1*(2), 1–7. https://doi.org/10.51836/jedma.v1i2.155

Taherdoost, H. (2018). Validity and reliability of the research instrument: How to test the validation of a questionnaire/survey in a research. *SSRN Electronic Journal*, *5*(3), 28–36. https://doi.org/10.2139/ssrn.3205040

Tsai, T. P., Lin, J., & Lin, L. C. (2018). A flip blended learning approach for ePUB3 eBook-based course design and implementation. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(1), 123–144. https://doi.org/10.12973/ejmste/79629

Uluçinar, U. (2023). The effect of problem-based learning in science education on academic achievement: A meta-analytical study. *Science Education International*, *34*(2), 72–85. https://doi.org/10.33828/sei.v34.i2.1

Wahab, R., Saprudin, S., & Achmad, R. (2023). E-modul interaktif materi kalor untuk meningkatkan hasil belajar siswa sekolah menengah pertama. *Jurnal Luminous: Riset Ilmiah Pendidikan Fisika*, *4*(1), 33–38. https://doi.org/10.31851/luminous.v4i1.10967

Weja, A. R., & Bano, V. O. (2023). penerapan model pembelajaran problem based learning (PBL) untuk meningkatkan hasil belajar siswa materi sistem pencernaan kelas VIIIb SMP Negeri 2 Waibakul. *Kognisi : Jurnal Penelitian Pendidikan Sekolah Dasar*, *4*(1), 1073–1080. https://doi.org/10.56393/kognisi.v2i4.1354

Wibisana, I. M. A. P., Suardana, I. N., & Sastrawidana, D. K. (2022). Pengembangan e-modul pembelajaran IPA SMP kelas VII berbasis komik berpendekatan jelajah alam sekitar untuk meningkatkan hasil belajar siswa. *Jurnal Pendidikan Mipa*, *12*(3), 700–713. https://doi.org/10.37630/jpm.v12i3.632

Widianti, Y. (2023). Penggunaan media pembelajaran video animasi interaktif terhadap peningkatan hasil belajar IPA materi sistem pencernaan manusia pada siswa sekolah dasar. *TAKSONOMI: Jurnal Penelitian Pendidikan Dasar*, *3*(1), 61–71. https://doi. org/10.35326/taksonomi.v3i1.3321

Wijaya, I., & Sefriani, R. (2017). Interactive modules based adobe director on computer assembling subjects for vocational secondary school students. *VOLT : Jurnal Ilmiah Pendidikan Teknik Elektro*, *2*(2), 73. https://doi.org/10.30870/volt.v2i2.2116

Wulandari, D. D., Adnyana, P. B., & Santiasa, I. M. P. A. (2020). Penerapan e-modul interaktif terhadap motivasi dan hasil belajar siswa pada pembelajaran biologi kelas X. *Jurnal Pendidikan Biologi Undiksha*, *7*(2), 66–80. https://ejournal.undiksha.ac.id/index.php/JJPB/article/view/29681