

## DEVELOPMENT OF PROBLEM-BASED LEARNING DIGITAL TEACHING MATERIALS USING HEYZINE FLIPBOOKS FOR THE MATRIX TOPIC

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**ABSTRACT** The problem addressed in this study is the persistence of teacher-centered learning and the limited innovation in developing digital teaching materials, which has resulted in students' low comprehension of mathematical concepts. This study aimed to develop digital teaching materials in the form of Heyzine Flipbooks using the Problem-Based Learning (PBL) model on the topic of matrices to improve students' conceptual understanding, while also meeting the criteria of feasibility and practicality. The research employed the ADDIE development model. Expert validators consisted of media experts, material experts, and design experts, while user trials involved mathematics teachers and Grade XI students at SMAN 8 Surabaya. Data were collected through expert validation sheets, as well as teacher and student response questionnaires. The results showed that media experts gave an average validation score of 3.98, material experts 3.98, and design experts 3.50, all categorized as very feasible. In addition, practicality scores were 3.96 from teacher responses and 3.86 from student responses, both categorized as very practical. These findings indicate that the developed teaching materials are feasible and practical to enhance students' conceptual understanding of mathematics.

**Keywords:** problem-based learning, digital teaching materials, heyzine flipbooks, matrix

**ABSTRAK** Permasalahan yang diangkat dalam penelitian ini adalah masih dominannya pembelajaran yang berpusat pada guru serta terbatasnya inovasi guru dalam mengembangkan bahan ajar digital, sehingga pemahaman konsep matematika siswa masih rendah. Penelitian ini bertujuan untuk mengembangkan bahan ajar digital berupa *Heyzine Flipbooks* dengan menggunakan model *Problem-Based Learning* (PBL) pada materi matriks untuk meningkatkan pemahaman konsep siswa, sekaligus memenuhi kriteria kelayakan dan kepraktisan. Penelitian ini menggunakan model pengembangan ADDIE. Validator ahli terdiri dari ahli media, ahli materi, dan ahli desain pembelajaran, sedangkan uji coba pengguna melibatkan guru matematika dan siswa kelas XI SMAN 8 Surabaya. Data dikumpulkan melalui lembar validasi ahli serta angket respons guru dan siswa. Hasil penelitian menunjukkan bahwa ahli media memberikan skor rata-rata validasi sebesar 3,98, ahli materi 3,98, dan ahli desain 3,50, semuanya termasuk kategori sangat layak. Selain itu, skor kepraktisan diperoleh sebesar 3,96 dari respons guru dan 3,86 dari respons siswa, keduanya termasuk kategori

sangat praktis. Temuan ini menunjukkan bahwa bahan ajar yang dikembangkan layak dan praktis untuk meningkatkan pemahaman konsep matematika siswa.

**Kata-kata kunci:** problem-based learning, bahan ajar digital, heyzine flipbooks, matriks

## INTRODUCTION

In the Industrial 4.0 era, education must align with 21st-century learning demands, often referred to as the 4Cs: Critical Thinking, Communication, Collaboration, and Creativity. The field of education in this era also emphasizes the importance of digital literacy (Susanto et al., 2020). One strategy to prepare students for the challenges of the rapidly changing information and technology age is the implementation of 21st-century learning, which enables students to access various resources, collaborate with peers and teachers, and develop essential technology and information skills (Sumarni et al., 2023). Furthermore, the demand for a workforce equipped with both technical expertise and the capacity for critical and creative thinking continues to increase in the current era of globalization and rapid technological advancement (Dewi et al., 2024).

To respond to these demands, innovative and effective learning strategies are needed to foster 21st-century literacy. One such approach is problem-based learning (PBL). PBL has been shown to develop collaboration, personal, and social skills (Sumarni et al., 2023). In today's educational environment, the integration of PBL encourages active student participation, critical thinking, and the practical application of mathematical concepts (Situmorang et al., 2024). The primary objective of PBL is to engage students in solving real-world problems relevant to their lives. Through PBL, students actively seek knowledge, engage in discussions, and collaborate to develop solutions (Dewi et al., 2024).

Among the basic literacies emphasized in 21st-century education, numeracy literacy holds a central role. Numeracy literacy refers to students' ability to acquire, interpret, apply, and communicate numbers or mathematical symbols to solve real-life problems and analyze information presented in various forms, such as narratives, graphs, tables, and charts, in order to make informed decisions (Rahmah et al., 2023). The goal of mathematics learning is therefore to develop the ability to formulate, apply, and interpret mathematics in diverse contexts. This involves nurturing mathematical reasoning and using concepts, procedures, and facts as tools to explain, describe, and predict phenomena. Mathematical literacy thus becomes a means of appreciating the value of mathematics in the real world and a foundation for social cognition and decision-making (Setiawan et al., 2019).

Mathematics is important in everyday life because of its usefulness and wide range of applications. Learning mathematics fosters critical, logical, systematic, and creative thinking. These skills are essential to help students absorb, organize, and apply knowledge in daily life (Turnip et al., 2021). One important aspect in mathematics education is students' initial mathematical ability, which refers to their

capacity to understand mathematical concepts, recognize the relationships among concepts, and apply them accurately and effectively in problem-solving (Suri & Rachmadtullah, 2021).

However, based on field observations, several problems remain. Many students are less enthusiastic and less active in learning because teachers continue to rely on conventional teaching materials, such as worksheets and textbooks, and show limited innovation in developing engaging media. Another problem is students' tendency toward gadget addiction during learning. As members of Generation Z, today's high school students are heavily dependent on technology in daily life, including classroom activities and assignment completion. One way to increase student motivation is to design attractive digital teaching materials (Masru'ah et al., 2021), as technology has been shown to be an effective medium for supporting teaching and learning (Susanto et al., 2020).

Further observations reveal that teacher-centered methods remain dominant, resulting in low student participation in class. This is reflected in students' mid-semester scores, which remain below the minimum mastery level. Low mathematics achievement is also attributed to students' insufficient conceptual understanding, particularly of matrices and their operations. In addressing this issue, Heyzine Flipbooks offer one potential solution. Heyzine Flipbooks are digital books that can be designed by teachers using Canva for visual appeal and Liveworksheets for evaluation. They can be accessed across devices, including smartphones, tablets, and laptops, making them flexible for learning. Teaching materials in the form of Heyzine Flipbooks are therefore expected to be an alternative solution to improve students' conceptual understanding of matrices and their operations.

Previous studies on flipbooks support their potential in education. Santoso et al. (2023) found that PBL-based e-modules improved students' critical thinking skills. Indrasari et al. (2023) reported that PBL-based teaching modules enhanced mathematical communication skills. Ambarwati et al. (2022) showed that PBL-based flipbook media improved mathematics learning outcomes, while Amaliyah et al. (2023) also highlighted improvements in critical thinking. Senja et al. (2024) demonstrated that Canva-assisted PBL e-modules increased student interest, and Erna et al. (2021) found that Kvisoft flipbook-based e-worksheets were both practical and effective in fostering critical thinking.

Based on this gap, the novelty of this study lies in the development of Heyzine Flipbooks integrated with the PBL model for teaching matrices and their operations. In addition, the study combines multiple platforms—Canva, Heyzine Flipbooks, and Liveworksheets—in designing the product. The teaching materials are designed to be practical for both teachers and students, accessible anytime and anywhere, and technology-based to suit the learning needs of Generation Z. Accordingly, this study aims to develop and validate digital mathematics teaching materials using Heyzine

Flipbooks and a PBL model to improve students' conceptual understanding of matrices.

## METHODS

This study employed a Research and Development (R&D) approach to produce digital teaching materials in the form of Heyzine Flipbooks. The R&D method was chosen to enable the development of a teaching material product followed by an assessment of its feasibility and practicality. The development process adopted the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The conceptual framework of the ADDIE model is presented in Figure 1.

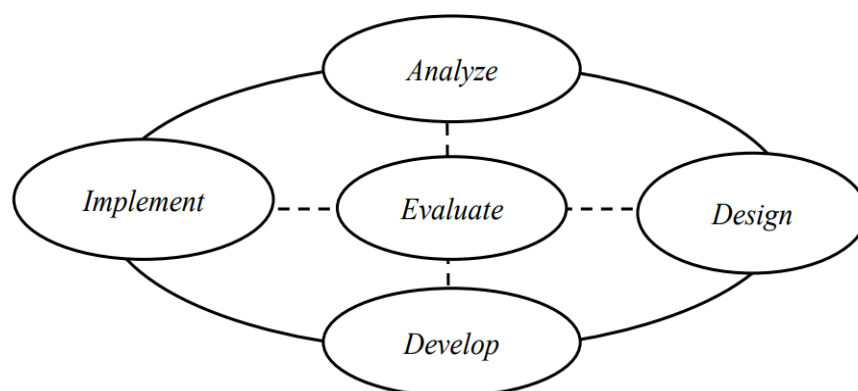


Figure 1. ADDIE Model (Branch, 2010)

The study was conducted from November 2024 to March 2025 at SMA Negeri 8 Surabaya. The trial design consisted of two main stages, namely expert testing and user trials (adapted from Walid, 2017). In the expert testing stage, validation was carried out by experts in learning media, learning materials, and learning design. Feedback from subject teachers or peers was also considered at this stage. The results of expert validation were then followed by Revision 1 to improve the product. Subsequently, the user trial stage was implemented through several steps. First, a one-on-one trial (individual trial) was conducted, which was followed by Revision 2. This stage was continued with a small group trial, after which Revision 3 was made to refine the product further. Finally, a field trial involving a larger group of students was conducted, leading to Revision 4 in order to achieve the final product.

The iterative process of expert validation and user trials ultimately produced a learning material in the form of a Flipbook-based hygiene text integrated with a Problem-Based Learning (PBL) model, which had been systematically refined to meet pedagogical, material, and media quality standards.

A questionnaire regarding the feasibility of Heyzine Flipbooks' teaching material products was distributed to subject teachers, students, and expert validators in learning materials, learning media, and learning design. The instruments used were

adapted from previous research instruments that had been tested prior to their use in this study. The questionnaire employed a Likert scale with four response categories: 1 (very poor), 2 (poor), 3 (good), and 4 (very good). The guidelines for calculating the converted instrument scores are presented in Table 1.

**Table 1.** Guidelines for Calculating Instrument Scores

Score Interval	Criteria
$\bar{x} > x_i + 1.8sb_i$	Very Feasible / Very Practical
$x_i + 0.6sb_i < \bar{x} \leq x_i + 1.8sb_i$	Feasible / Practical
$x_i - 0.6sb_i < \bar{x} \leq x_i + 0.6sb_i$	Enough Feasible / Enough Practical
$x_i - 1.8sb_i < \bar{x} \leq x_i - 0.6sb_i$	Not Feasible / Not Practical
$\bar{x} \leq x_i - 1.8sb_i$	Very Unfeasible / Very Unpractical

Source: adapted from Juniati in Utami (2023)

Description:

$$x_i = \frac{1}{2}(\text{maximum score} + \text{minimum score})$$

$$sb_i = \frac{1}{6}(\text{maximum score} - \text{minimum score})$$

Furthermore, the average score of the teaching material products is calculated using the following formula:

$$\bar{x} = \frac{\sum x}{N}$$

where:

$\bar{x}$  = average score quality

$\sum x$  = total score obtained

$N$  = number of instrument items

Based on these calculations, the guidelines for converting quantitative data into qualitative categories are as follows: Very Feasible/Very Practical ( $\bar{x} > 3,4$ ) , Feasible/Practical ( $2,8 < \bar{x} \leq 3,4$ ) ,, Enough Feasible/Enough Practical ( $2,2 < \bar{x} \leq 2,8$ ) , Not Feasible/Not Practical ( $1,6 < \bar{x} \leq 2,2$ ) , and Very Unfeasible/Very Unpractical ( $\bar{x} \leq 1,6$ ).

## FINDING AND DISCUSSION

According to the Problem-Based Learning approach, this study creates Heyzine Flipbooks teaching materials. The following describes each developmental stage.

### Analysis Stage

At this point, the Merdeka curriculum, which is the curriculum utilized at SMA Negeri 8 Surabaya, was seen by the researchers. Next, look at the learning outcomes to identify areas of similarity between the advanced mathematics and mathematics learning objectives, particularly concerning the class XI or Phase F Matrix material. Researchers found that students continued to use their smartphones to search for additional information even when math teachers taught Matrix and its operations, which only involved direct instruction and used textbooks borrowed from the school.

Based on an analysis of their characteristics, researchers discovered that students cannot be removed from their devices when studying mathematics. With the use of Canva Integrated Liveworksheets, material Matrix and its operation using the Problem-Based Learning model, researchers want to create Heyzine Flipbooks as teaching materials. So that students will be able to use their gadgets to access these digital teaching materials. In addition, their use can increase student motivation and learning activities. Consequently, as a learning style that works well with the Merdeka curriculum, problem-based learning is advised (Mardiah et al., 2024).

### Design Stage

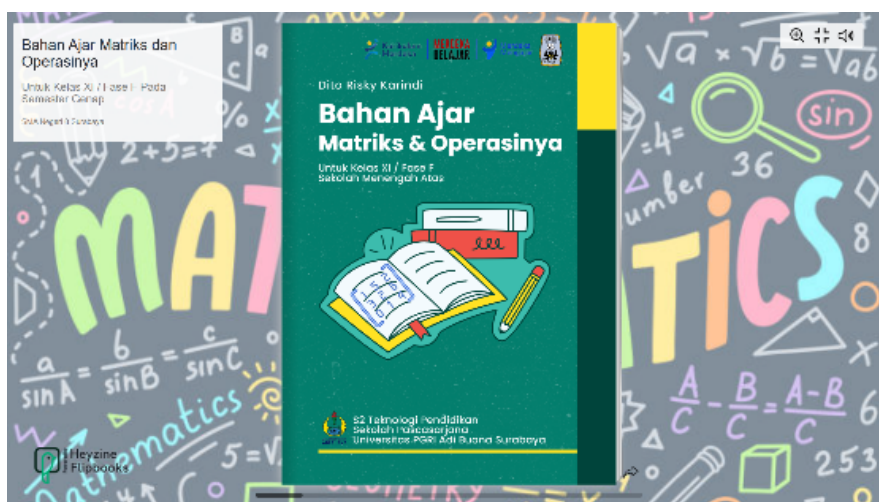
The teaching materials were developed by compiling content on matrices and their operations, which were then designed using the Canva platform and integrated into the Heyzine Flipbooks website. The structure of the Heyzine Flipbooks teaching material consists of three main sections.

The opening section includes the cover page, title page, foreword, list of figures, list of tables, concept map, table of contents, general instructions, and guidelines for using the teaching material. The main section presents the core content, which covers an introduction to matrices and their operations, definitions and types of matrices, matrix equality, special types of matrices, matrix dimensions, addition and subtraction of matrices, scalar multiplication, matrix multiplication, and determinant of a matrix. It also includes examples, practice questions, assignments, and assessment rubrics. Finally, the closing section consists of the summary of matrix material, self-reflection, self-assessment, glossary, references, author biography, and the back cover. This systematic design ensures that the teaching material is structured, comprehensive, and aligned with both pedagogical and content requirements.

### Development Stage

The Canva platform was used to design the teaching materials, which were then converted into the Heyzine Flipbooks format. The initial output of the Flipbook-based teaching material is presented in the form of a prototype cover, as shown in Figure 2. After being developed, the teaching materials were subjected to expert validation to determine their feasibility before proceeding to user trials. In this stage, validation instruments were prepared by adapting previous research instruments

and were directed to three types of validators: learning media experts, learning material experts, and learning design experts.



**Figure 2.** The Cover of Teaching Materials

The validation by the learning media expert is summarized in Table 2.

**Table 2.** Learning Media Expert Validation Results

No	Aspect	Quality Score	Category
1.	Display Design	3.94	Very Feasible
2.	Usage	4.00	Very Feasible
3.	Appropriateness and Consistency	4.00	Very Feasible
4.	Expediency	4.00	Very Feasible
5.	Graphics	4.00	Very Feasible
	Average	3.98	Very Feasible

The average score given by the learning media expert was 3.98 (very feasible). Recommendations for improvement included adding icons or navigation buttons to facilitate access to specific pages, making the Flipbook more interactive, and adjusting background sounds so they would not interfere with the audio of videos or music. In addition, the validator suggested that content titles should be explicitly mentioned to improve clarity and linkage to relevant learning materials.

The validation results from the learning material expert are presented in Table 3.

**Table 3.** Learning Material Expert Validation Results

No	Aspect	Quality Score	Category
1.	Content Feasibility	3.94	Very Feasible
2.	Presentation Feasibility	4.00	Very Feasible

No	Aspect	Quality Score	Category
3.	Language Assessment	4.00	Very Feasible
<b>Average</b>		<b>3.98</b>	<b>Very Feasible</b>

The average score from the learning material expert was 3.98 (very feasible). Recommendations included refining terminology, such as replacing *bilangan-bilangan* with *bilangan-bilangan/elemen-elemen* in the definition of matrices (page 3). Overall, the validator emphasized that the material was excellent and highly suitable for testing.

The validation results from the learning design expert are displayed in Table 4.

**Table 4.** Learning Design Expert Validation Results

No	Aspect	Quality Score	Category
1.	Learning Design	3.57	Very Feasible
2.	Materials and Technology	3.50	Very Feasible
3.	Messages and Communication	3.44	Very Feasible
<b>Average</b>		<b>3.50</b>	<b>Very Feasible</b>

The learning design expert gave an average score of 3.50 (very feasible). Suggestions for improvement included diversifying the typefaces in the teaching material to enhance visual appeal in future revisions.

The combined validation results of the three experts are summarized in Table 5.

**Table 5.** Validation Results of the Three Validators

No	Aspect	Quality Score	Category
1.	Learning Media Expert	3.98	Very Feasible
2.	Learning Material Expert	3.98	Very Feasible
3.	Learning Design Expert	3.50	Very Feasible
<b>Average</b>		<b>3.82</b>	<b>Very Feasible</b>

The validation results from the three experts yielded an overall average score of 3.82, placing the teaching materials in the “very feasible” category. This indicates that the Heyzine Flipbooks teaching materials are appropriate for user trials. These findings are consistent with previous studies, which also reported that mathematics e-modules developed with a Problem-Based Learning model were rated “very valid” by expert validators (Ramadanti et al., 2021; Prasetya et al., 2022). Similarly, validation results of mathematics e-modules for elementary schools showed that products were categorized as “very feasible” by material experts, media experts, and

linguists (Izzah et al., 2023). In line with these findings, other research also confirmed an average feasibility rating of 85% (Hasbulloh et al., 2022).

### Implement Stage

At this stage, the feasibility of the Heyzine Flipbooks teaching material—particularly those integrating the Problem-Based Learning model—was examined through a sequence of evaluations. The first step involved obtaining assessments from subject teachers to measure the suitability of the materials for classroom use. Parallel to this, one-on-one trials were conducted to capture students' responses concerning readability, attractiveness, and overall usability. Revisions identified at this stage were incorporated before proceeding to the small-group trial. Following additional feedback and improvements, the teaching materials were then subjected to a large-group trial to evaluate their overall effectiveness.

The responses of two subject teachers are summarized in Table 6.

**Table 6.** Subject Teacher Response Results

No	Aspect	Quality Score	Category
1.	Content Feasibility	3.97	Very Feasible
2.	Presentation Feasibility	3.97	Very Feasible
3.	Language Assessment	3.93	Very Feasible
	<b>Average</b>	<b>3.96</b>	<b>Very Feasible</b>

The subject teachers' evaluation yielded an average score of 3.96, categorized as very feasible. Recommendations highlighted the need for more instructional resources to foster student engagement, a more systematic and coherent sequencing of material, and a more appealing visual design of the Flipbooks.

The one-on-one trial involved three students randomly selected from classes XI-8, XI-9, and XI-11, representing varied ability levels. The results are shown in Table 7.

**Table 7.** One-on-one Test Learner Response Results

No	Aspect	Quality Score	Category
1.	Content Feasibility	3.88	Very Feasible
2.	Expediency	3.62	Very Feasible
3.	Language Assessment	3.88	Very Feasible
4.	Graphics	4	Very Feasible
	<b>Average</b>	<b>3.84</b>	<b>Very Feasible</b>

The one-on-one evaluation resulted in an average score of 3.84, indicating a very feasible category. Students noted that the materials were clear, easy to understand, and motivating for learning. Suggestions for improvement included clarifying the

explanation for Problem 1 to enhance comprehension and correcting typographical errors, such as changing *penamannya* to *penamaannya*.

The small-group trial involved nine students randomly selected from the same three classes (XI-8, XI-9, and XI-11) with heterogeneous abilities. The trial aimed to further assess readability, attractiveness, and overall practicality of the teaching materials before their implementation in larger groups.

**Table 8.** Small Group Trial Learner Response Results

No	Aspect	Quality Score	Category
1.	Content Feasibility	3.81	Very Feasible
2.	Expediency	3.85	Very Feasible
3.	Language Assessment	3.91	Very Feasible
4.	Graphics	3.92	Very Feasible
<b>Average</b>		<b>3.87</b>	<b>Very Feasible</b>

The small-group trial produced an average score of 3.87, placing the teaching material in the very feasible category. Student feedback emphasized that the Heyzine Flipbooks teaching materials were excellent, engaging, and easy to use independently. All participants indicated that the materials were clear, simple to understand, and suitable for use in classroom learning. No revisions were deemed necessary following this stage.

The next stage was the field trial, which involved 36 students from Class XI-10, representing a group with heterogeneous abilities. The data obtained from this stage reflects students' overall responses to the Flipbook-based teaching materials in a real classroom setting.

**Table 9.** Field Trial Learner Response Results

No	Aspect	Quality Score	Category
1.	Content Feasibility	3.93	Very Feasible
2.	Expediency	3.80	Very Feasible
3.	Language Assessment	3.88	Very Feasible
4.	Graphics	3.90	Very Feasible
<b>Average</b>		<b>3.88</b>	<b>Very Feasible</b>

The field trial produced an average score of 3.88, which falls into the very feasible category. Student feedback highlighted that the Heyzine Flipbooks teaching materials were engaging, particularly due to the integration of music and videos, which made independent learning enjoyable and straightforward. The inclusion of

formative and summative assessments through Liveworksheets was also appreciated, as it provided a new and interactive learning experience.

Students noted that the teaching materials effectively connected the concept of matrices with real-life contexts, which facilitated comprehension and application. The implementation of the Problem-Based Learning model was reported to be enjoyable, able to capture attention, and capable of enhancing motivation and enthusiasm for learning mathematics. Furthermore, the technology-based nature of Heyzine Flipbooks was considered practical and accessible, since the materials could be used flexibly with student-owned devices anytime and anywhere.

Overall, the Flipbook-based teaching materials were deemed highly feasible for classroom implementation, and no further revisions were considered necessary. These findings align with prior studies, which demonstrated that electronic modules with interactive features foster student engagement, promote positive learning attitudes, and improve problem-solving skills (Endaryati et al., 2023).

**Table 10.** User Trial Research Results

No	Test Subject	Quality Score	Average Score	Category
1.	Teacher or Peer	3.96	3.96	Very Practical
2.	One-on-one Trials	3.84		
3.	Small Group Trials	3.87	3.86	Very Practical
4.	Field Trials	3.88		

The practicality of teaching materials is defined as practical, which can be measured by their ease of use and support. Teaching materials can be considered practical if teachers and students give a good response to them (Damayanti & Nursalam, 2022). The results showed that responses from subject teachers or peers received a quality score of 3.96 as well as responses from students on one-on-one trials, small group trials, and field trials received an average quality score of 3.86 where both were in an excellent category, allowing for the conclusion that Heyzine Flipbooks teaching materials have a level of practicality in the category is "very practical". This is in line with the findings of earlier studies, which showed that 94% of students rated the usage of e-modules as learning media as "very good." In the meantime, 98% of teachers rated e-modules as "very good" learning resources (Aritonang et al., 2023).

### Evaluate Stage

The evaluation stage is the final phase of the ADDIE development paradigm used by researchers to create Heyzine Flipbooks learning materials. Researchers evaluate things that need to be improved or added to Heyzine Flipbooks teaching materials. The completed Heyzine Flipbooks teaching materials are the result of various adjustments and assessments made at each stage.

Problem-Based Learning model has its basis in cognitive psychology theory, specifically constructivism and Vygotsky and Piaget's theories. Through interacting with their surroundings, students build the knowledge they are studying during the teaching and learning process, according to constructivist philosophy. Students can learn by methodically looking for answers to contextual problems while creating their knowledge using the PBL methodology. PBL also calls for students to actively study issues to find solutions, with teachers serving as facilitators. Students' higher-order thinking capabilities and general thinking abilities are improved during this learning process (Sani, 2015). According to constructivism, students' understanding is built through an active process in which they learn from their own experiences and create new ideas. In line with the constructivist theory developed by figures such as Jean Piaget and Lev Vygotsky, this principle encourages students to think critically and independently when solving problems (Wiraningtyas, 2024). Constructivism is closely related to connectivism, where students can learn through digital networks and collaborate to acquire knowledge. Constructivism uses technology to encourage broader social engagement, enabling problem-based learning and interaction within digital communities (Nasar, 2024). Thus, problem-based learning integrates digital teaching materials by constructivist theory because in such learning, students can indirectly discover knowledge for themselves through their experiences and social activities. In addition, such learning is student-centered and collaborative, making the learning experience more meaningful.

## **CONCLUSIONS AND RECOMMENDATIONS**

The development of Heyzine Flipbooks integrated with the Problem-Based Learning (PBL) model on the topic of matrices and their operations provides a relevant learning innovation for 21st-century education, particularly for Grade XI (Phase F) students at SMA Negeri 8 Surabaya. The results of expert validation and user trials indicate that the materials meet the criteria of "very feasible" and "very practical." Students reported that the Flipbooks were engaging, motivating, and easy to understand because the mathematical concepts were presented in connection with real-life contexts. The integration of multimedia elements such as music, video, and Liveworksheets enhanced interactivity and provided students with meaningful and enjoyable learning experiences, thereby improving comprehension and fostering enthusiasm for mathematics learning.

Based on these findings, Heyzine Flipbooks with the PBL model are suitable for use in mathematics learning, especially for teaching matrices and their operations. Future research may focus on extending the development of Flipbooks to other mathematics topics or across different subjects, while also exploring more advanced integrations with digital platforms to maximize interactivity and engagement. In addition, longitudinal studies are recommended to investigate the long-term effects

of these teaching materials on students' problem-solving abilities, learning attitudes, and sustained motivation in mathematics learning.

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