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DESIGN OF A VECTOR TEACHING MODULE FOR HIGH SCHOOL IN THE INDEPENDENT CURRICULUM BASED ON PROBLEM-BASED LEARNING INTEGRATION NUMERACY ABILITY

Ari Panuli[1], Nandang[2], Diki Mulyana[3*], Wiwit Damayanti Lestari[4]
[1,2,3,4]Departement Mathematics Education, Universitas Wiralodra, Kab. Indramayu, West Java, Indonesia
*Correspondence: diki.mulyana@unwir.ac.id

ABSTRACT
The purpose of this research was to design a high school vector learning module within the Independent Curriculum based on Problem-Based Learning (PBL) integrating numeracy skills with valid and practical criteria. This research was R&D (Research and Development), and the research model used was ADDIE (analysis, design, development, implementation, and evaluation). Data collection used validation instruments and questionnaires. The module was validated by five expert validators, and its practicality was piloted by two teachers and 15 students. Based on the research results, the PBL-based learning module design integrating numeracy skills was declared highly valid with an average validity percentage of 76% and met the criteria for highly practical with an average practicality percentage of 89%. The research concluded that the PBL-based learning module design met the criteria for highly valid and practical, making it suitable for use in the 10th-grade high school mathematics learning process for vectors.

Keywords: Teaching Module, Problem Based Learning, Numeracy Ability.

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PRELIMINARY

Over the past two decades, Indonesia has faced serious challenges in the education sector, as reflected in the results of the Programme for International Student Assessment (PISA). The PISA report shows that Indonesian students' achievement in numeracy, literacy, and science remains alarming compared to other countries (Nugraha, 2022). This data reflects the suboptimal quality of learning, particularly as there has been no significant improvement over the past 10 to 15 years. This condition indicates systemic stagnation that requires immediate and comprehensive addressing.

Furthermore, approximately 70% of Indonesian students aged 15 have not yet reached the minimum competency level in reading and mathematics. This fact indicates that most students lack the essential basic skills to face the challenges of 21st-century life (Makarim, 2022). This situation is often referred to as a learning crisis, which demands strategic policies and innovative solutions to effectively and sustainably overcome this gap.

In this context, PISA plays a crucial role as an international measuring tool that provides a comprehensive overview of student abilities, particularly in mathematics, a key indicator of educational quality (Febriyani & Setyaningsih, 2024). Mathematical ability is not only a benchmark for academic success but also plays a crucial role in preparing individuals to compete and contribute productively in the modern world of work based on technology and data analysis (Mumfaza & Setyaningsih, 2024).

As stated by Santi Ambarrukmi, Director of Professional Education and Teacher and Education Personnel Development at the Indonesian Ministry of Education, Culture, Research, and Technology, PISA rankings in Indonesia are still relatively low, placing Indonesia among the lowest-ranking countries. Furthermore, in 2018, Indonesia's PISA scores were a concerning position, falling short of the average score of the Organisation for Economic Co-operation and Development (OECD) countries (Dian 2022).

Indonesia's 2018 PISA results placed it sixth from the bottom, specifically at 74th. Indonesian students' literacy skills ranked 74th with a score of 371, numeracy skills ranked 73rd with a score of 379, and science skills ranked 71st with a score of 396 (Suprayitno, 2019). These data indicate that students' numeracy skills are still low and need improvement. Numeracy skills play a crucial role in achieving mathematics learning objectives (Yunarti & Amanda, 2022). Numeracy skills are the ability to reason, apply, understand, and analyze mathematics in the real world, and solve problems related to students' daily lives (Baharuddin et al. 2021).

The Covid-19 pandemic has exacerbated the learning crisis in Indonesian educational institutions, with instruction shifting to online learning (Ariga, 2022). Based on analysis validated by external research, literacy has lost six months of learning in one academic year, while numeracy has lost five months, resulting in what is referred to as learning loss (Donnelly & Patrinos, 2022).

The Ministry of Education and Culture (Kemendikbud) designed a curriculum to facilitate Indonesian educational institutions in catching up on literacy and numeracy by launching an emergency curriculum during the pandemic as a first step towards the Independent Curriculum.In the emergency curriculum, the amount of material is drastically reduced, focusing only on essential topics. The Ministry of Education and Culture offered schools throughout Indonesia the emergency curriculum, and 31.5% of schools switched to it. This indicates that the emergency curriculum was chosen because it was simpler, more adaptable, and less burdensome with material. Consequently, the school only experienced a learning loss of about one month (Makarim 2022).

The current national curriculum structure has many weaknesses and is inflexible, the material is too dense, and digital technology has not been optimally utilized (Pratycia et al., 2023). The first changes were made to the emergency curriculum, while other changes will be developed through the Independent Learning Curriculum, a development of the emergency curriculum (Makarim, 2022). The Independent Learning Curriculum has several fundamental differences that form the basis of the new regulations. One of these is the replacement of lesson plans (RPP) with teaching modules. While lesson plans in the previous curriculum followed a general format, the new curriculum in the Independent Learning Curriculum gives teachers the freedom to choose, create, implement, and design a broad range of lesson plans (Malikah et al., 2022). There are three core components that must be considered when creating lesson plans: learning objectives, learning activities, and assessments. These lesson plans are known as teaching modules (Maulida 2022). Teaching modules are the main focus in helping teachers design learning activities (Nesri, F. D. P., & Kristanto 2020). Teachers need to maximize their skills in developing teaching modules, but most teachers still don't understand the techniques for developing and designing teaching modules in the Independent Curriculum (Maulida 2022).

The Independent Curriculum has three school categories: (1) Independent Learning, schools that still use the 2013 curriculum but incorporate the principles of the Independent Curriculum; (2) Independent Change, schools that already use the Independent Curriculum but still use teaching materials or modules from the Independent Teaching platform; and (3) Independent Sharing, schools that implement the Independent Curriculum by developing their own teaching materials or modules as a reference for other schools (Priambodo 2022).

The researcher's interview with the Vice Principal for Curriculum at SMAN 1 Lohbener revealed that the school is still using the 2013 curriculum but is working to implement the Independent Learning Curriculum and is categorized as an independent learning school. A mathematics teacher at SMAN 1 Lohbener stated that the school still uses lesson plans (RPP) and does not use teaching modules due to difficulties in creating them. Furthermore, students' numeracy skills at the school are still low, as seen from student learning outcomes. Therefore, the researcher is interested in conducting research on the design of high school vector teaching modules for the Independent Curriculum based on PBL integration with numeracy skills. This study aims to comprehensively analyze the validity and practicality of a teaching module on vectors for high school students, designed using a PBL approach and integrated with numeracy skills development, as part of the implementation of the Independent Curriculum, which emphasizes contextual, participatory learning and is oriented toward developing 21st-century competencies.

METHODS

This research applies a Research and Development (R&D) approach, a systematic method aimed at developing a specific product and testing its effectiveness in a real-world context (Winaryati et al., 2021). The R&D approach is highly relevant for developing learning media or tools because it allows researchers to continuously design, implement, and evaluate products based on user needs and field trial results.

This research uses the ADDIE development model, which is an acronym for five core stages: Analysis, Design, Development, Implementation, and Evaluation. This model was first developed by Dick and Carey as a systematic framework for designing effective and efficient learning systems (Rusmayana, 2020). Each stage in the ADDIE model plays a crucial role: the Analysis stage identifies learning needs and problems; the Design stage develops the product strategy and structure; the Development stage involves product creation; and the Implementation stage involves implementing the product in a real-world environment. The evaluation stage serves to assess effectiveness and provide feedback for product improvement. By following these stages sequentially, it is hoped that the product developed will not only be valid and practical, but also effective in improving the quality of learning.

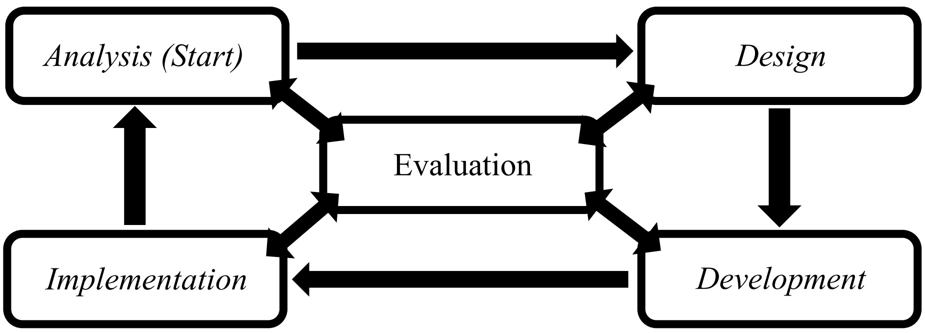


Figure 1. ADDIE Design and Development is a systematic model that includes five stages for effectively designing and developing learning tools. (Winaryati et al. 2021)

This research produced a valid and practical product. The resulting product is a PBL-based teaching module. The designed teaching module was piloted on 10th-grade high school students using a quantitative research approach aimed at describing the validity and practicality of the teaching module.

The instruments used in this study consisted of a validation sheet and a questionnaire, designed to support the development and assessment of the teaching module. The validation sheet was used to analyze the feasibility of the teaching module through expert assessment. The validation process involved five experts: three lecturers with expertise in materials, media, and language, and two high school mathematics teachers who acted as learning experts. This validation aimed to ensure that the teaching module met the feasibility standards in terms of content substance, presentation, language, and media suitability.

Meanwhile, a questionnaire was used as an instrument to assess the practicality of the teaching module. This instrument was administered to teachers and students, the direct users of the teaching module, to obtain feedback on ease of use, understandability of the material, and the module's usefulness in supporting the learning process. The results of these two instruments served as the basis for assessing the quality and readiness of the teaching module before its widespread implementation.

The data analysis technique used in this study was a quantitative approach, implemented through data collection and analysis using a validation sheet. This instrument was structured in the form of a Likert scale because it is considered more practical, systematic, and able to provide a representative picture of the level of validity of a development product, in this case, a teaching module. The Likert scale was chosen as a measuring tool because of its ability to reveal the validators' perceptions in a structured manner through a clear and easily interpreted score range. After the validation stage demonstrated that the module met the validity criteria based on expert assessments, this study continued with a practicality test. The practicality test aimed to determine the extent to which the teaching module was feasible and easy to use by teachers and students in a real learning context. The results of the module validity assessment are presented in the form of a Likert scale score distribution as a basis for considering the feasibility of the development product.

Table 1. Likert Scale Assessment Categories

No.	Information	Score	
		Positive	Negative
1	Very good	5	1
2	Good	4	2
3	Quite good	3	3
4	Not good	2	4
5	Very bad	1	5

(Sugiyono, 2022)

The results of the teaching module validity test are calculated using the following validity percentage:

$$Percentage = \frac{Number\ of\ scores\ obtained}{Total\ score} \text{ x } 100\% \text{ (Arikunto, 2019)}$$

Table 2. Percentage Criteria for Module Eligibility

Percentage of achievment	Interpretation
$P \geq 75\%$	Very Valid
$55\% \leq P < 75\%$	Valid
$40\% \leq P < 55\%$	Quite Valid
$P < 40\%$	Not Valid

(Arikunto 2019)

Comments and input from the validators were used to revise the module. A module was declared valid if it received a percentage of valid or very valid interpretations. The module's practicality was determined from teacher and student responses using a questionnaire. The module's practicality was assessed using the Ghuttman scale, which provides two answer options: "yes" or "no".

Table 1. Ghuttman Scale

Answer	Score
Yes	1
No	0

(Sugiyono 2022)

Calculation of the percentage of data obtained using the following formula.

$$\text{Practicality (\%)} = \frac{\textbf{Total score for each statement}}{\textbf{Number of Respondents}} \text{ x } 100\% \text{ (Meyninda 2020)}$$

Analysis of teacher and student response questionnaires with score interpretation criteria is shown in the following table.

Table 2. Module Eligibility Percentage Criteria

Percentage (%)	Category
0-50	Not practical
50-70	Quite practical
70-85	Practical
85-100	Very Practical

(Musyafak et al. 2022)

RESULT AND DISCUSSION

This research was conducted to analyze the validity and practicality of a PBL-based teaching module design. Validity was assessed by five experts by providing validation sheets and teaching modules. Practicality was assessed by piloting the teaching module in a class of 10 at SMAN 1 Lohbener, followed by distributing questionnaires to teachers and students.

This high school vector teaching module contains material on the concepts of vector definitions and vector operations, as well as practice problems to hone students' numeracy skills. The designed teaching module met the criteria for validity and practicality, as assessed by expert validators to determine the validity of the teaching module design and by student and teacher assessments to determine its practicality. The following describes the stages of the module design process:

1. Analysis Stage

The product produced during the analysis stage is a design for a teaching module on vectors for high school. Information collected includes curriculum analysis, student characteristics, and relevant concepts for module development.

a. Curriculum Analysis

The school is currently still implementing the 2013 Curriculum, but is working to adopt the principles of the Independent Curriculum as a basis for transitioning to a more modern curriculum. The Independent Curriculum is known for its learning approach that focuses on strengthening literacy, numeracy, and developing student character in accordance with the Pancasila Student Profile. In its implementation, teachers are given the freedom to choose and develop teaching materials independently, adapting to available capacities and resources.

One essential teaching tool in the Independent Curriculum is the teaching module, which must be designed based on the potential and characteristics of the school environment.

An analysis of the curriculum implemented in the school indicates that teachers need optimal preparation to support the implementation of the Independent Curriculum.

In line with this, this study designed a teaching module that refers to the principles of the Independent Curriculum.

b. Student Character Analysis

Student characteristics are an important foundation in designing a teaching module on vectors for high school students, designed in line with the principles of the Independent Curriculum (Curriculum) based on PBL. This study involved 10th-grade students as research subjects, with an average age of 16 to 17 years. At this stage of cognitive development, students generally have the ability to construct knowledge independently through personal experience and observations of phenomena encountered in everyday life. This student character analysis aims to identify individual characteristics, including academic potential and level of learning motivation, by referring to previous learning outcomes.

c. Concept Analysis

This analysis aims to identify mathematics learning materials that are relevant to designing the teaching module. The researcher focused the development of the material concept on the topic of vectors, with subtopics covering the definition and notation of vectors. The competency achievement indicator used is the ability to explain the concept of a vector and distinguish it from a scalar quantity. The results of this analysis served as the basis for the development of a vector learning module for high school students under the Independent Curriculum, which was designed based on PBL with the integration of numeracy skills.

2. Design Stage

In the design stage of the vector learning module for high school students under the PBL-based Independent Curriculum with the integration of numeracy skills, the module was designed to facilitate the learning process while increasing student motivation. Furthermore, the learning module is expected to optimize the development of students' numeracy skills, support independent learning activities outside the school environment, and facilitate educators in designing and implementing effective learning processes.

The use of contextual objects in mathematics learning plays a strategic role in strengthening numeracy skills because it bridges abstract concepts with real-world situations relevant to students' lives. Contextual objects, such as everyday phenomena, environmental data, or social events, help students understand numeracy concepts in a more meaningful and applicable way. Through this approach, students not only perform calculations but also develop their ability to reason, interpret quantitative information, and make data-based decisions.

Furthermore, relevant contexts increase students' motivation and active engagement in learning because they perceive the material as having direct benefits in their lives. This approach also supports the strengthening of the Pancasila Student Profile, particularly in the areas of critical, independent, and responsible thinking, in line with the direction of the Independent Curriculum, which emphasizes numeracy literacy as an important provision for facing real-world challenges. The learning modules are equipped with images appropriate to the school environment to facilitate students' understanding of the material. The following objects can be taken from the SMAN 1 Lohbener environment as applications in explaining high school vector teaching materials:

a. Water flowing in a river

Near SMAN 1 Lohbener, there is a large river known as the Cimanuk River. A rubber dam can be seen in the river, which functions to hold back the flow of water, causing changes in the water flow velocity. This phenomenon can serve as an initial problem context for students to understand the concept and definition of vectors in learning.

Figure 2. Lohbener River

From the image, students are asked to determine the direction and speed of the water's movement. Students will look for water moving in the same or different directions, and the fastest or slowest water movement, so they can understand the concept of vectors.

b. Directional Signs

One vector concept found in SMAN 1 Lohbener is the direction signs for Lohbener or Indramayu. These directions are frequently used by SMAN 1 Lohbener students, providing students with valuable experience in learning about vectors.

Figure 3. Directional Signs

The image reminds students that distance and direction from one place to another are very important. This relates to the vectors they are studying, so students understand the importance of learning vectors.

c. Flag Ceremony

The red and white flag ceremony at SMAN 1 Lohbener is held every Monday. This activity incorporates the concept of vectors that students can learn.

Figure 4. Flag Ceremony

When the Paskibra officers raise the red and white flag from bottom to top, it represents a vector implementation, forming a 90-degree angle. Furthermore, students can see the rope moving downward and upward, representing an application of opposite vectors.

d. Floating Basketball

SMAN 1 Lohbener provides a basketball court for students interested in participating. In basketball, to score, the ball must be thrown upward toward the basket in a parabolic shape, increasing the chance of the ball going in.

Figure 5. Floating Basketball

When a ball is floating in the air, the event can be interpreted as a vector problem in a two-dimensional Cartesian coordinate system. The ball, initially at a certain point, will change position. Students can determine the length of the ball's path from its initial position to its final position.

e. Two Container Trucks Traveling in the Same Direction

SMAN 1 Lohbener is located on the Pantura road, so many motorcycles, cars, and other vehicles pass by, including container trucks. Two container trucks traveling in the same direction can be used as a daily application to explain two equivalent vectors.

Figure 6. Container Trucks

The image shows two container trucks moving at different speeds and in the same direction. They are at different positions but have vectors with the same velocity. Students can deduce the concept of two equivalent vectors, namely, that if vectors have the same magnitude and direction, then position is not a reference point.

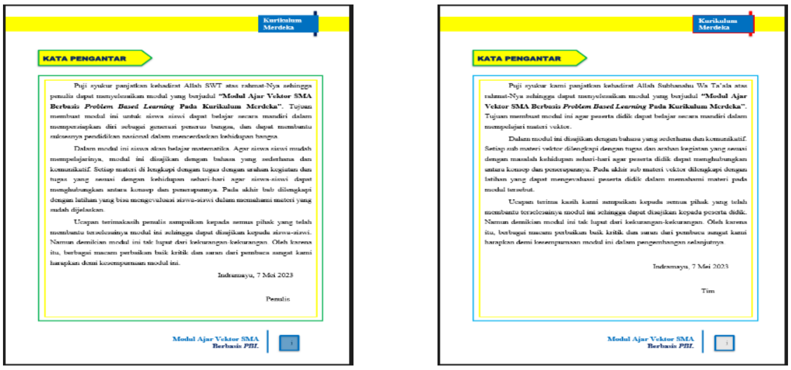
3. Development Stage

The development stage of the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning (PBL) for numeracy skills is discussed. This stage aims to assess the validity of the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning (PBL). Before being tested in class, the teaching module was first validated by five expert validators. The high school vector teaching module in the Independent Curriculum based on Problem-Based Learning was revised based on input from each validator. After the revisions were made, the teaching module could be trialed on a limited scale with 10th grade students in Mathematics and Natural Sciences. The following shows the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning for numeracy skills before and after revision based on input from each validator.

Before Revision After Revision

Figure 7. Adding image to the cover

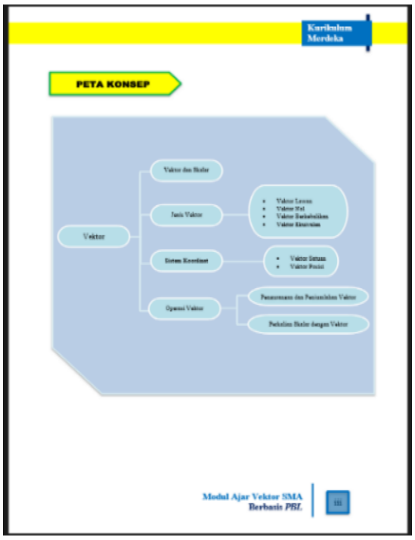
In Figure 7, improvements were made because the module cover was not yet linked to vector symbols and numeracy capabilities. Therefore, improvements were made to the module cover by adding symbols related to vectors and numeracy capabilities.

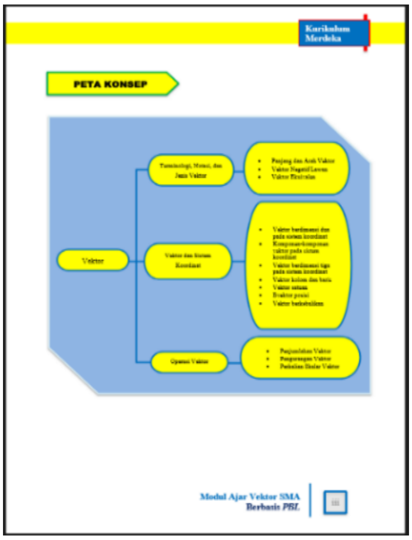


Before Revision After Revision

Figure 8. Correcting word Usage

In Figure 8, corrections were made due to the use of many inappropriate words. Therefore, corrections were made based on expert validation suggestions for the word "Author" changed to the word "We/Team", the term "students" changed to the term "students", the writing of "thank you" was spaced, and the word "completed" was left without spaces.

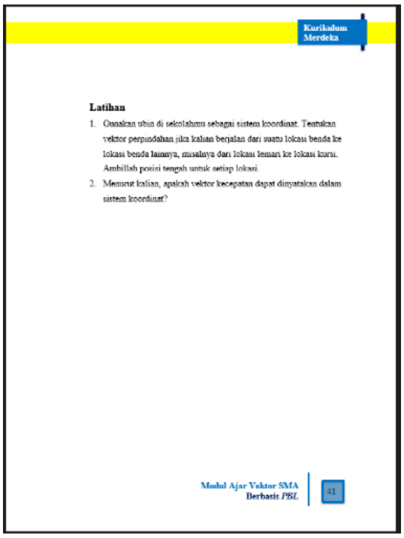


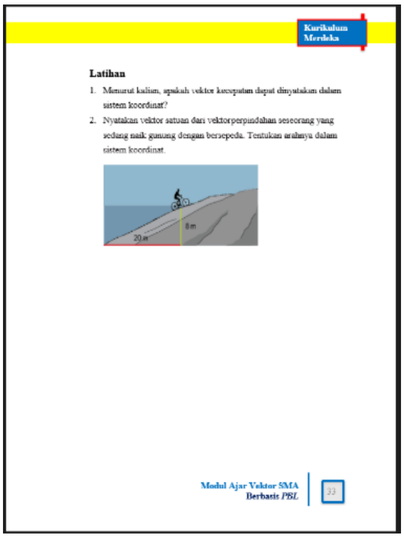


Before Revision After Revision

Figure 9. Diagram color fix

In Figure 9, corrections were made because the diagram and background colors in the concept map were not clearly differentiated, making them less visible. Therefore, the diagram and background were corrected by differentiating the colors to make them more visible



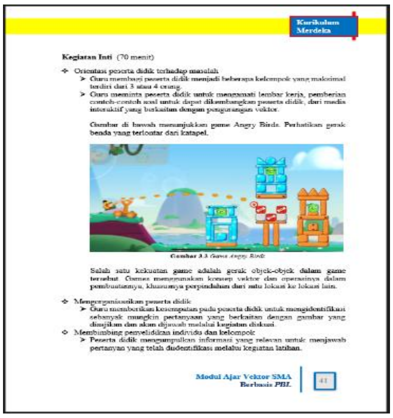


Before Revision After Revision

Figure 10. Change of question

In Figure 10, improvements were made because the questions were not well understood and were not varied, so improvements were made based on expert validators to change the practice questions to be easy to understand and of a variety of types.

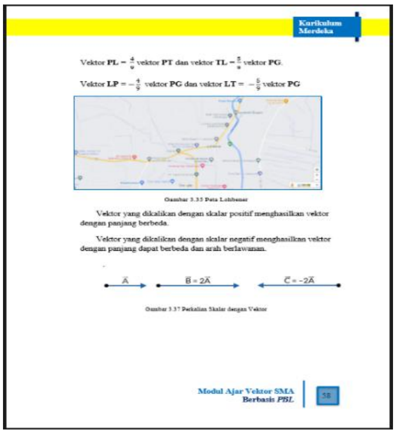
Before Revision



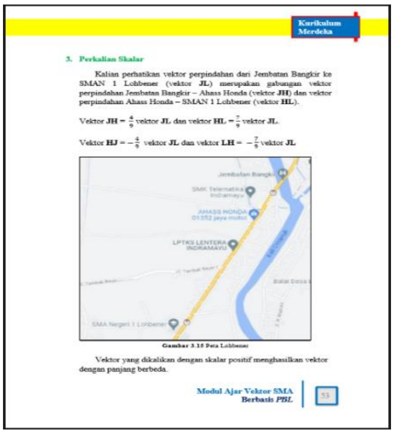
After Revision

***Figure 11.* Angry Birds image changes**

In Figure 11, corrections were made because the object in question, the catapult, was not clearly visible. Therefore, corrections were made by changing the image to clearly show the catapult.



Before Revision



After Revision

Figure 12. Map image correction

In Figure 12, corrections were made because the map image was not clearly visible. Therefore, corrections were made based on expert validators to make the map image clearer and enlarged to better display the intended map content.

4. Implementation Stage

This implementation stage analyzes the practicality of the teaching module by distributing questionnaires to two high school mathematics teachers and 15 grade 10 students in the Mathematics and Natural Sciences program. In the practicality analysis phase, the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning (PML) was used, with 15 statements for teachers regarding the practicality of the teaching module. Two respondents responded that the module was very practical at 89%, with a range of criteria for practicality.

Furthermore, in the practicality analysis phase, the high school vector teaching module based on Problem-Based Learning was used, with 12 statements for students regarding the practicality of the teaching module. This indicates that the 15 students, who responded to the module's practicality, scored 84%, with a practicality criterion. Both teacher and student samples demonstrated that the practicality of the teaching module was achieved with the "Very Practical" criterion for the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning for numeracy skills.

5. Evaluation Stage

This stage involves analyzing the distribution of teacher and student response questionnaires regarding the designed teaching module. The analysis results indicate that the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning for numeracy skills is very engaging, increases motivation and learning outcomes, is more time efficient, makes learning more enjoyable, and is easy to understand and use.

Validity Analysis Results

The validation of the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning was carried out by providing validation sheets to five expert validators. The following are the validation results of the high school vector teaching module design in the Independent Curriculum based on Problem-Based Learning for numeracy skills, as seen in Table 5.

Table 5. Results of the Validation Analysis of the Vector Teaching Module in the Independent Curriculum based on PBL for Numeracy Skills

No.	Assessment aspects	Number of validation scores	Maximal scores	Percentage (%)	Criteria
1.	Material	308	375	82%	Very Valid
2.	Presentation	162	225	72%	Valid
3.	Design	233	300	78%	Very Valid
4.	Graphics	91	125	73%	Valid
	Validation average			76%	Very Valid

Based on Table 5, the validity value of the high school vector teaching module obtained from the five validators was 76%, meeting the criteria for very valid. This indicates that the design of the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning for numeracy skills can be used in the mathematics learning process of vector material.

Practicality Analysis Results

1) Practicality Results by Teachers

The practicality test by teachers of the design of the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning for numeracy skills was generated from teacher questionnaire responses. The following analysis results can be seen in Table 6.

Table 6. Practicality Results of the High School Vector Teaching Module Based on PBL in the Independent Curriculum for Numeracy Skills by Teachers

No.	Assessment aspects	Number of validation scores	Maximal scores	Percentage (%)	Criteria
1.	Use of teaching modules	4	4	100%	Very practical
2.	Material content	10	14	70%	Practical
3.	Design	4	4	100%	Very practical
4.	Practicality of teaching modules	4	4	100%	Very practical
5.	Learning effectiveness	3	4	75%	Practical
	Total	25	30		
	Average teacher practicality			89%	Very practical

Based on Table 6, teachers' practicality scores for the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning (PBL) on numeracy skills were obtained, with an average percentage of 89% meeting the criteria for "very practical." Therefore, the module can be used by teachers in mathematics learning activities on vectors.

2) Student Practicality Results

A practicality test was also conducted with students. Student practicality results were taken from the student questionnaire responses. The following analysis results can be seen in Table 7.

Table 7. Practicality Results for High School Vector Teaching Modules in the Independent Curriculum Based on PBL on Students' Numeracy Skills

No.	Assessment aspects	Number of validation scores	Maximal scores	Percentage (%)	Criteria
1.	Student Interest	57	75	76%	Practical
2.	Usage Process	26	30	87%	Very practical
3.	Peningkatan Improving Student Creativity	28	30	93%	Very practical
4.	Evaluation	36	45	80%	Practical
	Total	147	180		
	Average student practicality			84%	Practical

Based on Table 7, students' practicality scores for the high school vector teaching module in the Independent Curriculum based on Problem-Based Learning (PML) for numeracy skills were obtained, with an average percentage of 84% meeting the practicality criteria and therefore suitable for use in learning vector material.

Through a teacher and student questionnaire conducted in class X 3 MIPA SMAN 1 Lohbener, the general results of practicality by teachers and students are depicted in Table 8.

Table 8. Results of Analysis of Practicality by Teachers and Students

No.	Practicality Analysis	Total Practicality Score	Maximum Score	Percentage (%)	Criteria
1.	questionnaire by teacher	25	30	83%	Practical
2.	questionnaire by student	147	180	82%	Practical
	Average			83%	Practical

Berdasarkan tabel 8 diperoleh hasil uji kepraktisan oleh guru dan siswa pada desain modul ajar vektor SMA pada Kurikulum Merdeka berbasis *Problem Based Learning* terhadap kemampuan numerasi dengan rata-rata persentase 83 % memenuhi kriteria praktis sehigga modul ajar dapat digunakan dalam proses pembelajaran.

CONCLUSION

Based on the trial data, it was concluded that the validity of the SMA vector teaching module design in the Independent Curriculum based on Problem Based Learning towards numeracy skills with an average percentage of 76% of the criteria was very valid. The practicality of the SMA vector teaching module design in the Independent Curriculum based on Problem Based Learning towards numeracy skills was stated to be practical with an average practicality percentage of 83% by teachers and students. These results conclude that the SMA vector teaching module design in the Independent Curriculum based on Problem Based Learning towards numeracy skills is very valid and practical so it is suitable for use in the learning process.

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