



FACILITATING PHYSICS PROBLEM-SOLVING SKILLS WITH GEOMETRY OPTICS E-MODULE FLIPBOOK VIEW: A RELIABILITY TEST

Ima Puspita Rukmi^{1,*}, Sindy Chintyawati², Bayu Setiaji³

^{1, 2, 3} Physics Education Department, Universitas Negeri Yogyakarta, Indonesia

ABSTRACT

Students' physics problem-solving skill is still low, especially in physics problems related to everyday life, not simple quantitative problems. This is because the learning modules used today still do not invite students to solve real problems around them related to physics. This study aims to test the feasibility of the E-Module with a flipbook view which was developed to improve students' problem-solving skills on the material of reflection and refraction of light. The research method used is Research and Development (R&D) with a 4-D development model. The stages of E-Module development in this research are only the define, design, and development stages. The research instrument was in the form of an E-Module feasibility test questionnaire via google form which was tested by 50 prospective physics teacher students. The results showed that the feasibility level of the developed E-Module was within the very feasible criteria. Thus, the developed E-Module is very feasible to improve students' problem-solving skills and can proceed to the broad trial stages.

INTISARI

Kemampuan pemecahan masalah fisika siswa masih rendah, khususnya pada permasalahan fisika yang berkaitan dengan kehidupan sehari-hari, bukan pada permasalahan kuantitatif sederhana. Hal ini dikarenakan modul pembelajaran yang digunakan saat ini masih kurang mengajak siswa untuk memecahkan permasalahan nyata di sekitarnya terkait fisika. Penelitian ini bertujuan untuk menguji kelayakan dari E-Modul dengan tampilan *flipbook* yang dikembangkan untuk meningkatkan kemampuan pemecahan masalah siswa pada materi pemantulan dan pembiasan cahaya. Metode penelitian yang digunakan yaitu Penelitian dan Pengembangan (R&D) dengan model pengembangan 4-D. Tahapan pengembangan E-Modul dalam penelitian ini hanya pada tahap *define*, *design*, dan *develop*. Instrumen penelitian berupa angket uji kelayakan E-Modul melalui google form yang diuji oleh 50 mahasiswa calon guru fisika. Hasil penelitian menunjukkan bahwa tingkat kelayakan E-Modul yang dikembangkan berada pada kriteria sangat layak. Dengan demikian, E-Modul yang dikembangkan sangat layak untuk meningkatkan kemampuan pemecahan masalah siswa dan dapat dilanjutkan ke tahap uji coba luas.

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* Corresponding author:

Ima Puspita Rukmi, Physics Education Department, Universitas Negeri Yogyakarta, Indonesia

✉ imapuspitarukmi@gmail.com

A. Introduction

The problem-solving skill becomes one of the 21st-century skills to master by learners in this era. The skill suggests the learners actively participate, learn, find, and seek information individually so that they can solve problems [1]. Problem-solving skill is important for high-order thinking skill to manage real and complex problems in the world [2], [3]. Therefore, problem-solving skill is important for learners to train continuously.

One of the activities to improve the problem-solving skill is - a learning process. The problem-solving process should consider the learners' problem-solving skills instead of learners' conceptual understandings and their capabilities of constructing new knowledge [4], [5]. The physics learning process in the class seems to emphasize conceptual mastery instead of physics problem-solving skills. This matter causes the learners to have lower physics problems when they encounter real physics problems [5]. Most students could solve simple quantitative problems but they could not solve more complex problems. Most students had difficulties in solving physics problems because the teachers only taught the learners to solve problems with mathematical calculation. This matter makes the learners only recognize and memorize the given formula without realizing the qualitative and conceptual meaning of the formula [6], [7]. Thus, most learners had difficulties when they encountered a complex physics problem.

Many scholars studied the problems of physics problem-solving. Mulhayatiah, et al [8] found that most learners could not solve physics questions with daily problems. Azizah, Yulia, and Latifah [6] also found that learners tended to apply mathematical methods while working on physics questions without analyzing the questions. Thus, the students could not think complexly and had difficulties solving complex problems. The findings showed that learners' problem-solving skills were low and not optimum. Thus, they had to improve their skills.

The accurate method to improve the learners' problem-solving skills is to apply problem-solving skill stages in a learning process. Polya [9] explains four problem-solving stages. They are: (1) recognizing and understanding the problems; (2) planning the problem-solving strategy; (3) solving the problems based on the plan, and (4) checking and evaluating the steps. These steps could improve the learners' problem-solving skills.

Many learning processes encountered difficulties due to a lack of learning resources because the process mostly applied presentations with *PowerPoint* and textbooks downloaded from the Internet [10] [11]. These actions made the learners lazy to learn and inactive. The other factor of lower problem-solving skills was - a huge amount of materials to deliver. This matter made physics teachers could not deliver all materials. From these findings, a learning process requires a learning source in the form of a learning module. A learning module has specific and different characteristics from other learning resources: (1) *Self-instructional* refers to a

characteristic that allows learners to learn autonomously, (2) *self-contained* refers to the capability of the module to cover all required materials for the learners; (3) *stand-alone* refers to the dependency feature of a module; (4) *adaptive* refers to the high adaptability of a module with the current development of science and technology and applicability, and (5) *User-friendly* refers to the convenience while using the module [12]. Therefore, the existence of a learning module facilitates the learners' needs.

Developing a learning module requires some aspects to consider, for example, the completeness of the content, the applied language, the display of the cover, the layout arrangement, etc. The other component to provide is - the key answer to the evaluative questions. This component facilitates learners to check their success while understanding a material [13]. The applied language in a module should be adjusted to PUEBI, General Guidelines for Indonesian Spelling. Depdiknas, the Department of National Education [14], explains that all teaching materials must consider the language components, such as the language reliability to facilitate learners in understanding the learning materials. The other aspect to consider is the tidiness of the module, including the cover. A cover of a module is important to describe the materials and the applied learning approach [15]. Daryanto [16] also explains that the combination of colors, figures, shapes, and letters should be harmonious to realize an attractive cover of a module. A module with a tidy layout will attract learners to read the module. Ramadhani and Mahardika [17] explain the graphic aspects of developing a module, such as the size or module format, the layout, the design, and the tidiness of the content. Thus, developing a module must consider those elements to ensure an optimum and useful module for learners.

Some learners may assume that physics is a difficult lesson. Suyoso and Nurohman [18] explain that physics is a difficult lesson so the lesson needs a creative approach and follows the learners' learning styles. The implementation of a printed book may not be practical because the printed module is not interesting for learners. Moreover, the printed module cannot provide materials in the form of figures and videos [12]. Learners need creative and attractive physics modules that do not make them difficult to learn.

One of the efforts to realize the ideal module is - applying digital technology with E-Module, the electronic module. E-Module has some benefits. They are (a) content of materials and various questions supported with figures and videos, and (b) accessibility and facilitation for learners based on their material interest. One of the E-Module innovations is E-Module with Flipbook display. The strong points of E-Module with Flipbook display are (1) providing the flip effect as if the readers were reading real books; (2) providing facility to use, and (3) providing figures, sounds, and videos [19]. On the other hand, E-Module also has some drawbacks, such as a lack of learning device supports found on a computer or other electronic devices [20]. Although E-Module has some drawbacks, E-Module still has more superiority over the printed module.

A commonly printed module could not invite the learners to solve physics problems. The cause of this problem was the linear feature of a printed module. The physics learning module mostly presents principles and concepts, examples of the questions, exercise questions, and discussions of the answers. However, they lack real problems from the learners' surrounding environment [5]. These situations do not provide learners with adequate opportunity to develop their problem-formulating skills, problem-solving skills, and understanding. Therefore, a physics module that could improve learners' problem-solving skills is important.

The development of a physics module to improve problem-solving skills is important, especially for the materials of reflection and refraction. The materials are observable from the surrounding areas and many learners encounter these phenomena [21]. However, many learners could not understand the concept and could not connect the phenomena in their learning. Azizah, Yuliati & Latifah [6] and Saputri & Nurussaniah [22] found that learners encountered difficulties in solving problems related to optics material, especially about the refraction of light within two mediums with different refraction indexes. These difficulties could be managed by E-Module with the problem-solving model on refraction and reflection of light.

From the explanations, the teachers must use supportive learning sources to improve the learners' problem-solving skills [23]. The learning source is an E-Module with a flipbook display. Hermawati [24], explains that an electronic module with a flipbook display could be a solution to manage the poor problem-solving skills of the learners. The content of an E-Module with a *flipbook* look had to consider the problem-solving skills of the learners. In this research, the researchers determined the reliability of the physics E-Module with a *flipbook* display to improve the learners' problem-solving skills about the materials of light reflection and refraction.

B. Method

In this research, the researchers applied Research & Development model proposed by Thiagarajan. Thiagarajan [25] proposed a 4D model to develop a product, starting from defining, designing, developing, and disseminating. The researchers selected this model to develop the E-Module because the model had clear procedural stages. The stages were clear, complete, understandable, and systematic. In this research, the stages of developing the E-Module began with defining, designing, and developing. Then, in this research, the researchers excluded the dissemination stage because the current research aimed to test the reliability of the developed E-Module. Thus, the researchers stopped the process in the development stage since this stage represented the objective of the research.

In the beginning, the researchers promoted the defining stage. The researchers did this stage by reviewing the works of literature and the published articles from journals as references to design the developed E-Module. The researchers conducted the literature study by collecting and analyzing the problems from various journal

articles. Then, the researchers analyzed the need for E-Module as an alternative to the printed module since the printed module was considered less practical. Then, the researchers did the final step by analyzing the material of geometric optic for the developed E-Module.

In the designing stage, the researchers applied some steps. The researchers initially designed the E-Module with *canvas* and *web.issuu.com*. In this step, the researchers also chose references to create materials about the reflection and refraction of light. In this step, the researchers made the questionnaire on the developed E-Module reliability.

Then, the researchers stopped the process in the development stage because this stage was the last stage of this research. In this stage, the researchers promoted a validity test and revised the developed product based on criticisms and suggestions of the validators. The tested reliability aspect included the content, language, and display aspects. The reliability aspect includes four indicators to assess. They are: (1) the requirement and the order of the materials, for the reflection and refraction of light, designed in the E-Module; (2) the clarity of each explained problem solution stated in the guideline of E-Module implementation, and (3) the relevance of the questions in the E-Module to improve problem-solving skills; and (4) the relevance of the E-Module with daily life problems presented in the E-Module within the materials of light reflection and refraction. The language aspects include four indicators to assess. They are: (1) the relevance of the applied language in the E-Module and the General Guideline of Indonesian Language Spelling, PUEBI; and (2) the applied communicative and informative language in the module. The presentation aspect includes four indicators to assess. They are: (1) the relevance of the E-Module's cover design and the presented materials; (2) the appropriateness of the font options, the layouts between the explanation and the figures about the materials; (3) the relevance, the accuracy, and the clarity of figures and videos presented in the E-Module about the materials; and (4) the accessibility of the E-Module's link containing the materials of light reflection and refraction.

The applied instrument was a reliability questionnaire shared via *Google Form*. The researchers determined the quality of the developed E-Module based on the assessments and suggestions from the examiners. In this research, the examiners consisted of 50 physics teacher candidates. With this procedure, the researchers expected to determine the reliability of the developed product. Thus, the researchers needed the physics teachers candidates because they were aware of the materials so they could determine the reliability of the E-Module. The researchers considered the E-Module reliable if the examiners shared their assessment, very excellent. In this case, the examiners could also share their expectations, criticisms, and reasons for further reference to revise the product. Thus, the product will be more effective to improve the learners' problem-solving skills.

The data from the reliability test were ordinal. Then, the researchers converted the data into interval data so that the researchers could analyze the data statistically. The researchers converted the ordinal data into interval data with *Microsoft Excel*. The applied criteria for the research instrument were based on the conversion formula proposed by Djemari [26]. The converted data results were quantitative into qualitative data with the modified 4-scale as shown in Table 1.

Table 1. Assessment Criteria

Quantitative Score Interval	Category
$X \geq M_i + 1,5SB_i$	Very reliable
$M_i \leq X < M_i + 1,5SB_i$	Reliable
$M_i - 1,5SB_i \leq X < M_i$	Fairly Reliable
$X < M_i - 1,5SB_i$	Unreliable

Remarks:

X = Final mean

M_i = The ideal mean calculated with the formula

$$M_i = \frac{1}{2}(\text{skor maksimum ideal} + \text{skor minimum ideal})$$

SB_i = The ideal standard of deviation calculated with the formula

$$SB_i = \frac{1}{6}(\text{skor maksimum ideal} - \text{skor minimum ideal})$$

C. Results and Discussion

The undergoing stages in this development were *defining*, *designing*, and *developing*. The defining stage revealed the problems about learners' problem-solving skills, the physics module, and the materials of light reflection and refraction. From the works of literature, the researchers determined the problem-solving skill level of the learners. The skills were very low, especially in physics lessons [5]. The analysis results, based on the literature, showed that the module applied to the learners was not practical. Most modules were non-electronic modules and only contained exercise questions without any problem-solving stages [27]. From the literature, the researchers found that the materials of reflection and refraction were mostly encountered by learners in their daily life, moreover for Senior High School learners. However, they still had difficulties solving problems dealing with the materials [21], [22].

In the designing stage, the initial design of the E-Module consisted of a cover; preface; table of content; the objective of the lesson; conceptual map; introduction; material explanation, such as *did you know*, *information corner*, *let's exercise*, and *tips & trick*; Polya-based problem-solving questions [9], a column for asking questions; bibliography; and identity of the authors. The researchers developed the E-Module by

considering the learning components, starting from the texts, figures, videos, and evaluative questions. Here are the figures in the E-Module.

E-MODUL
PEMANTULAN DAN PEMBIASAN CAHAYA

Oleh:
Ima Puspita Rukmi
Sindy Chintyawati

Tahukah kamu ?

Peristiwa pemantulan cahaya matahari yang mengenai permukaan bumi merupakan salah satu contoh dari pemantulan baur. Cahaya matahari mengenai permukaan bumi yang memiliki permukaan yang kasar atau tidak teratur maka terjadilah pemantulan baur. Pemantulan baur inilah yang menyebabkan sinar matahari atau cahaya matahari bisa sampai ke dalam ruangan rumah – rumah, walaupun rumah tertutupi atap yang menghalangi cahaya matahari masuk ke dalam ruangan. Meskipun ruangan di dalam rumah tidak terkena cahaya matahari secara langsung tetapi ruangan tersebut dapat terkena sinar matahari sehingga kita bisa melihat isi ruangan dengan jelas tanpa bantuan lampu atau alat sinar lain.

Ayo menambah pemahaman !
Untuk dapat menambah pemahaman kalian mengenai hukum pemantulan cahaya, ayo klik ikon dibawah ini!

TRIK JITU!
Ada sebuah trik untuk menghafalkan sifat – sifat bayangan pada cermin!
1. Ruang bayangan + Ruang benda = 5
2. Bayangan **nyata** selalu **tegak** dan bayangan **nyata** selalu **terbalk**.
3. Jika nomor ruang benda < nomor ruang bayangan, maka bayangan **diperbesar**. Sebaliknya, jika nomor ruang benda > nomor ruang bayangan, maka bayangan **diperkecil**.

MARI BERTANYA
Setelah memahami uraian materi di atas, jika masih ada penjelasan yang kurang dapat dipahami dan ingin ditanyakan, silakan bertanya dengan mengklik ikon di bawah ini.

Mari Berlatih!
"Melukis pembemakan bayangan pada cermin cekung". Setelah mempelajari serta memahami uraian materi di atas, sekarang waktunya untuk berlatih. Dengan menggunakan pemahaman mengenai tiga berkas sinar istimewa, lakukanlah pembemakan bayangan pada cermin cekung ketika berada di R I, R II, R III, R IV, tepat pada titik fokus F, dan tepat pada pusat kelengkungan (R) serta tuliskan sifat – sifat bayangannya!

Pojok Informasi!
Pembagian ruang pada cermin cekung:

f = fokus cermin cekung bernilai positif (+)
 s (+) = bayangan nyata (di depan cermin)
 s (-) = bayangan maya (di belakang cermin)

Figure 1. The Example of the E-Module Content

In the development, the package of the E-Module presented material explanation by considering the learners' problem-solving skills. The E-Module explains the materials about refraction and reflection of lights in daily life. These materials

facilitated the learners to develop their problem-solving skills, such as formulating problems, solving problems, and constructing their knowledge. Most modules did not provide adequate opportunities for learners to develop their problem-solving skills [5]. In this research, the researchers expected the implementation of the E-Module could improve the learners' physics problem-solving skills.

Figure 2 shows the descriptions of the E-Module related to the reflection and refraction of lights and the surrounding problems and phenomena. One of them was material about light reflection. In this research, the researchers connected the material, light reflection, rearview mirrors, and convex mirrors on the roads. These examples made the learners think about the phenomena and inquired how the phenomena happened. Mulhayatiah, et al [8] found that most learners could not solve physics questions with daily problems. The E-Module also explains the materials and their connections with daily life problems. Thus, the learners could improve their skills in solving daily physics problems.



Figure 2. The Researchers Connected the Content of the Materials with the Surrounding Phenomena.

Besides the material explanation related to daily life problems, the developed E-Module also presented questions based on Polya's problem-solving stage guideline [9]. Thus, learners could not only solve quantitative problems or mathematical calculations with formulas, but they could solve more complex problems. Azizah, Yuliati, and Latifah [6] explain that learners must receive complex physics questions to train their problem-solving skills. Therefore, with the developed E-Module, the researchers expected the learners could manage their difficulties to solve complex physics problems in daily life.

One example of the question is observable in Figure 3. The figure shows the content of the E-Module titled "Ayo Memecahkan Permasalahan." This section consisted of questions with materials of light reflection based on a real phenomenon, the rearview mirror of a car. The learners had to work on this question based on Poly's problem-solving stages [9]. In the beginning, the learners had to identify the problems based on the concepts. Then, they had to determine the most relevant concept to solve the problem. In the third step, the learners had to explain the problem-solution based on the selected concept. The last stage was - inviting the learners to recheck the appropriateness of the concept to solve the problems. The questions made the learners think carefully about the answer. They had to answer with a systematic step. From this activity, the learners could improve their problem-solving skills.

Ayo Memecahkan Permasalahan!

Setelah memahami konsep pemantulan cahaya pada cermin cembung, kini saatnya memecahkan masalah yang berkaitan dengan konsep tersebut. Kerjakan soal di bawah ini dengan berpedoman pada tahap - tahap pemecahan masalah menurut Polya (2014).

1. Perhatikan kaca spion pada motor, mobil ataupun alat transportasi di sekitar kalian! Saat kalian melihat seperti halnya kaca spion tersebut, bagaimana bentuk bayangan yang terlihat pada kaca spion tersebut? Apakah jenis cermin yang digunakan pada kaca spion tersebut? Apakah kegunaan menggunakan jenis cermin tersebut? Bisakah diganti dengan jenis cermin lain? Apakah konsep yang dapat menjelaskan hal itu?

Jawab:

(1) Mengenal serta memahami masalah
 Note: Mengidentifikasi masalah berdasarkan konsep.

(2) Merencanakan strategi penyelesaian masalah
 Note: Menentukan konsep mana yang sesuai untuk memecahkan masalah.

(3) Menyelesaikan masalah sesuai perencanaan
 Note: Menjelaskan cara menyelesaikan masalah sesuai konsep.

(4) Melakukan pengecekan kembali atau evaluasi
 Note: Mengecek kembali apakah konsep yang dipakai telah sesuai untuk memecahkan masalah tersebut.

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Figure 3. The Problem-Solving Questions

The developed E-Module was based on the module characteristics as suggested by Daryanto [16], especially in terms of adaptive and user-friendly characteristics. The developed E-Module had high adaptability toward the science and technology development in which learners mostly used their handphones and laptop computers rather than their books. The preference of the learners made this E-Module suitable for the learners. Then, the module could be accessed via handphone or laptop.

The E-Module also had a flipbook display as an effort to develop creative, interesting, and unique teaching materials. The strength points of the E-Module's flipbook display were the figures, the gift animations, and the videos that were accessible via YouTube. Thus, the module could make the learners' understanding

better. Besides that, the flipbook display also had animations that made the learners experience the sensation of flipping real books. Asini explains the strong points of E-Module with Flipbook display are (1) providing the flip effect as if the readers were reading real books; (2) providing facility to use, and (3) providing figures, sounds, and videos [19]. Thus, the use of a flipbook would be a new thing for the learners. This new matter became the additional value of the developed E-Module because the module was accessible anytime and anywhere with an interesting display. The researchers expected the E-Module could improve the learners' interest to learn physics.



Figure 4. The Flipbook Display of the E-Module

After designing the modules with some excellent features, the next step was - the developing stage. In this stage, the researchers examined the reliability of the E-Module by involving 50 examiners to judge the content, language, and display aspects. The developed E-Module was categorized as very valid if the mean score of each variable was $\geq 3,25$. The reliability test results of the content, language, and display are observable in these figures.

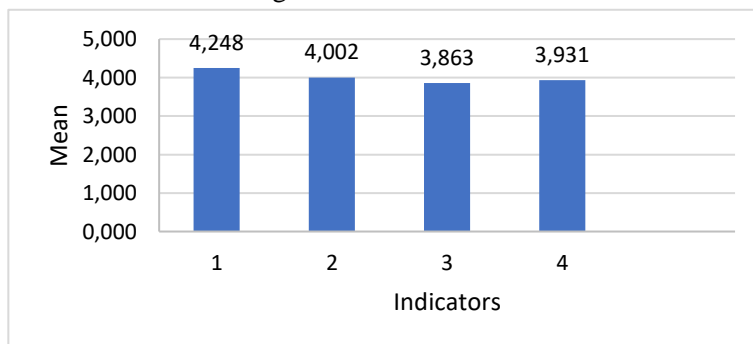


Figure 5. The Reliability Test Results on Content Aspect

Generally, the examiners found the content aspect of the developed E-Module was very reliable. The evidence was the obtained mean score of each indicator, higher

than 3.25. In this aspect, the highest score was observable from the first indicator, the completeness and the material order of light reflection and refraction presented in the E-Module. The score indicated that the presented material in the E-Module accommodated all materials about refraction and reflection of light. In this case, the researchers designed the materials orderly based on the core competence, basic competence, indicator, and learning objective. The completeness of the module fulfilled a characteristic of a module, *self-contained*. Thus, the developed E-Module contained all materials needed by the learners [16]. The module package was complete and started from the clear objectives and material summary.

In the content aspect, the researchers found an indicator with a lower score, the third indicator. This indicator dealt with the relevance of the questions to improve learners' problem-solving skills. Although the third indicator was categorized as very reliable, the experts provided some suggestions. One of them was - the need for key answers to facilitate learners measuring and evaluating their problem-solving skills. Auliya and Kosim [13] found that key answers could facilitate learners to check their achievements in understanding certain materials.

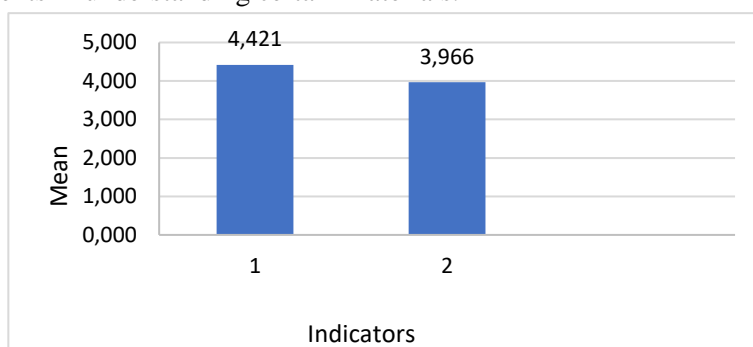


Figure 6. The Reliability Test Results on Language Aspect

Generally, the examiners found the language aspect of the developed E-Module was very reliable. In this aspect, the first indicator, the relevance of the applied language in the E-Module, based on the General Guideline of Indonesian Language Spelling, obtained a higher mean than the second indicator. The score shows that the applied language was relevant to the General Guideline of Indonesian Language Spelling. The relevance of the PUEBI, the General Guideline of Indonesian Language Spelling, could prevent ambiguity and improve the readability of the text. Thus, readers would understand the content. Depdiknas, the Department of National Education [14], explains that all teaching materials must consider the language components, such as the language reliability to facilitate learners in understanding the learning materials.

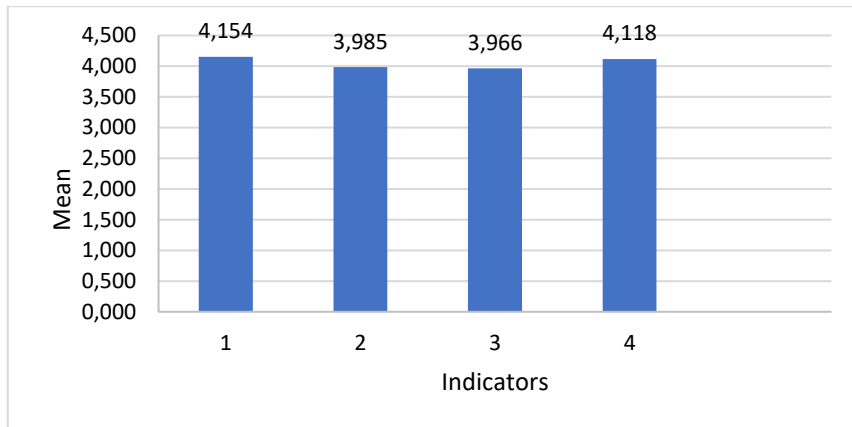


Figure 7. The Reliability Test Results on Display Aspect

Generally, the examiners stated the display aspect of the E-Module was very reliable. In this aspect, the first and the second indicators obtain similar results. The first indicator, the relevance of the E-Module design with the presented materials, indicated that the materials were excellently presented in the module. In this case, the presented materials were the geometrical optics in terms of reflection and refraction. The relevance of the cover design of the presented material would make the learners an initial portrayal of the contained materials. Thus, they would read the content. A cover of a module is important to describe the materials and the applied learning approach [15]. Daryanto [16] also explains that the combination of colors, figures, shapes, and letters should be harmonious to realize an attractive cover of a module.

The second and the third indicators obtained similar results. These indicators had lower scores than the other indicators. For the third indicator, dealing with relevance, accuracy, and clarity of the figures and videos in the module with the materials, the results showed a very reliable category. However, the results also suggested some revisions. The suggestions were to put the layout of the figures above the page border. Thus, the layout would be tidier and the distance between paragraphs could be enlarged. These layouts would allow readers to read easily. Ramadhani and Mahardika [17] explains that tidiness is important. They also explain some graphic aspects while developing a module, such as the size, the format, the layout, the design, and the content.

Based on the reliability test results, the developed E-Module was categorized as very excellent. However, there were some revisions to do based on the suggestions. One of them was to tidy up the figures on each page border. Here is the figure for the pre-revised module (left) and the post-revised module (right).

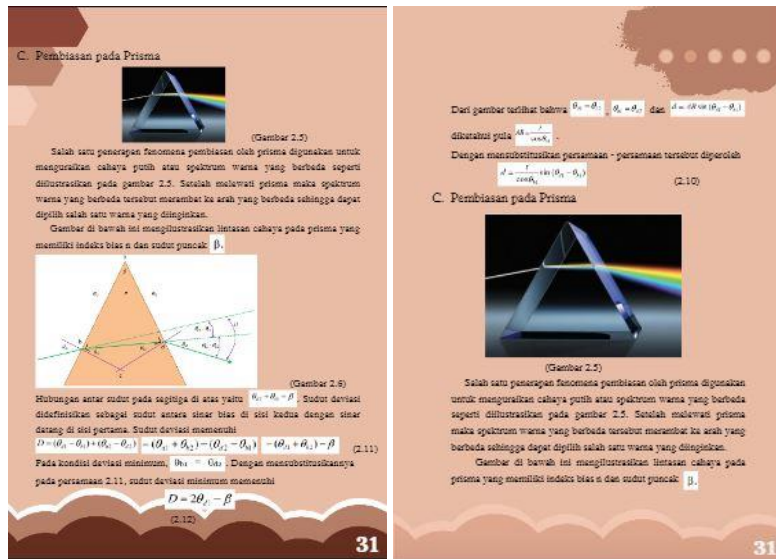


Figure 8: The Revision based on the Experts' Suggestions

Based on the explanations, the developed E-Module was categorized as excellent. Therefore, the developed module could proceed to the next stage, the field test by involving students. This test would be useful to determine the effectiveness of the module in improving the problem-solving skills of learners, especially within the materials of light reflection and refraction. Eventually, if the field test of the developed module was effective to improve the problem-solving skills, then the module could be developed for other materials.

D. Conclusion

From the research results and discussion, the researchers concluded that the E-Module could improve the problem-solving skills of the learners on the materials of light reflection and refraction with the developed *flipbook* display. The product was also reliable to use. The reliability was observable from the material, language, and media assessment. These three aspects obtained a score higher than 3.25, categorized as very excellent. Therefore, the developed module could be tested for a wider field to determine the effectiveness and improve the quality of learners' problem-solving skills.

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