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DEVELOPMENT OF INTERACTIVE E-MODULES FOR HIGH SCHOOL PHYSICS LEARNING BASED ON PROBLEM BASED LEARNING (PBL)

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Abstract. Interactive multimedia is one factor that can increase student interest and learning outcomes. One of the interactive multimedia is interactive e-modules. The aim of this research is to describe the planning, design and development of learning e-modules, assess the theoretical, conceptual and practical feasibility of interactive e-modules, describe peer responses and describe the attractiveness of interactive e-modules based on Problem Based Learning (PBL). The research method used is Research and Development. The research subjects were students at Ash-Shiddiiqi Jambi IT High School. The development model used as a reference is the Lee and Owen development model, with stages Analysis, Design, Development, Implementation, and Evaluation (ADDIE). The research results showed that the material expert validation results were 97.33% with a very feasible category. And the validation results from media experts were 90.77% in the very feasible category. And the teacher response was obtained with a score of 90.91% in the very appropriate category. Then the one-to-one trial obtained a score of 77.22% in the good category. Next, a small group trial was carried out with a score of 84.73% and a field trial of 89.26%. So interactive e-modules for PBL-based physics learning are suitable for use by SMA IT Ash-Shiddiiqi Jambi students.

INTRODUCTION

Education in the broadest sense, education is all learning experiences that last a lifetime in all environments and situations that have a positive influence on the growth of each individual. That education lasts throughout life/long life education (Annisa, 2022). Education has an important role in improving the quality of human life. Through the education process, it is hoped that all human activities will increase. Therefore, improving the quality of Indonesian education must always be carried out in accordance with national education goals. The aim of national education is to develop abilities and shape the character and civilization of a dignified nation in order to educate the life of the nation, to develop the potential of students to become people who are faithful and devout, have noble morals and have mature personalities (Sukendra et al., 2023).

21st century learning prepares students to face technological advances, so that they can produce citizens with a global perspective. Learning in this century also makes students have the ability to solve problems in life and the surrounding environment (Purnadewi & Widana, 2023). Apart from that, 21st century learning also forms characters to respect each other and be open in discussions. Therefore, students are equipped with 6C abilities (Critical Thinking, Collaboration, Communication, Creativity, Character, Citizenship). In other words, various skills and knowledge using technology need to be mastered by Human Resources (HR), becoming a benchmark for a nation to participate in global competition (Kembara et al., 2022).

The curriculum is a description of the materials presented in learning, it is also a very important component in an education system, the curriculum is a tool for achieving educational goals and also serves as a guideline for implementing teaching at all types and levels of education (Setiyadi et al., 2020). Curriculum changes are an effort to improve the quality of education in Indonesia. This change requires educators to continue learning and developing their abilities in the learning process to adapt to technological developments. The 2013 curriculum has the principle that it must be able to provide space for students to learn according to their interests, personal abilities and learning styles (Evi Yupani & Widana, 2023). The learning process is student-centered where students must always be active in finding solutions in learning activities. In the Merdeka curriculum there is a breakthrough known as Merdeka Belajar, which is a concept created so that students can explore their respective interests and talents. Apart from that, this curriculum also prioritizes project-based learning. This means that students will implement their learning through projects or case studies, so that understanding of concepts is better achieved.

Physics is a subject that studies the basic properties of matter, energy and the interactions between the two. At the secondary education level, especially in class XI, temperature and heat are important topics to study. The concepts of temperature and heat are closely related to physical changes in objects, transfer of thermal energy, and changes in dimensions or shape of matter and are often encountered in everyday life.

Teaching materials are one of the supports for success in the learning process (Yasa et al., 2023). Teachers have a role in preparing and selecting appropriate teaching materials to achieve learning objectives. The selected teaching materials must be complete and in accordance with the characteristics of the students to make it easier for students to absorb information from the teaching materials. Teaching materials are all materials that are arranged systematically, which display a complete figure of competencies that will be mastered by students and used in the learning process with the aim of planning and studying learning implementation. For example, textbooks, modules, handouts, worksheets, models or mockups, audio teaching materials, interactive teaching materials and so on (Prastowo, 2011).

One of the teaching materials that can be used is a module. The modules available and used in the learning process are still monotonous, less interesting and not fully suited to the needs and character of students (Damayanthi et al., 2022). One of the Physics learning modules available on the internet is the high school physics learning module for class However, this PDF format module only presents text and images so it seems monotonous. Conventional modules like this do not attract students in the learning process.

Ash-Shiddiiqi Integrated Islamic High School (SMA IT) is one of the boarding schools or boarding schools in Jambi province. Ash-shiddiiqi IT High School is part of the Indonesian Integrated Islamic School Network (JSIT), which is an organization that operates in the field of education and oversees Integrated Islamic (IT) schools throughout Indonesia. This school adopts the good old education and accepts technological changes as a source/media in education. The school with the jargon "*Today's school, Qur'anic generation, Achievement generation*" launched the Smart Class program. In the learning process, they no longer use manual books and pens which are then replaced with tablets (Ipad) as learning tools which are named learning tools (Abel). Of course, the launch of this program will greatly influence the use of digital-based sources and media in the classroom learning process.

Through interviews with physics teachers at Ash-Shiddiiqi IT High School, the results showed that there was no e-module for learning physics that suited the character of the boarding school and the students. Apart from that, from the results of the analysis of the final semester assessment questions, it was found that only 40.67% of the questions on temperature and heat were complete. The development of e-modules in class XI physics learning regarding temperature and heat has the potential to increase the effectiveness and efficiency of the learning process. E-modules can present physics material in a more interesting and interactive way, so that it can increase students' interest and understanding of the physics concepts being taught. Apart from that, e-modules can also provide flexibility for students to access and study physics material wherever and whenever they want.

Based on the explanation given, this research is considered important and urgent to be carried out. It is important because learning must be balanced with technological changes and urgent because as a teacher you must immediately prepare digital-based learning modules so that the learning is in line with current learning and the character of students and in accordance with the school program being launched. So the author is interested in conducting research with the title "**Development of Interactive E-modules for High School Physics Learning based on Problem Based Learning (PBL)**

METHOD

This research uses research and development methods. The subjects and place of research were Class XI students at SMA IT Ashu-Shiddiiqi Jambi. The research was conducted between June 2023 and April 2024. Data was collected using questionnaire techniques. The questionnaire was addressed to: 1) material experts; 2) media expert; 3) students for one-on-one testing; 4) students for small groups; and 5) students for field tests, and 6) peer teachers.

Data analysis used the Miles & Huberman (1994). Meanwhile, to test the validity of the data, triangulation techniques from different sources were used. By using triangulation techniques to test the validity of the data, the data obtained will be more consistent, complete and certain (Sugiyono, 2013).

The development of an interactive e-module based on a PBL learning model on temperature and heat material was carried out using the Lee & Owens (2004) development model which has five stages, namely analysis, design, development, implementation and evaluation). The choice of this model was based on several reasons,

namely: the Lee and Owens development model is specifically used in developing learning multimedia, this model has a general basic framework and is easy to implement, this model has been widely used for developing learning media and has been proven to produce good products. Lee and Owen's development model is said to be a procedural model because the sequence of steps in the process is structured systematically and each development step has a clearly structured sequence of development steps (Iskandar et al., 2022).

Descriptors on the 12-item media expert validation questionnaire. Theoretically, a minimum score of 12 and a maximum of 60 will be obtained. The interpretation of the score is as follows:

Minimum score : 1 x 12 (assessed descriptor) =12
Maximum score : 5 x 12 (assessed descriptors) =60
Criteria category : 5
Value range : 9

The following is a table of expert validation level categories and educator responses

Table 1. Categories of Expert Validation Levels and Educator Responses

No	Value Scale	Score	Validation Level
1	5	51-60	Very Worth It
2	4	41 -50	Worth it
3	3	34-40	Decent Enough
4	2	22-32	Not Worth It
5	1	12-21	Totally Not Worth It

Then, for the purposes of making a decision regarding whether or not this development product is appropriate, the decisionmaking criteria as in the following table are used:

Table 2. Decision Making Criteria

Percentage of Achievement	Qualification	Information
81% - 100%	Very Worth It	No Revision Required
61% - 80%	Worth it	Needs Minor Revision
51% - 60%	Not Worth It	Requires Considerable Revision
< 50%	Totally Not Worth It	Need to Repeat

RESULTS AND DISCUSSION

Analysis

Based on an analysis of the needs and characteristics of 40 students in class using digital learning media (PPT, learning videos, interactive multimedia and Android applications, through computer laboratories) compared to printed learning media (package books and worksheets). 92.5% of students also choose learning by presenting concrete problems.

Apart from that, only 38.5% of students carried out repetitions independently using physics notebooks and printed books. This can be seen from the results of the semester assessment, especially that the temperature and heat material only had a completeness of 40.67%.

Design and development

Based on the framework and storyboard that has been created is then developed in accordance with the framework and storyboard the. Here's a look e-module which has been developed.

Image 1. E-module cover

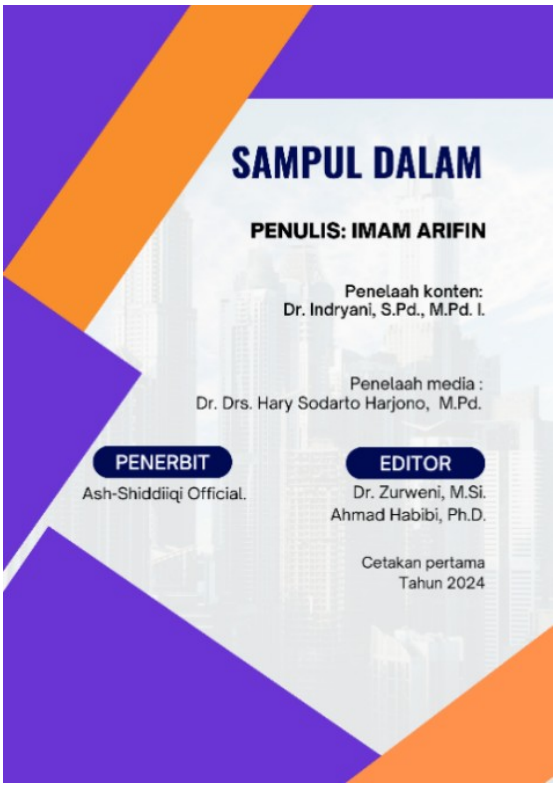
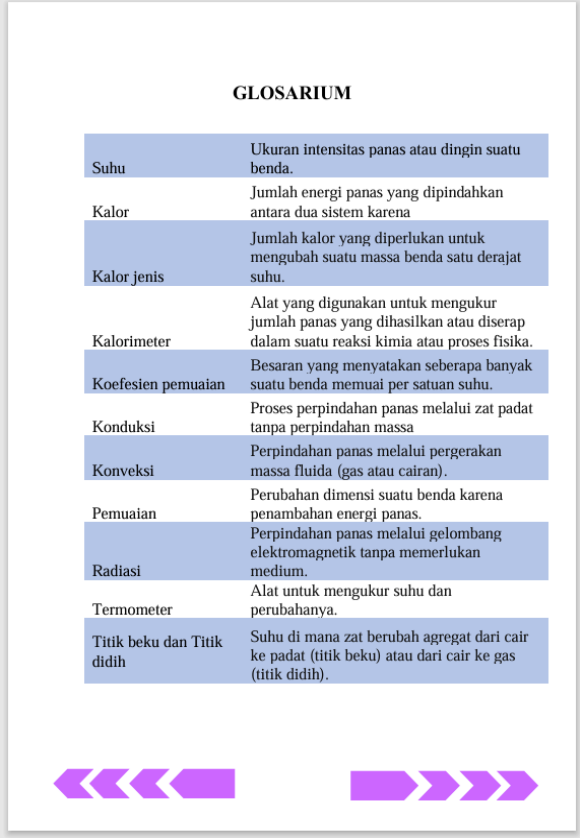


Image 2. Inside cover



GLOSARIUM

Suhu	Ukuran intensitas panas atau dingin suatu benda.
Kalor	Jumlah energi panas yang dipindahkan antara dua sistem karena
Kalor jenis	Jumlah kalor yang diperlukan untuk mengubah suatu massa benda satu derajat suhu.
Kalorimeter	Alat yang digunakan untuk mengukur jumlah panas yang dihasilkan atau diserap dalam suatu reaksi kimia atau proses fisika.
Koefesien pemuaian	Besaran yang menyatakan seberapa banyak suatu benda memuai per satuan suhu.
Konduksi	Proses perpindahan panas melalui zat padat tanpa perpindahan massa
Konveksi	Perpindahan panas melalui pergerakan massa fluida (gas atau cairan).
Pemuaian	Perubahan dimensi suatu benda karena penambahan energi panas.
Radiasi	Perpindahan panas melalui gelombang elektromagnetik tanpa memerlukan medium.
Termometer	Alat untuk mengukur suhu dan perubahanya.
Titik beku dan Titik didih	Suhu di mana zat berubah agregat dari cair ke padat (titik beku) atau dari cair ke gas (titik didih).

Image 3. Glossary

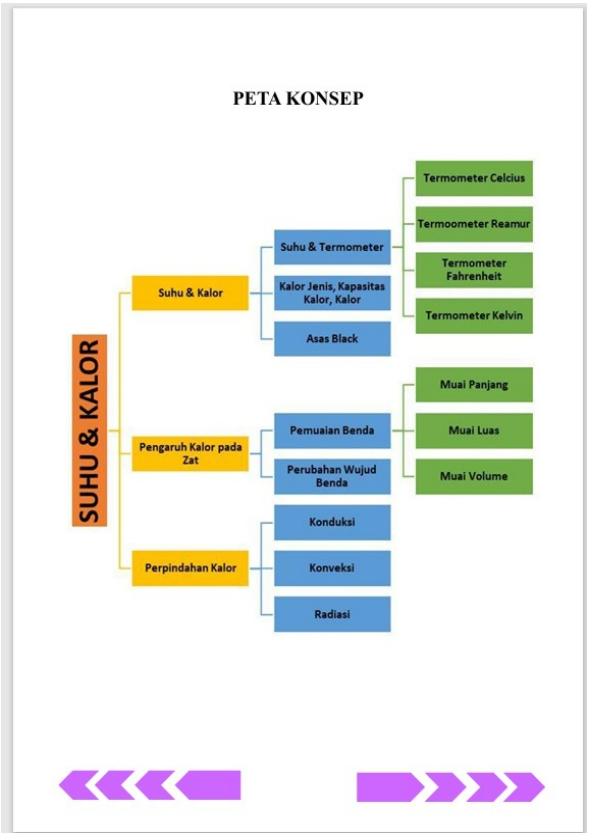
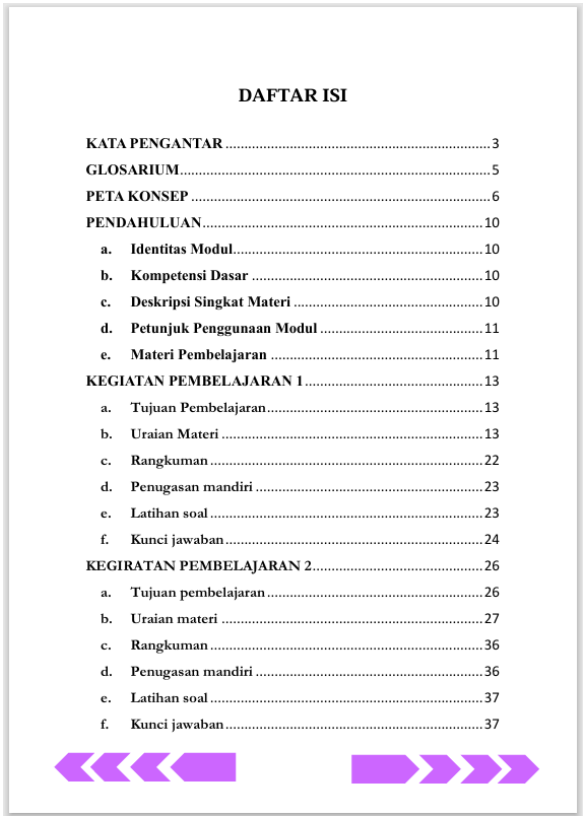
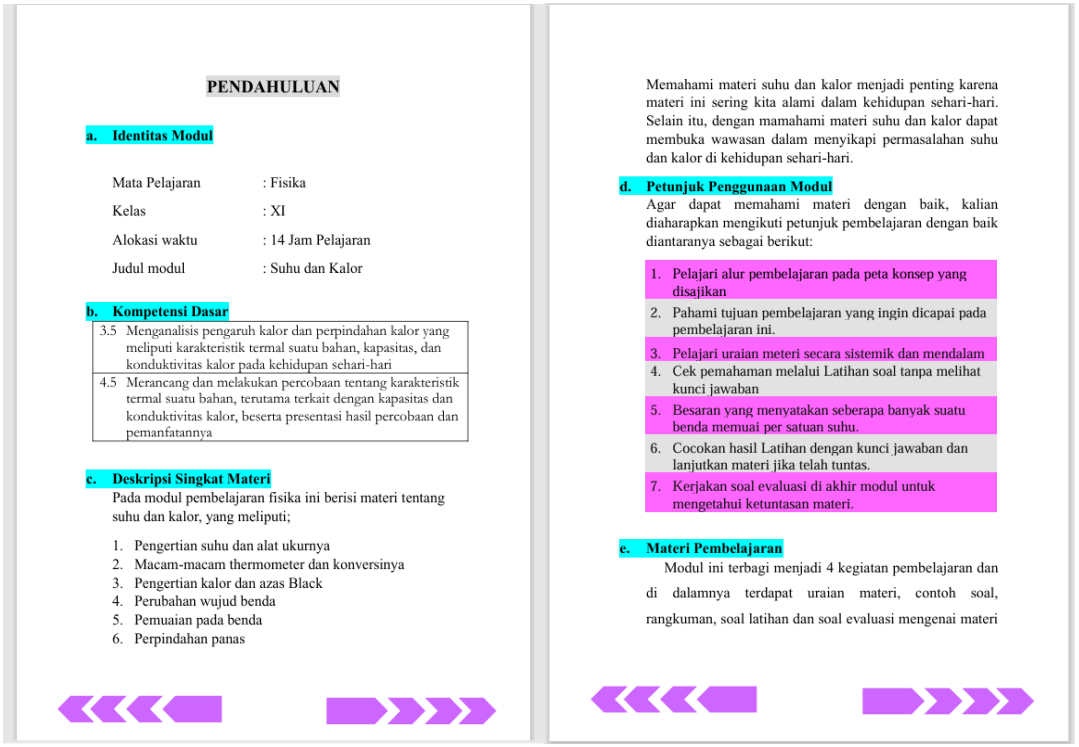


Image 4. Concept map



DAFTAR ISI

Image 5. Table of contents



PENDAHULUAN

a. Identitas Modul

Mata Pelajaran : Fisika
Kelas : XI
Alokasi waktu : 14 Jam Pelajaran
Judul modul : Suhu dan Kalor

b. Kompetensi Dasar

3.5	Menganalisis pengaruh kalor dan perpindahan kalor yang meliputi karakteristik termal suatu bahan, kapasitas, dan konduktivitas kalor pada kehidupan sehari-hari
4.5	Merancang dan melakukan percobaan tentang karakteristik termal suatu bahan, terutama terkait dengan kapasitas dan konduktivitas kalor, beserta presentasi hasil percobaan dan pemanfatannya

c. Deskripsi Singkat Materi

Pada modul pembelajaran fisika ini berisi materi tentang suhu dan kalor, yang meliputi;

1. Pengertian suhu dan alat ukurnya
2. Macam-macam thermometer dan konversinya
3. Pengertian kalor dan azas Black
4. Perubahan wujud benda
5. Pemuaian pada benda
6. Perpindahan panas

Memahami materi suhu dan kalor menjadi penting karena materi ini sering kita alami dalam kehidupan sehari-hari. Selain itu, dengan mamahami materi suhu dan kalor dapat membuka wawasan dalam menyikapi permasalahan suhu dan kalor di kehidupan sehari-hari.

d. Petunjuk Penggunaan Modul

Agar dapat memahami materi dengan baik, kalian diaharapkan mengikuti petunjuk pembelajaran dengan baik diantaranya sebagai berikut:

1. Pelajari alur pembelajaran pada peta konsep yang disajikan
2. Pahami tujuan pembelajaran yang ingin dicapai pada pembelajaran ini.
3. Pelajari uraian meteri secara sistemik dan mendalam
4. Cek pemahaman melalui Latihan soal tanpa melihat kunci jawaban
5. Besaran yang menyatakan seberapa banyak suatu benda memuai per satuan suhu.
6. Cocokan hasil Latihan dengan kunci jawaban dan lanjutkan materi jika telah tuntas.
7. Kerjakan soal evaluasi di akhir modul untuk mengetahui ketuntasan materi.

e. Materi Pembelajaran

Modul ini terbagi menjadi 4 kegiatan pembelajaran dan di dalamnya terdapat uraian materi, contoh soal, rangkuman, soal latihan dan soal evaluasi mengenai materi

Image 6. Introduction: Module identity, Basic Competencies, material description and instructions for using the module

KEGIATAN PEMBELAJARAN 1

SUHU DAN TERMOMETER

a. Tujuan Pembelajaran

Setelah mempelajari kegiatan pembelajaran 1, tentang suhu dan thermometer kalian diharapkan mampu membedakan antara pengertian suhu kalor beserta alat ukurnya dan mampu membandingkan penggunaan skala pada thermometer.

b. Uraian Materi

Apa sih bedanya antara suhu dengan energi panas?

Sebelum masuk ke pembahasan materi silahkan buka dan perhatikan video berikut dengan cara klik pada gambar /logo video

Dari video yang telah kalian amati, menurut kalian apa yang membuat tangan terasa panas dan dingin? Adakah

Image 7. Learning activities

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Image 8. Bibliography

Results and Material Expert Discussion

Reviewing learning materials in media development is a step that must be taken in developing learning e-modules. This is because the material is the substance of the learning e-module itself. So that learning messages can be easily accepted by students, implemented and practiced in everyday life. The learning material that will be delivered of course refers to the applicable curriculum, namely the 2013 curriculum, but still takes into consideration the latest curriculum, namely the independent curriculum, so that e-modules can be used continuously. The following are the results of the interactive e-module validation test for physics learning that has been carried out:

Table 3. Material validation test results

Aspect	Indicator	Score
Curriculum	Conformity of material content with basic competencies	5
	Suitability of material content to objectives Learning	5
Material	The correctness of the concept of the material presented	5
	The complexity of the concepts of the material presented	5
	Completeness of the material concept Served	5
	The depth of the concept of the material presented	5
	The attractiveness of presenting the material	5
	Suitability of the image to clarify the material contained in the question	5
	Appropriateness of the presentation of examples to the material	5
	Suitability of material to student characteristics	5
	The material is supported by appropriate media	4
Grammar	Use of language in accordance with linguistic rules	4
	The language used is appropriate to the characteristics of the students	5
PBL	Presenting problem orientation at the beginning of learning	5
	Directs investigation/experimental activities in each lesson.	5
	Total	73
	Rate-rate	4,87
	Percentage	97,33 %

From the overall assessment results, the Material Expert validation results have met the required criteria. Category is at 97.33% or Very Eligible. Material experts also gave positive responses to the validated e-module. The response was in the form of suggestions to continue developing learning e-modules for further materials, share good practices with fellow teachers and help fellow students to complete their final assignments.

Media Expert Discussion

After completing the editing process, the e-module needs to be validated by a media expert so that it can achieve the goals as planned. Based on the validation results, a total score of 59 was obtained, an average value of 4.54 and a percentage of 90.77% or very decent. Developers also receive suggestions and input in the form of: improving the

layout of the module usage instructions and answer keys as well as adding sources for each image used.

One-to-One Trial

One-to-one trials were carried out on three students at Ash-Shiddiqi IT High School. The selected students represent students with low, medium and high academic abilities, during the trial process the students did not experience any obstacles. Trials are carried out for the purpose of improving and evaluating the media so that the media can become even better. Individual trials are carried out one by one on students. At the individual trial stage, students operate the e-module independently, then students are given a questionnaire regarding responses to using the developed product.

Developers make observations during the testing process. From these observations it was found that all students were able to use e-modules well to learn independently without any fatal obstacles or even explanations. Only students with moderate abilities asked to zoom out the learning e-module display. Based on the results of one-on-one trials, a total score of 139 respondents was obtained with a percentage of 77.22% in the range of 61-80% which was declared "good". Apart from that, students also gave positive responses to the use of e-modules.

Small Group Trials

Small Group Evaluation is carried out simultaneously by opening the e-module link that has been given to students using a laptop/computer. After reading the e-module, students are given a questionnaire regarding responses to using the developed e-module. The number of small groups carried out is 10 people. The questionnaire given to students is a questionnaire with a Likert scale. The scale in the questionnaire has alternative answers from 1 to 5. A small group test was carried out to see the feasibility of the e-module product being developed.

Meanwhile, the results of observations of students' learning activities showed enthusiasm in participating in learning. Students try to collaborate, both with educators and fellow friends. Students read the e-module carefully, try to actively learn, discuss, express opinions, ask questions and other learning activities. This activity is relevant to what was conveyed by Trollip & Alessi (2001) who stated that the development of ICT-based learning will provide many advantages, including: learning materials will be more easily accessible from anywhere, more interesting, cheaper in cost, and save more time student learning (Astawayasa et al., 2022).

Large Group Trials

Large group tests were carried out to see procedural effectiveness and feasibility, so field trials used pre-tests and post-tests. The pre-test is carried out before students use the e-module. The posttest is carried out after students use the PBL-based physics learning e-module. This activity was carried out to find out whether the PBL-based physics learning e-module was effective in making students understand the physics content of temperature and heat. Field trials were carried out by 33 students at Ash-Shiddiiqi IT High School. Next, the pretest and posttest scores were analyzed using the SPSS program. Based on analysis using SPSS, it was found that the data was normally distributed using a non-parametric test. Next, a sample paired test can be carried out to determine the difference in pretest and posttest results. From the results of the interpretation of the Paired Samples

Test. Based on the output above, the Sig (2-tailed) value is 0.0000 < 0.05, which means that there is a significant difference between the pretest and posttest scores. If we look at the t-calculated value (-14.138), it is smaller than the t-table (-2.034515), indicating that there is a significant influence on the use of PBL-based physics learning e-modules. So it can be concluded that the use of PBL-based physics e-modules is very effective and can improve students' ability to think creatively. The physics e-module based on problem based learning (PBL) is very effective for students' independent learning (Andani et al., 2022).

Next, students are given a questionnaire to determine practical feasibility. Based on the results of the questionnaire recapitulation used, a percentage of 89.26% was obtained. This percentage is in the range of 81-100%, which shows that the development of PBL-based physics e-modules is very good. This shows that the e-module developed is very suitable for use. Apart from that, all respondents gave positive responses to the use of PBL-based physics e-modules in learning.

Revised Field Trial Responses

Suggestions and comments obtained from the results of field trials basically do not refer to the technical production of e-modules. In line with the questions asked in the trial questionnaire, the things asked were more about efforts to explore students' perceptions and opinions about the usefulness, attractiveness and ease of using PBL-based physics e-modules in learning. Therefore, students' suggestions and comments during the trial did not lead to theoretical technical aspects of e-module development. However, this does not mean that developers do not pay attention to suggestions and comments from students. Developers still pay attention to the slightest suggestions and comments given by students to improve the e-module that has been developed. The comments from students that can improve the quality of the e-module include one of the paragraphs written less clearly.

CONCLUSION

Based on the findings during the development process, it can be concluded that the expert validation results for the development of interactive e-modules for PBL-based physics learning have an average of above 90% with a very feasible category. Video media has feasibility, both theoretically, conceptually and procedurally. The development of interactive e-modules for PBL-based physics learning is also in the practically feasible category after being tested on students. The development of interactive e-modules for PBL-based physics learning is also very interesting so that it can not only increase students' interest in learning, but is also able to motivate and improve students' creative thinking abilities.

Recommendations that can be given from the results of this research are: 1) integrating the development of interactive e-modules for PBL-based physics learning in the high school curriculum is important, especially for complex material, to facilitate understanding and increase student involvement in the learning process; 2) develop interactive and engaging e-modules, which not only convey lesson content but also spark creative thinking and discussion among students; 3) provide training and resources to teachers to develop and use learning e-modules effectively, so that they can design materials that suit the needs and learning styles of high school students.

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