

Development of an Interactive E-Module on the History of Quantum Physics Assisted by Flip PDF Professional

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Abstract: The rapid development of technology greatly affects the education system in Indonesia, especially in the use of Information Technology (IT) devices such as hardware and software in the teaching and learning process. This research focuses on developing interactive e-modules using the Flip PDF Professional application to improve students' quantum physics learning experience. This research problem addresses the difficulties faced by students in understanding quantum physics concepts, which leads to low academic achievement. This study aims to assess the feasibility and user satisfaction of the interactive e-module "History of Quantum Physics" developed with the help of the Flip PDF Professional application. The research method used is ADDIE (Analyse, Design, Development, Implementation, Evaluation) which involves validation by material experts and trials on physics education students at two universities. The results showed that the feasibility of interactive e-modules of quantum physics history by media and material experts obtained results that were feasible to be tested without revision with a percentage of 81.8%. So that the e-module can be tested on undergraduate and postgraduate physics education students. User satisfaction test results show that e-modules can be used as a support for quantum physics learning media with a satisfaction percentage of 91.33% or very satisfied.

Keywords: ADDIE model; Flip PDF professional; Interactive e-modules; Quantum physics; Technology in education

Introduction

Education in Indonesia nowadays certainly follows advanced technological developments (Sukasni & Efendy, 2017). With the rapid development of science and technology, technology is often used around us, especially in education (Karunanathan et al., 2023). The teaching and learning process in schools uses a lot of information technology (IT) learning media, using hardware and software that can increase, such as hardware and software, that can increase the effectiveness of the learning process (Babu et al., 2023). Technological advances make it easier for teaching staff to teach material to students because the media can attract students to learn the material. Choosing the suitable learning media can undoubtedly help students

achieve learning goals so that they can improve achievement (Roro et al., 2022).

Many learning resources are used by teaching staff, such as textbooks, modules, teaching aids, and others. The media that is often used in learning currently is modules. Many educational institutions still use conventional modules (Arif et al., 2020). To keep up with the times, there is a need for development by creating electronic-based modules according to student needs. Educators often use e-modules because they are more practical, and students can understand the content in e-modules, which contain materials, methods, practice questions, evaluation questions, quizzes, and other exciting things (Ahmmmed et al., 2020). As time passes, smartphones are widely used in learning, so students prefer smartphones to print modules, which are more

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expensive and time-consuming (Fitriani & Indriaturrahmi, 2020).

The Flip PDF Professional application creates flipbooks with a more attractive appearance and contains images, video, audio, and other displays (Komikesari et al., 2020). Using the Flip PDF Professional application has advantages over other applications because just by dragging, dropping, and clicking, you can insert YouTube, hyperlinks, animated text, audio, images, and flash into the e-module we create (Seruni et al., 2020). E-Modules created through the Flip PDF Professional application are more attractive because a book effect can flip the sheet of material you want to open (Ellysia & Irfan, 2021).

Quoted from the website www.flipbuilder.com/, Flip PDF Professional is a flipbook maker software with many features and can also edit pages (Susanti et al., 2021). With Flip PDF Professional, users can create flipbooks smoothly and can be displayed on various devices such as smartphones, laptops, and desktops (Syuzita et al., 2023). In addition, in the Flip PDF Professional application users can also add multimedia such as images, audio, video, and hyperlinks easily (Febrianti, 2021). This application has an interface like a book that is opened. Moving pages can also be done very easily in this application, namely by dragging the currently open page or by pressing the feature to open the next page (Sriwahyuni et al., 2019).

The use of Flip PDF Professional can assist teachers in delivering material well with the support of various features that can be inserted with images, videos, and audio (Putri & Wulandari, 2022). The output of this software can be HTML-5, EXE, APP, and FBR. The HTML-5 output flips the book as an HTML-5 format that allows uploading to the website for online viewing (Nurani & Suyanta, 2024). The EXE output is an application that can be opened offline (Nurmasyitah et al., 2022). FBR is an output in the form of a book format that can be opened with the help of a flip reader tool. And the output in the form of APP can be used on Iphone, Ipad, Tablet, and others. So that when you want to publish, you can choose the version that will be used (Hunaidah et al., 2022).

The advantages of the Flip PDF Professional application according to the official Flip Builder website <https://www.flipbuilder.com/flip-pdf-pro/> are as follows can add video, audio, hyperlinks, and other multimedia (Maulia et al., 2024). Convenient to use on mobile devices. Online publication available. Various templates, themes, backgrounds, and plugins. Application display in multiple languages. Support with social media (Subari et al., 2022).

Module is a form of teaching material that is packaged as a whole and systematically, in which it contains a set of learning experiences that are planned

and designed to help users master specific learning objectives (Susanti, 2017). Through a learning module, it is expected to be able to bring users to the expected Course Learning Outcomes (Nuri et al., 2023).

There are several characteristics for a module to be well produced as follows self-instruction is very important in the module, because with this character it allows a person to learn independently and not depend on other parties (Agung et al., 2022). The module is said to be self-contained if all the required learning material is contained in the module. The purpose of this concept is to provide an opportunity for users to study the learning material thoroughly, because the learning material is packaged into a unified whole (Lestari et al., 2022). Stand alone is a module characteristic that means it does not depend on other teaching media, or does not have to be used together with other teaching media (Asmiyunda et al., 2018). Modules should have high adaptability to the development of science and technology. It is said to be adaptive if the module can adjust the development of science and technology. An example is the E-module that will be applied in this research (Hidayati et al., 2022). The module should also fulfill the rules of user friendly or friendly with the user. Every instruction and information exposure that appears is helpful and friendly to the user (Wulansari et al., 2018). This includes the ease with which the user can respond and access as desired. The use of simple language, easy to understand, and using commonly used terms, is one form of user friendly (Permatasari et al., 2021).

The development of science and technology encourages rapid changes in the world of education. Information and communication technology (ICT), has enormous potential as a means or tool to develop technological skills in the learning process (Maria & Paidi, 2024). One of the learning media that can be developed into digital media is modules that can be transformed into electronic modules (E-Modules) which can be equipped with other media components such as audio, video, animation, movies, quizzes, or interactivity (Ananda & Usmeldi, 2023). The advantages of E-Modules over printed modules are that they are interactive in navigation, allow for the display of images, audio, video, animation, and are equipped with tests/quizzes but do not eliminate the characteristics of a learning module in general (Sugihartini & Jayanta, 2017).

Physics is a science that is very closely related to everyday life around us. We often encounter quantum physics courses at universities, especially in the Physics Education study program (Major & Hubálovská, 2023). According to students, quantum physics is a complicated subject because it contains many derivative formulas and other things that are difficult to

understand, making it difficult for students to get good grades (Singh & Marshman, 2015). Therefore, there is a need for learning media to help students understand the material according to the desired goals, one of which is to create an e-module with the help of the Flip PDF Professional application. Of course, students use Android more because they feel it is more practical in learning quantum physics material. One of the materials in quantum physics is the history of the birth of quantum physics, which contains figures who discovered it. It also discusses physics experiments on particles and waves (Keimer & Moore, 2017).

Quantum physics, a field that has transformed our understanding of the universe, originated in the early 20th century. Quantum physics emerged as a revolutionary framework that challenged classical physics and provided new insights into the behavior of matter and energy at atomic and subatomic scales. The creation of this E-Module explores the milestones and key figures that shaped the development of quantum physics (Saregar, 2016). The origins of quantum physics can be traced back to the late 19th century when classical physics, governed by Newtonian mechanics and Maxwell's equations of electromagnetism, seemed to offer a complete description of the physical world. However, some phenomena could not be explained by classical theory (Baily & Finkelstein, 2009).

The history of quantum physics is a testament to human curiosity and ingenuity, transforming our understanding of the universe at the most fundamental level (Freire, 2004). From Planck's quantum hypothesis to the development of quantum mechanics and its modern applications, the field continues to inspire and challenge physicists, promising new discoveries and technologies that could shape the future (Sujito et al., 2019).

In this research, it is different from previous research, because in this research using Flip PDF Professional which is designed in an attractive and interactive way so that readers are easily interested in learning the e-modules made. In this e-module studying quantum physics material that many students are less interested in and do not understand the material. This e-module includes two types of tests, namely formative and summative tests. Formative tests are packaged in the form of gamification, conventional, and crossword puzzles. Summative tests and formative tests are presented conventionally and digitally with answer keys. There are also experiments on quantum physics and learning videos, namely supporting material videos and experiment videos. Therefore, this research is very important to do because with the help of learning media Flip PDF Professional can be developed in an attractive, practical, concise and use language that is easy to understand so that it can increase the interest and

learning objectives of students in studying quantum physics.

This research aims to determine the feasibility of the product produced and user satisfaction regarding the product produced, namely the history of quantum physics interactive e-module assisted by a flip pdf professional. During learning, many students are less active and less enthusiastic about learning due to several factors, one of which is that the lecturer, when explaining in front, only uses the lecture method, so students do not understand the presented quantum physics material. Therefore, there is a need for developments in learning media, including creating an E-Module with the help of Flip PDF Professional (Komikesari et al., 2020).

Method

The research method used is the Analyze, Design, Development, Implementation, Evaluation (ADDIE) development model (Zhang et al., 2024). The product produced in this research is an interactive e-module on the history of quantum physics with the help of Flip PDF Professional. This research is development research that aims to develop quantum physics learning media. This development research comprises feasibility tests, product development processes, and product trials (Sol et al., 2024).

This research procedure includes, among others, Analysis, at this stage, the researcher identifies the need for an interactive e-module on the history of quantum physics through initial analysis carried out through literature studies. Design, at this stage the researcher designs learning media in the form of e-modules, developing feasibility test instruments for material and media experts, and developing user satisfaction instruments. Development, this development stage includes creating e-modules through a consultation process, feasibility testing by material and media experts. Implementation, the application of this product is carried out on students who have taken quantum physics courses to measure user satisfaction, and Evaluation, this stage is the last in the development research process which aims to analyze whether the product being developed is appropriate or not (Cahyadi, 2019).

The e-module product trial consists of a feasibility test carried out at the development stage and a user test carried out at the implementation stage. The test subjects for this research consisted of material and media experts, and the users were physics education students at Yogyakarta State University and Ahmad Dahlan University who had taken quantum physics/quantum mechanics lectures. The types of data used in this research are quantitative and qualitative. Quantitative

data was obtained from assessing the results of user satisfaction questionnaires and feasibility tests by validators, while qualitative data was obtained from feasibility test comment data.

The data analysis technique used in this research is a qualitative data analysis technique obtained from an open questionnaire by analyzing it thoroughly, drawing out important parts, revising (if necessary), and concluding (Barada, 2013). Apart from that, quantitative data analysis techniques were obtained from the results of material and media expert assessment questionnaires, and user satisfaction was measured using data analysis techniques using a Likert scale. Likert scale analysis is analyzed using the percentage equation to assess each aspect, as seen in equation (1).

$$P_i = \frac{\text{score gained}}{\text{maximum score}} \times 100\% \tag{1}$$

The P_i percentage in equation (1) aims to calculate the weighted average as seen in equation (2).

$$P_i = \frac{\sum n_i P}{\sum n_i} = \frac{\sum n_i P_i}{n} \tag{2}$$

with P_i : percentage of each aspect, P : weighted average percentage, n_i : number of questions for each aspect, and n : number of questions.

The classification of user satisfaction levels and the classification of e-module feasibility levels can be seen in Table 1 and Table 2.

Table 1. Classification of E-Module User Satisfaction Levels

| Range | Information |
|----------------|-------------------|
| 0% < P ≤ 25% | Very Dissatisfied |
| 25% < P ≤ 50% | Less satisfied |
| 50% < P ≤ 75% | Satisfied |
| 75% < P ≤ 100% | Very satisfied |

Table 2. Classification of E-Module Eligibility Levels

| Range | Information |
|----------------|-----------------|
| 0% < P ≤ 25% | Very Inadequate |
| 25% < P ≤ 50% | Not Worth It |
| 50% < P ≤ 75% | Worthy |
| 75% < P ≤ 100% | Very Worth It |

Result and Discussion

Needs Analysis

The needs analysis stage begins with literature studies and informal interviews with lecturers who teach quantum physics courses. The results of these studies concluded that quantum physics material was considered difficult by Physics Education students and that there was a lack of interactive e-module-based learning media for the history of quantum physics.

Design

At this stage, the researcher developed an interactive e-module learning media history of quantum physics assisted by a flip pdf professional based on the needs analysis results. The e-module developed is presented in an attractive, practical, concise manner and uses language that is easy to understand. The material presented is divided into each activity; four activities can be studied. Activity one presented background material on the birth of quantum physics with sub-discussions on the photoelectric effect, black body radiation, and the double slit experiment. Activity two presented material on the differences between quantum physics and classical physics. Activity three presented a timeline of the history of quantum physics with an explanation based on the year of discovery of the phenomena that underlie the birth of quantum physics. Most activities presented simple experimental material on quantum physics.

Apart from the material, the e-module includes two types of tests: formative and summative tests. Formative tests are packaged in gamification, conventional, and crossword puzzles. Summative tests and formative tests are presented conventionally and digitally equipped with answer keys. There are also learning experiments on quantum physics and videos, namely supporting material videos and experimental videos. The e-module can be accessed via the link <https://online.flipbuilder.com/drflg/drpl/>. Figure 1 shows the appearance of the developed e-module.

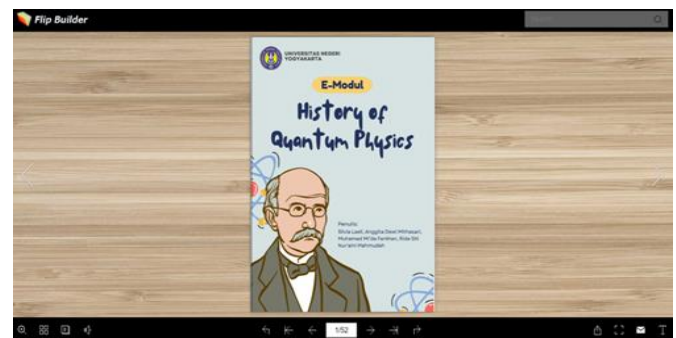


Figure 1. View of the e-module cover



Figure 2. Display foreword and table of contents



Figure 3. Activity page display



Figure 5. Sumative test display



Figure 4. Formative test display

Development

At the development stage (validation test results) of the history of quantum physics interactive e-module, validation was carried out by 11 master students in Physics Education at Yogyakarta State University as validators who would assess the suitability of the e-module which users would test. Validation is carried out by distributing material and media questionnaires, which the validator will fill out. The development stage produces qualitative data and quantitative data. Qualitative data in the form of suggestions and comments from validators. Then, for qualitative data, the validation test results can be seen in Table 3.

Table 3. Data on Suggestions and Comments on Validation Test Results by Validator

| Item | Suggestions and Comments |
|------|---|
| I | The module that has been created is suitable, all that remains is to finish it and tidy it up |
| II | The overall content of the module is good and continues to be improved. |
| III | The e-module used is quite good, engaging, and straightforward. |
| IV | The e-module used is good and very interesting to read. |
| V | Overall, it is good, and there are no comments yet because it is already interesting. |
| VI | The module is excellent, keep going |
| VII | It is pretty good and interesting |
| VIII | Suggestions for naming images: Perhaps it would be better if they were captioned. For example, image 1 shows light as a particle, image 2 shows light as a wave, etc. |
| IX | In formative tests (TTS), etc., it is a good idea for students to be able to fill them in directly on the website/ APK |
| X | Some pictures are not clear, and maybe they could be enlarged a bit |
| XI | It is good and can be improved again! |

In addition, at the development stage, quantitative data was also obtained from the material and media suitability questionnaire for the history of quantum physics interactive e-module. Table 4 shows the results of the quantitative data analysis of the e-module's feasibility.

Table 4. Results of E-Module Feasibility Validation Tests

| Aspect | Earned Score | Max Score | % | Category |
|-------------|--------------|-----------|------|---------------|
| Visual | 200 | 220 | 90.9 | Very Worth It |
| Ease of use | 202 | 220 | 91.8 | Very Worth It |
| Interactive | 206 | 220 | 93.6 | Very Worth It |
| Usefulness | 206 | 220 | 93.6 | Very Worth It |

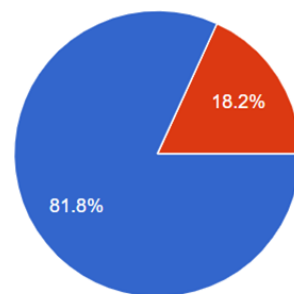


Figure 6. E-module feasibility diagram from the results research google forms

From the results of the validation test as shown in table 4, it can be seen that the history of quantum physics

interactive e-module is very suitable for use because, from the visual aspect, it is obtained at 90.9%, this shows that the visualization presented by the e-module is interesting to study, so it is very suitable for use by users. Furthermore, in the aspect of ease of use, a percentage of 91.8% was obtained, which shows that the e-module created is very easy to use from both laptops and smartphones, so it is categorized as very suitable for use. Then, in the interactive and usefulness aspects, the same percentage value was obtained, namely 93.6%, which

means that the e-module that has been created increases student activity in studying the material and helps students find information, so the history of quantum physics interactive e-module is very feasible. The following is a diagram of the conclusions of the 11 validators.

Figure 6 shows that 81.8% of the interactive quantum physics e-modules are suitable for use by users and ready to be tested, while only 18.2% experienced improvements.

Table 5. Conclusion Data for Suggestions and Comments from User Trials

| Item | Suggestions and Comments |
|------|---|
| I | The module developed is attractive, especially in its bright appearance. It is equipped with pictures and experimental videos; the material presented is structured systematically and is easy to read and study independently. Finally, a glossary containing important terms in quantum physics can be added if possible. |
| II | It's good and looks interesting to use in learning |
| III | Media is very easy to use and comfortable to read |
| IV | Division of information into clear points such as Did you know? make the material exciting and easier to follow and understand. Using illustrations or pictures helps clarify the concepts explained in the text. Suggestions may be added in the do-you-know section, for example, award winners from quantum physics or examples from everyday life from quantum physics. |
| V | Maybe to clarify the formula equation more clearly. Apart from that, it's okay |
| VI | Overall, the e-module is good |
| VII | The developed e-module is hoped to be used on a broader distribution among students. |
| VIII | It's good and can help you learn independently |
| IX | The visuals are very good in terms of design. Hopefully, the development team will make versions for other materials later. |

Implementation

The implementation phase of the interactive e-module history of quantum physics was tested on 27 undergraduate, postgraduate, and doctoral students in physics education at Yogyakarta State University and Ahmad Dahlan University who had taken courses in quantum physics or quantum mechanics. The trial implementation period was over two days, from 8 - 9 June 2024. The trial was carried out independently by the respondents. At this implementation stage, qualitative data and quantitative data are produced. Qualitative data are in the form of suggestions and comments from users. Qualitative data from the trial results can be seen in Table 5.

Table 6. Results of Quantitative Data Analysis of E-Module User Satisfaction

| Aspect | Earned Score | Max Score | Satisfaction Percentage |
|-----------------------------|--------------|-----------|-------------------------|
| Subject content | 295 | 324 | 91.05 |
| Language | 302 | 324 | 93.21 |
| Visual | 683 | 756 | 90.34 |
| Presentation | 488 | 540 | 90.37 |
| Usefulness | 198 | 216 | 91.67 |
| Weighted average percentage | | | 91.67 |

In addition, at this stage, quantitative data was also obtained from the user satisfaction questionnaire

regarding the history of the quantum physics interactive e-module. The results of the quantitative data analysis of e-module user satisfaction can be seen in Table 6.

The linguistic aspect received the most significant percentage of satisfaction, 93.21%, which shows that the grammar presented in the media is appropriate and easy for students to understand, so the percentage of satisfaction is high. Next there is the aspect of usefulness with a satisfaction percentage of 91.67%. The material aspect obtained a percentage of 91.05% and the presentation and visual aspects respectively obtained a percentage of 90.37% and 90.34%. Based on the percentage of satisfaction from each aspect, using equation (1), the weighted average percentage of satisfaction is obtained at 91.33% and is included in the very satisfied category.

Evaluation

At the evaluation stage, each step of the activity is assessed so that the media that has been created and developed is in accordance with needs. Based on the results of the feasibility test analysis by media and material expert validators, it was concluded that the history of quantum physics interactive e-module was worth testing without any improvements. Next, the researchers conducted a trial using a user satisfaction questionnaire. In the user satisfaction questionnaire,

there are products developed and guidelines for their use so that users can test the product independently. From the test results, it was concluded that users were very satisfied with the e-module. However, there are still suggestions and comments regarding further development of the e-module such as adding a glossary section, developing other materials, and displaying equations that need to be improved.

Conclusion

In this research, it was concluded that the results of the feasibility test of the history of quantum physics interactive e-module by media and materials experts obtained results that were suitable for testing without revision with a percentage of 81.8%. So that the e-module can be tested on undergraduate and graduate students in physics education. The results of the user satisfaction test show that the e-module can be used as a support for quantum physics learning media with a satisfaction percentage of 91.33% or very satisfied.

Author Contributions

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Conflicts of Interest

No conflict interest.

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