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Islamic Values-Oriented Mathematical Physics Module: Design, Validity, Practicality

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Abstract

Mathematical physics has been known as a complex subject for most students to understand. The Islamic values-oriented mathematical physics module was developed to support students learning independently and help them improve intellectually and spiritually in mathematical physics courses. This research aimed to determine the Islamic values-oriented mathematical physics module's development process, validity, and practicality. This research is R&D based on the 4D model, which consists of four steps, namely define (needs analysis and curriculum review), design (module design), develop (module validation with material, media, and tafsir expert validators), and disseminate (student and lecturer responses test). Two aspects related to the developed module are identified: validity and practicality. The validity aspect is obtained from the assessment results by expert validators.

Meanwhile, the practicality aspect was obtained from the responses from the lecturers and students who took the mathematical physics course. The novelty of the research is integrating Islamic values into the mathematical physics module so students can improve intellectual and spiritual aspects. The results of the assessment by the expert validator show that the Islamic-values-oriented mathematical physics module is valid and practical to use, with a percentage of assessment by material experts of 94% (excellent), assessment by media experts of 92% (very valid), and assessment by tafsir experts 97% (perfect). Meanwhile, the students' evaluation of the practicality of the module was 96% (efficient), and the evaluation by the lecturers was 97% (efficient). Further researchers are advised to develop research results by involving more research subjects with physics education students from other universities.

INTRODUCTION

The learning process at all levels of education requires students to be more independent in managing their time and learning process. Students must be able to adapt, organize, and control themselves [1], including when facing busy learning activities and complex tasks [2]. Therefore, an active and independent effort is needed by students to help them direct the learning process toward the goals they want to achieve [3]. Being independent in learning is one aspect that influences success in the learning process at school and in college [4] so that learning becomes more productive [5]. Millennial students must be able to study independently to be ready to face the challenges of the 21st century, especially in taking courses with a high level of difficulty, such as Mathematical Physics [6]. Students' independence in learning needs to be supported by a lecture

atmosphere and the availability of learning resources that can create aspects of autonomy in learning [7].

Mathematical physics is studied in the Physics Department and Physics Education Department. This course discusses the application of mathematics and the development of mathematical methods in solving physics problems. Physics problems are generally comprehensive because they relate to natural and abstract concepts [8] as well as microcosm to macrocosm, so they require students to have mathematical competence both analytically and quantitatively [9, 10] [10]. Students are also required to have the ability to think logically, systematically, critically, and creatively when solving problems [11] and use mathematical concepts and logic in solving problems related to the field of physics [11] [12].

Mathematical physics is mandatory in the Physics Education Department, Faculty of Tarbiyah and Teacher Training, Ar-Raniry State Islamic University of Banda Aceh. Based on the curriculum, the discussion of mathematical physics is divided into two, namely Mathematical Physics I and II. Mathematical Physics I discusses material related to basic mathematical theory for solving physics cases, such as infinite series, matrices and determinants, vector analysis, partial differentials, and multiple integrals [13]. A good understanding of mathematical physics will support the following semester's lectures in Mathematical Physics II. Mathematical physics supports learning other subjects such as mechanics, statistical physics, quantum physics, and magnetic electricity.

Several significant findings were obtained based on interviews with lecturers teaching mathematical physics, heads of department, and several students from the Physics Education Department at Ar-Raniry State Islamic University. Mathematical physics was considered difficult for students to understand. Based on the evaluation results, it was found that only around 35% of students got final grades of A, A-, B+, and B in this course, and many had to repeat or improve their grades in the following semester. Undoubtedly, this impacts students' study periods, which can increase, making it difficult for them to graduate on time. Apart from the problematic content of the material, another thing that influences this phenomenon is that students' initial mathematical abilities tend to be low, and there are no modules that support students in learning independently. The Physics Education Department also does not yet have a mathematical physics module based on Islamic values, even though it is essential to pay attention to support the achievement of the scientific vision and goals of the department. One innovation that can be carried out to increase students' understanding of mathematical physics is the development of teaching materials [14] [15].

The mathematical physics teaching module oriented towards Islamic values is one alternative solution to solve this case, considering that students must be willing to study independently to have optimal understanding in lectures with lots of mathematical equations. Besides, teaching modules based on Islamic values will help build student characters spiritually [16]. Islamic values are spiritual values in Islamic teachings contained in the Koran, and the behavior of the Prophet Muhammad SAW guides their implementation. Muslim values are defined as everything that plays a role in perfecting human life according to their nature [17] [18]. The values in Islamic teachings are divided into three types: the value of aqidah, the value of worship, and moral values. [19].

Several researchers have carried out many studies on the development of teaching modules. Billah (2019) developed a module for basic physics concepts to compile teaching modules that support the learning process and are appropriate to the characteristics of students and the learning environment. The results of the validation assessment for the appropriateness of the content, language, presentation, graphics, and context are all in the outstanding category, so the module created is suitable for use. Marisda (2021) conducted a study on the design and validity of modules with the 4D model and found that the Mathematical Physics module was declared very feasible. This module helps students learn more independently and better understand complex mathematical equations. Hikmah (2021) is also developing a Mathematics e-module based on Islamic values. This e-module is suitable for use and can increase understanding of Islamic character values such as religious attitudes, caring, honesty, discipline, and tolerance in students so they do not feel bored when studying.

It is essential to develop a mathematical physics module oriented towards Islamic values that supports students' independent learning because the module currently used is more suitable for non-

teaching students. Apart from being required in lectures, the development of this module also supports the department's scientific vision to produce qualified graduates with an Islamic character. This research aimed to determine the Islamic values-oriented mathematical physics module's development process, validity, and practicality.

RESEARCH METHODS

This research is a development research or R&D (Research and Development). The steps in this research consist of studying related research studies, developing products, testing, and making improvements to revise the weaknesses [20]. This research was carried out in March-June 2023 in the Physics Education Department, Faculty of Tarbiyah and Teacher Training, Ar-Raniry State Islamic University of Banda Aceh. The research subjects consisted of expert validators (material, media, and tafsir experts), mathematical physics lecturers, department heads, and the Physics Education Department students who program mathematical physics. This research procedure is guided by the Thiagarajan or 4D research and development stages, namely defining, designing, developing, and disseminating [13]. The details of the research stages can be explained in Table 1 below.

Table 1. Details of Research Activities

Steps	Activities
Define	a. I am conducting a needs analysis for Physics Education Department students learning mathematical physics through administering questionnaires.
	b. I am interviewing the lecturer who teaches mathematical physics and the head of the Physics Education Department.
	c. I am analyzing the Physics Education Department curriculum and teaching materials for mathematical physics courses.
Design	a. I am designing a mathematical physics module according to student characteristics and incorporating Islamic values.
	b. Develop indicators of student achievement in mathematical physics.
Develop	a. Validate the draft module that has been prepared with expert validators.
	b. Obtain a valid teaching module.
Disseminate	a. Conduct small group trials on students taking mathematical physics courses and lecturers of mathematical physics.
	b. Obtain a practical teaching module.

The instruments used to collect research data are: (1) questionnaires and needs analysis interview sheets, which aim to obtain initial information from students, teaching lecturers, and heads of study programs regarding the need for developing teaching modules; (2) validation sheet by expert validators, used to obtain validity assessments and input on the draft module developed from expert validators. This sheet consists of a validation sheet for material, media, and interpretation of Al-Quran verses and (3) questionnaire responses from students and lecturers aimed at finding out the practicality assessment and responses of students and lecturers to the module.

The data analysis carried out refers to the following stages: (1) analyzing the results of questionnaires and needs analysis interview sheets related to the need for developing teaching modules, as well as analyzing curriculum and teaching materials related to mathematical physics lectures; (2) analyzing the module draft validation sheet involving expert validators; (3) analyzing student and lecturer response questionnaire sheets for modules that have been validated and revised. The results of this response are tabulated, and the percentage is calculated using the equation above. (4) determines the category level of validity and practicality of the results obtained in points (2) and (3) based on Table 2 below.

Table 2. Module Validity and Practicality Categories [21]

Percentage (%)	Validity Level	Practicality Level
81-100	Very Valid	Very Practical
61-80	Valid	Practical
41-60	Fairly Valid	Fairly Practical
21-40	Less Valid	Less Practical
0-20	Invalid	Not Practical

RESULTS AND DISCUSSION

The development of the mathematical physics module that has been carried out consists of four steps, which can be explained in detail as follows. Developing a mathematical physics module toward Islamic values begins with a *define*d step. This step involves several essential activities, which can be explained as follows. The first activity is to conduct a needs analysis for Physics Education Department students who are programming mathematical physics courses by giving a questionnaire. Researchers distributed questionnaires to students to determine which courses required teaching modules [22] [23]. The results of the questionnaire analysis show that students of the Physics Education Department need a mathematical physics module that is easier to understand and supports students' independent learning.

Second, interview with the lecturer who teaches mathematical physics and the head of the Physics Education Department. From this interview, it was obtained that the lecturer still uses modules for non-physics education students in mathematical physics classes. If there is a particular teaching module for physics education students, implementing mathematical physics lectures will be more optimal because students are more supported in independent learning. The department also needs modules oriented towards Islamic values. It is essential to help achieve the scientific vision and objectives of the department, namely developing physics education science based on Islamic science and producing research through integration with Islamic sciences.

Third, analyze the Physics Education Department curriculum and the teaching materials for mathematical physics courses. From the results of this analysis, it was obtained that based on the KKNI curriculum year 2020, the study program has determined course learning outcomes and expected final abilities for mathematical physics courses which the students can: (1) use infinitive series to solve physics problems; (2) use matrix operations correctly to solve physics problems; (3) use vectors in various operations to solve physics problems; (4) use differential equations to solve physics problems; and (5) use multiple integrals in various operations to solve physics problems.

This second step in developing the mathematical physics module is design that aims to create a mathematical physics module design oriented towards Islamic values. This step utilizes the Canva and Microsoft Word 2016 applications guided by course learning outcomes and expected final abilities for mathematical physics courses. The module is designed on B5 size paper, portrait orientation, margins 3-3-3-2.5 cm, Arial 11 font, and spacing 1.15. On the first page of the module, a cover is presented, which was designed using the Canva application with a black base color and silhouettes of mathematical notations. Next, there is a foreword that outlines the initial idea for writing the module and its characteristics, as well as a table of contents that aims to make it easier for module users to find pages on the subject to be studied. The description and instructions for using the module aim to make it easier for users. The design of the module is presented in Figure 1 below.

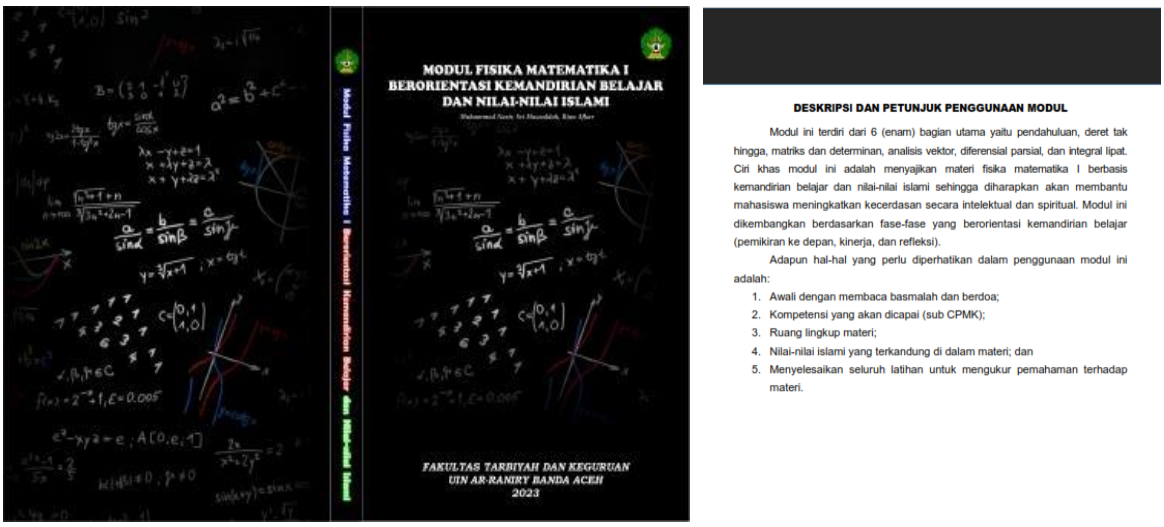

Figure 1. Design of cover and description instructions for using the module

The material in this module consists of six chapters, comprising an introduction, infinite series, matrices and determinants, vector analysis, partial differentials, and multiple integrals. Each chapter (except the introductory chapter) has example questions and exercises that users can use to measure their understanding of the material being studied. Meanwhile, each subject is always linked to verses from the Koran and Islamic values that can be obtained from the concepts contained in the material. These Islamic values include piety, honesty, hard work, wisdom, generosity, tolerance, trust, and respect for the rights and obligations of every human being. From the infinite series of materials, students can learn about coexistence and tolerance towards other people (Ar-Ra'd: 4 and Al-Baqarah: 261). Students can learn about hard work, wisdom, unity, and endurance from matrices and determinants (Ash-Shaff: 4 and Al-An'am: 128). Meanwhile, vector analysis material teaches the students many things about honesty, trust, and generosity (Ar-Rahman: 60 and An-Nisa: 123). Students also can learn from partial differential and multiple integrals some values such as generosity, respect for rights, and piety (Al-Baqarah: 261 and Al-Qasash: 88). Example of Islamic values presented in the module is shown in Figure 2 below.

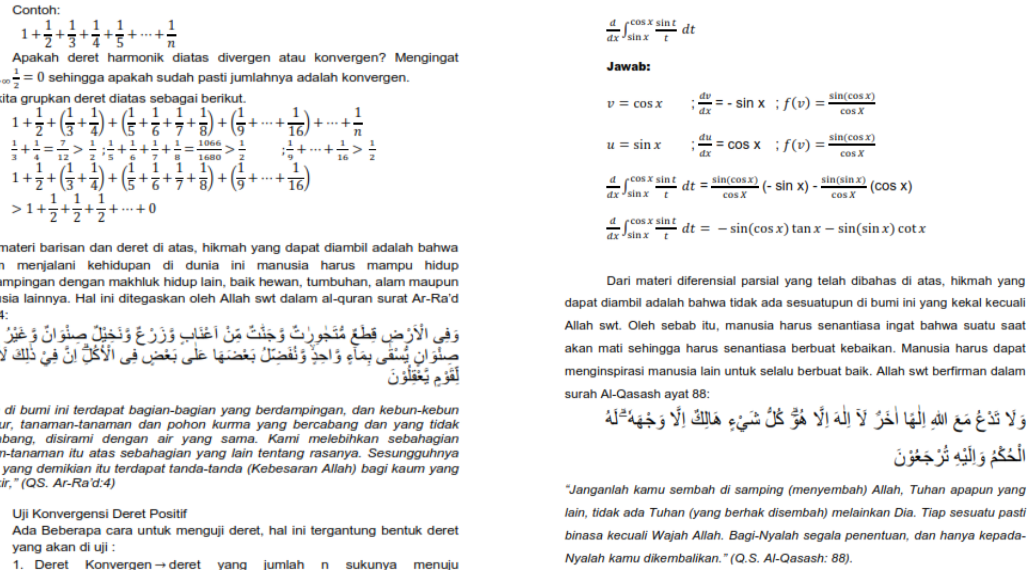

Figure 2. Examples of Islamic values presented in the module

The next step is to develop. The validity of the module that has been designed is tested by expert validators to obtain suggestions in the form of constructive input in module development. The validators who will test the validity of the module consist of two media experts, two material

experts, and two experts in interpreting Koran verses (tafsir expert). The results obtained for the module validity assessed by validator experts are presented in Figure 3 below.

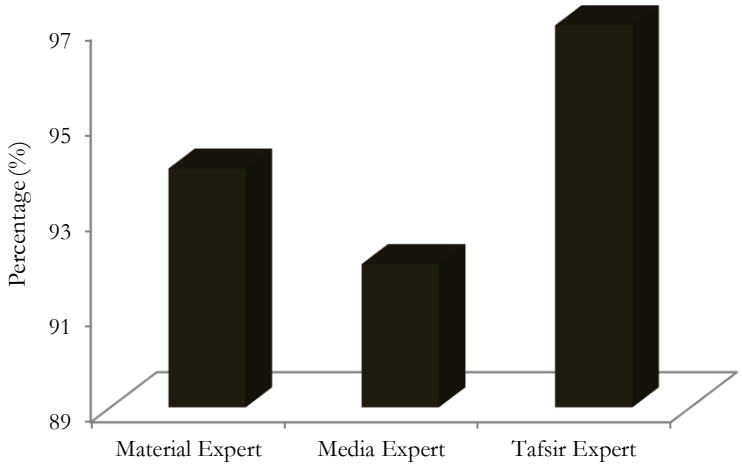

Figure 3. Results of module validity assessment by expert validators

Based on the graph above, it can be stated that the assessment by tafsir experts obtained the highest score, namely 97% (very valid), then the evaluations by material experts with a score of 94% (excellent), and an assessment by media experts with a score of 92% (very valid). The overall validation results by expert validators can be obtained by adding all the assessment scores by each expert validator and then dividing them by the maximum score so that 94% is received in the very valid category. These results are not much different from those obtained by Ramadhan (2020), who developed a basic physics e-module based on independent learning using the 4D model. The material expert validator scored 90% (very valid), while the media expert gave 82% (very good). The product user assessment results received a score of 4.24 (excellent) [24]. Marisda (2021) also carried out the design and validity of the mathematical physics module with a 4D model and found that the module on systems of linear equations and matrices was categorized as very suitable for use, with a score of 80.5. The indicator with the highest score from expert validators is adaptive (90), and the lowest score is self-contained (70) [13].

The last step in developing the module is dissemination. At this step, the module is distributed to students and lecturers to obtain information regarding its practicality. The practicality of a module can be seen from several aspects, namely ease of use, attractiveness, and straightforward interpretation by users. Determine if the limited trial was conducted on 16 students of the Physics Education Department and two lecturers teaching mathematical physics courses. The results obtained for the module practicality are presented in Figure 4 below.

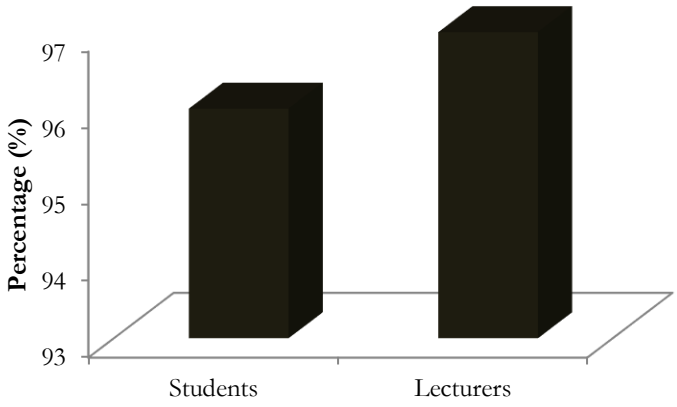

Figure 4. Results of module practicality assessment by students and lecturers

Based on the graph above, it can be stated that the assessment of students and lecturers to the mathematical physics module showed that the lecturers' and students' responses obtained a practicality percentage of 96% (very practical) and 97% (efficient). These results show that the mathematical physics module oriented towards Islamic values is convenient—research conducted by Nuraini (2023) regarding developing modern physics teaching modules. The teaching module developed is suitable for use. The average score obtained from the material validator was 3.4 (very good), the score from the media validator was 3.4 (very good), and student responses from the limited trial results gave a result of 75.6% (high) [15]. Pratiwi (2019) also developed a linear algebra teaching module based on Islamic values, which received a student response assessment that the linear algebra module was perfect for lecture use [25].

Mathematical physics discusses the application of mathematics and developing mathematical methods to solve complex and abstract physics problems [26]. Mathematical physics is a subject that is considered problematic by the majority of students [27] [28], even though this subject plays an essential role in supporting the learning of other subjects such as mechanics, statistical physics, quantum physics, and magnetic electricity [29]. According to Ramadhan's (2020) and Marisda's (2021) research, Several factors cause this phenomenon, such as students' low basic mathematics abilities and the available modules not following students' characteristics. Murtafiah (2022) and Prahastiwi (2023) also find that mathematics ability relates to learning physics. Mathematics ability affects students' physics cognitive aspect. It is hoped that the presence of this module will be an appropriate learning reference for physics and physics education students to understand mathematical physics more independently. In the end, students will be able to master physics more comprehensively as a preparation for later entering the world of work [30], both in educational institutions and other institutions.

The Islamic values-oriented mathematical physics module developed using a 4D model consists of four steps: define, design, develop, and disseminate. The module is suitable and very valid for use with a percentage of assessment by material experts of 94%, assessment by media experts of 92%, and assessment by experts of interpretation of Koran verses of 97%. These results differ significantly from those obtained by Ramadhan (2020) and Marisda (2021), who developed a basic physics e-module based on independent learning using the 4D model. Both of them got a very valid assessment from the experts. The Islamic values-oriented mathematical physics module is also convenient, with a 96% student assessment score and 97% by the lecturer. This result aligns with research conducted by Nuraini (2023) regarding developing modern physics modules. The results are similar to those of Pratiwi (2019), who developed a linear algebra teaching module based on Islamic values and received a student response assessment that the linear algebra module was perfect for lecture use.

CONCLUSION

Based on the analysis of research data, it can be concluded that the process of developing the Islamic values-oriented mathematical physics module has been carried out using a 4D model which consists of four steps, namely define (needs analysis and curriculum review), design (module design), develop (module validation with material expert validators, media, and interpretation of Koran verses), and disseminate (testing responses from students and lecturers). The mathematical physics module is suitable and valid for use with a percentage of assessment by material experts of 94% (excellent), evaluation by media experts of 92% (perfect), and assessment by experts of interpretation of Koran verses of 97% (very valid). The module is also efficient, with the practicality assessment by students at 96% (efficient) and the assessment by the lecturer at 97% (efficient). Further researchers are advised to develop research results by involving more research subjects from other universities with Physics Education Department students.

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