M A T H L I N E
JURNAL MATEMATIKA DAN PENDIDIKAN MATEMATIKA
ISSN 2502-5872 (Print)
ISSN 2622-3627 (Elektronik)

Volume 7 Nomor 1, Februari 2022, halaman 131-141

DEVELOPING INQUIRY BASED MODULE FOR ORDINARY DIFFERENTIAL EQUATION COURSE

PENGEMBANGAN MODUL BERBASIS INKUIRI PADA MATA KULIAH PERSAMAAN DIFERENSIAL BIASA

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ABSTRAK

Penelitian ini bertujuan untuk mengembangkan modul berbasis inkuiri pada mata kuliah persamaan diferensial biasa yang valid dan praktis. Hal ini dilatarbelakangi oleh kesulitan mahasiswa dalam mempelajari materi persamaan diferensial biasa disebabkan karena buku teks yang digunakan belum mampu menarik perhatian mahasiswa untuk mempelajari sendiri materi sehingga menyebabkan mahasiswa kurang termotivasi untuk belajar. Oleh karena itu perlu dirancang sebuah modul yang dapat membantu mahasiswa dan memberikan kesempatan untuk menemukan sendiri konsep dan berbagai cara menemukan solusi dari berbagai bentuk persamaan diferensial. Jenis penelitian ini adalah penelitian pengembangan dengan rancangan penelitian yang terdiri atas 3 tahap yaitu tahap define (pendefenisian), tahap design (perancangan), tahap develop (pengembangan). Instrumen penelitian yang digunakan adalah lembar validasi untuk mengukur validitas modul, dan angket respon untuk mengukur kepraktisan modul. Hasil penelitian menunjukkan bahwa modul berbasis inkuiri pada mata kuliah persamaan diferensial biasa 1) sangat valid dalam aspek kelayakan isi, penyajian, kebahasaan dan kegrafikan, 2) sangat praktis dalam aspek mudah digunakan, menarik dan efisien.
Kata kunci: Modul, Inkuiri, Persamaan Diferensial Biasa

ABSTRACT

This study aims to develop an inquiry-based module for ordinary differential equations course that is valid and practical. This is motivated by the difficulty of students in studying ordinary differential equations material because the textbooks used have not been able to attract students' attention to study the material themselves, causing students to be less motivated to learn. Therefore, it is necessary to design a module that can help students and provide opportunities to find their own concepts and various ways of finding solutions to various forms of differential equations. This type of research is development research with a research design consisting of 3 stages, namely the define stage, the design stage, and the develop stage. The research instrument used was a validation sheet to measure the validity of the module, and a response questionnaire to measure the practicality of the module. The results showed that the inquiry-based module in the ordinary differential equations course was 1) very valid in terms of the feasibility of content, presentation, language and graphics, 2) very practical in terms of being easy to use, attractive and efficient.
***Keywords**: Module, Inkuiri. Ordinary Diferential Equation*

How to Cite: Yuberta, K. R. (2022). Developing Inquiry Based Module For Ordinary Differential Equation Course. *Mathline: Jurnal Matematika dan Pendidikan Matematika*, Vol. 7 No. 1, 131-141.
DOI: https://doi.org/10.31943/mathline.v7i1.274

PRELIMINARY

Differential equation is a branch of mathematics that expresses a complex relationship between one dependent variable and one or several other independent variables. This Differential Equation has developed since the time of Isaac Newton and Leibnitz and until now has a large role and is widely applied in various fields of science such as physics, engineering, biology, chemistry, ecology, economics and other sciences (Oktavia & Pramujiyanti, 2016). The term differential equation was introduced by Leibniz in 1676 (Yunika & Rohana, 2018). By using differential equations we can compose and solve mathematical models formed from problems in everyday life (Rejeki & Setyaningsih, 2016).

In this course, students are required to be actively involved in understanding and finding solutions to various forms of ordinary differential equations using various learning resources that have been determined. So they are focused on discussing the subject matter and doing exercises in solving ordinary differential equations based on the understanding they have gained. So that later students can master this course so that it can be applied to other scientific fields.

However, the reality on the ground shows that not all students have been able to achieve the expected lecture goals. Many students find it difficult to master the ordinary differential equations lecture material, including the difficulty to apply the theorem in solving differential equations. Based on observations in ordinary differential equations lectures at Institut Agama Islam Negeri Batusangkar, students have difficulty understanding the concepts being taught because of the high dependence of students on lecturers in understanding the material. They only rely on explanations from lecturers without wanting to find out in advance about the material to be studied from other sources such as books, the internet or other learning resources. Textbooks used by students are also limited to only the main books used by lecturers without any other references.

In addition, the textbooks used in the learning process have not been able to attract the attention of students to study the material themselves. The presentation of the material contained in textbooks and practice questions is still not able to help students learn to understand it effectively and comprehensively. In addition, the textbooks used did not involve students actively in making discoveries in order to build concepts on the material they were studying, resulting in students easily forgetting the material they had learned. Students' misunderstanding of the presentation of material in the textbooks used causes

students to be less motivated to study independently. They only rely on the lecturer's explanation without any desire to find a solution to the existing problems.

Seeing the existing problems, it is necessary to develop a teaching material that can activate students so that they become more familiar with the lecture material and become more independent in finding solutions to differential equations. One of them is the inquiry-based module. Previous studies have shown that using modules in learning can improve student learning outcomes (Hamdunah, et al, 2016; Kariman, et al, 2019). With the module students are given the opportunity to find their own concepts and various ways of finding solutions to various forms of differential equations.

In a book published by Diknas (Prastowo, 2012), the module is defined as a book written with the aim that students can learn independently without or with teacher guidance. The explanation states that with the module students can learn independently even though there is no teacher in the learning process. With the module, it is hoped that the limitations of the textbook can be overcome, because the material in the module is packaged more attractively with language that is easier to understand and presents important information about the material and can challenge students to solve the problems given.

To produce a good module, it is necessary to pay attention to the characteristics needed in making the module (Suastika & Rahmawati, 2019), namely: (a) Self-instruction, allowing one to learn independently and not depending on other parties; (b) Self contained, all required learning materials are contained in the module; (c) Stand alone, a module that does not depend on other teaching materials/media; (d) Adaptive, adapted to science and technology; (e) User friendly, the module should use simple language, easy to understand, and use commonly used terms; (f) Consistency in the use of fonts, spacing, layout; and (g) Have a clear writing organization.

The module with the inquiry approach is a module developed using the principles of inquiry learning strategies. Inquiry learning is learning that involves all students' abilities to the fullest to seek and investigate systematically, critically, logically and analytically, so that students can formulate their own findings with confidence (Suyadi, 2013). In the learning process, many students are involved in learning activities to find solutions to the problems they face. In this kind of learning process, educators act as facilitators and guides for students, so that they can be more focused so that the learning process goes well and learning objectives are achieved according to the previous design. So the inquiry-based learning module is a learning media designed based on an inquiry

learning model which can allow students to be more active in learning and be able to find solutions to the problems given themselves.

In addition, inquiry can also develop values and attitudes that are needed by students to be able to think scientifically (Suyadi, 2013). This is also in line with Wayan's opinion (2017) that inquiry learning aims to develop the level of thinking and critical thinking skills. In addition, inquiry learning can also produce better mathematics learning achievement (Mashuri, 2012). Based on this, the aim of this research is to develop an inquiry-based module in the subject of ordinary differential equations that is valid and practical.

METHOD

Referring to the research objectives that have been stated, this research is classified as research and development, which is a research method used to produce certain products, and test the effectiveness of these products (Sugiyono, 2017). This research was conducted at Institut Agama Islam Negeri Batusangkar involving 32 fifth semester students majoring in Mathematics Education IAIN Batusangkar.

The development of module is carried out with a 4-D model, which consists of Define, Design, Develop and Disseminate (Trianto, 2009) as follows: (1) Defining Phase, this stage aims to determine and define the form of the module. In determining and determining the form of the module, it begins with an analysis of the needs of the developed module. (2) Design Phase, this stage aims to prepare a prototype module. Prototype preparation is done by determining the components that must be in the module and the structure of the designed module. (3) Development Phase, this stage aims to produce an inquiry-based module in the ordinary differential equations course that has been revised based on input from experts. (4) Dissemination stage, this stage is the stage of using mathematics modules that have been developed on a wider scale. However, in this study, the research procedure only reached the development stage.

Data were collected through validation sheets and questionnaires. The validation sheet aims to collect data on the validity of the inquiry-based module in the ordinary differential equations course that was developed. Practical data were obtained through student response questionnaires.

After obtaining data for each validation sheet used from several validators, then look for tabulation of the data using the formula:

$$P = \frac{Total\ score\ for\ each\ item}{maximum\ score} \times 100\%$$

Based on the percentage results, each aspect is categorized as in table 1 (Riduwan, 2007).

Table 1. Validity Category

Interval	Category
0,00 <$P\leq$ 0,20	Invalid
0,20 <$P\leq$ 0,40	Less valid
0,40 < $P \leq$ 0,60	Quite valid
0,60 <$P\leq$ 0,80	Valid
0,80 <$P\leq$ 1,00	Very valid

Student response data on the ease of using the product from the response questionnaire was processed using the formula:

$$P = \frac{Total\ score\ for\ each\ item}{maximum\ score} \times 100\%$$

Based on the percentage results, each aspect is categorized as in table 2.

Table 2. Praticality Category

Interval	Category
0,00 <$P\leq$ 0,20	Impractical
0,20 <$P\leq$ 0,40	Less practical
0,40 < $P \leq$ 0,60	Quite practical
0,60 <$P\leq$ 0,80	Practical
0,80 <$P\leq$ 1,00	Very Practical

RESULT AND DISCUSSION

Research on the development of an inquiry-based module in the ordinary differential equation course is carried out in 3 stages, namely the definition stage, the design stage and the develop stage. The following is a description of each stage:

1. Define Stage

This stage begins with analyzing problems in lectures on ordinary differential equations courses. At this stage it is known that it is known that students have difficulties in understanding the material of ordinary differential equations. This is evidenced by the number of students who get low grades from year to year. This is because students have difficulty in learning the material from the textbooks used. Many students complained that the presentation of the textbooks used was difficult to understand. Moreover, the language of instruction for the textbook is English. So that they are overwhelmed in interpreting every definition and theorem in order to understand the problem to find a solution to the

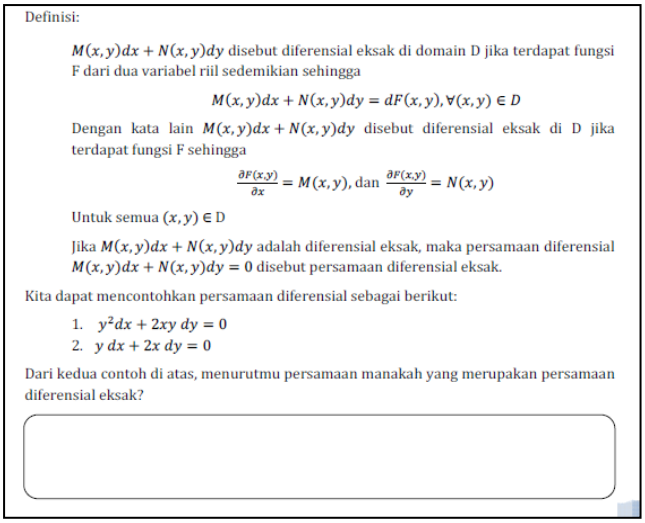
given ordinary differential equation. This causes students to only rely on explanations from lecturers without wanting to find out for themselves the material to be studied. Therefore, it is necessary to develop a module so that students can learn independently. The same thing was expressed by Tjiptiany et al (2016) that in order for students to be actively involved and have direct experience in the learning process, the module must be packaged in learning so that students construct their own knowledge, namely inquiry learning.

2. Design Stage

Based on the results at the definition stage, the next stage is the design stage. This stage is carried out to design and prepare a prototype of the module. The module developed in this study has the following characteristics: (1) contains initial material on ordinary differential equations; (2) inquiry-based in which the presentation of the material contains the steps and principles of inquiry learning; (3) the modules developed are arranged as simply as possible to accommodate the practical value of the modules. The module refers to the module components, namely: lecturer instructions, college student activity sheets, college student worksheets, college student worksheet keys, test sheets and test sheet keys (Rudi & Cepi, 2007).

The description of the material in the module is sourced from several ordinary differential equations textbooks. The presentation of the material is adjusted to the principles and steps of inquiry learning, where students are required to find and investigate problems so that they can formulate their own findings. The inquiry learning process in the module follows the following steps:

1) Orientation, in the module, learning outcomes are presented so that students know the goals to be achieved and are ready to carry out the learning process.
2) Formulating the problem, in the module a problem is presented after students know a certain definition or theorem. Students will analyze the definitions or theorems given through the examples given.
3) Formulating hypotheses, before analyzing the problem, students will formulate temporary answers to the problems given. One example of the module as shown in Figure 1.



Definisi:

$M(x,y)dx + N(x,y)dy$ disebut diferensial eksak di domain D jika terdapat fungsi F dari dua variabel riil sedemikian sehingga

$$M(x,y)dx + N(x,y)dy = dF(x,y), \forall (x,y) \in D$$

Dengan kata lain $M(x,y)dx + N(x,y)dy$ disebut diferensial eksak di D jika terdapat fungsi F sehingga

$$\frac{\partial F(x,y)}{\partial x} = M(x,y), \text{ dan } \frac{\partial F(x,y)}{\partial y} = N(x,y)$$

Untuk semua $(x,y) \in$ D

Jika $M(x,y)dx + N(x,y)dy$ adalah diferensial eksak, maka persamaan diferensial $M(x,y)dx + N(x,y)dy = 0$ disebut persamaan diferensial eksak.

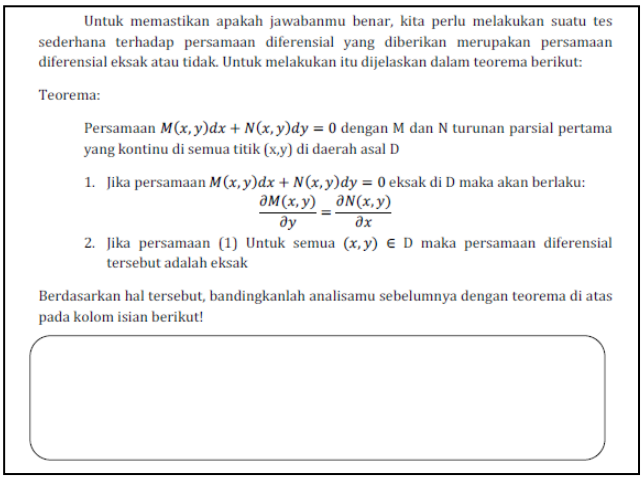
Kita dapat mencontohkan persamaan diferensial sebagai berikut:

1. $y^2dx + 2xy\,dy = 0$
2. $y\,dx + 2x\,dy = 0$

Dari kedua contoh di atas, menurutmu persamaan manakah yang merupakan persamaan diferensial eksak?

Figure 1. Formulating the Hypothesis on the Module

4) Collecting data, students will look for the information needed to test the proposed hypothesis.
5) Testing the hypothesis, after collecting the necessary information students will test the proposed hypothesis. Collecting data and testing hypotheses on the module can be seen in Figure 2.



Untuk memastikan apakah jawabanmu benar, kita perlu melakukan suatu tes sederhana terhadap persamaan diferensial yang diberikan merupakan persamaan diferensial eksak atau tidak. Untuk melakukan itu dijelaskan dalam teorema berikut:

Teorema:

Persamaan $M(x,y)dx + N(x,y)dy = 0$ dengan M dan N turunan parsial pertama yang kontinu di semua titik (x,y) di daerah asal D

1. Jika persamaan $M(x,y)dx + N(x,y)dy = 0$ eksak di D maka akan berlaku:
$$\frac{\partial M(x,y)}{\partial y} = \frac{\partial N(x,y)}{\partial x}$$
2. Jika persamaan (1) Untuk semua $(x,y) \in$ D maka persamaan diferensial tersebut adalah eksak

Berdasarkan hal tersebut, bandingkanlah analisamu sebelumnya dengan teorema di atas pada kolom isian berikut!

Figure 2. Testing the Hypothesis on the Module

6) Formulating conclusions, after collecting data and testing hypotheses, students formulate conclusions from what they have found.

The criteria for the success of learning with an inquiry strategy are not determined by the extent to which students are able to master the material but the extent to which students are active in searching and finding something (Suyadi, 2013). So the module is designed so that students have activities in finding. The module is also equipped with

blank columns provided to encourage students to think critically and to give students the freedom to try according to the development of their reasoning abilities. This is in accordance with the conditions required for the emergence of inquiry activities to students, namely an open atmosphere that invites students to discuss (Trianto, 2009).

3. Develop Stage

The next stage is the development stage. The following describes the steps taken:

a. Validation

After the module has been designed, the module is validated by 3 validators who are experts in the field of education and have taught ordinary differential equations courses. Several discussions with the validator resulted in some improvements. Following are the results of the module validation from each validator in table 3.

Table 3. Module Validation Results

Aspects	Validator rating	Max Score	%	Category
Content	94	108	90.33	Very Valid
Presentation	118	132	93.09	Very Valid
Language	41	48	89	Very Valid
Graphical	57	72	80.5	Very Valid
Total	310	360	86.1	Very Valid

Based on table 3, it can be seen that the results of the inquiry-based module validation in the ordinary differential equations course are in the very valid category with a percentage of 86.1%. This is in line with the opinion of Prabowo et al (2016) which states that if the results of the analysis show valid results then the module is feasible to use, whereas if the results are invalid then further revision is necessary.

b. Practical stage

The module that has been validated and improved according to the validator's suggestions is tested on a limited group of students consisting of 10 students. The aim is to see if there are still deficiencies in the module that must be improved and to see the obstacles faced by students in using this module. The weaknesses of the modules that were tested in small groups were then corrected and then tested on large groups. In a small group limited trial, it was found that students responded positively to the module in the ordinary differential equations course but in the module there were still some writing errors. One of them is a typo in the problem so that the differential equation cannot be solved. After being repaired, the module was tested on 32 students taking ordinary differential equations courses. In this

trial, students are given a module as a learning resource in ordinary differential equations lectures. Then students were asked to fill out a questionnaire to see the student's response to the use of the module in lectures. The results of the questionnaire can be seen in table 4.

Table 4. Questionnaire Results

Aspects	Total Score	Max Score	%	Category
Easy to use	673	768	92,97	Very Practical
Interesting	424	512	82,81	Very Practical
Efficient	346	384	90,1	Very Practical
Total	1443	1664	86,72	Very Practical

Based on the questionnaire that has been filled out by students, the highest percentage is on ease of use due to the instructions for using the module with a percentage of 92.97%. For the attractiveness aspect of the module, the use of color in the module has the lowest percentage, which is 79.81%. This is because the color composition of the module is still lacking, so it still needs to be added. As for the efficiency aspect, the activity items in the module can be done by students individually and in groups having the highest percentage of 91.41%. This is in line with the opinion of Sukardi (2009) which states that the practicality of a product is seen from the aspect of ease of use, attractiveness and efficiency.

Based on student comments on the questionnaire given, this module is very helpful and makes it easier for them to understand ordinary differential equations. This is because the language used is easier to understand. Then the student suggested that the module add more examples of questions and their discussion. In addition, they suggested that the module be continued for all subjects of ordinary differential equations.

CONCLUSION

This research has produced an inquiry-based module in a valid and practical ordinary differential equation course, with the characteristics of loading the initial material on ordinary differential equations, inquiry-based which in the presentation of the material contains the steps and principles of inquiry learning, arranged as simply as possible to accommodate practicality values. from the module. The results of the inquiry-based module validation in the ordinary differential equation course are very valid based on the assessment of 3 validators in terms of the feasibility of content, presentation, language, and graphics with an average score of 86.1%. While the results of the trial were limited to 32

fifth semester students who took ordinary differential equations courses, the modules developed were very practical for aspects that were easy to use, attractive, and efficient. For further development, all materials in the ordinary differential equations course can be tested and their effectiveness tested.

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