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Validity of Physics Module Development in Electronics Subject Project-Based Operational Amplifier Material

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Abstract

This study aims to develop teaching materials in physics learning modules in project-based operational amplifier material electronics courses that are valid for use. This type of research is development research with a research and development method and a 4-D development model that includes four stages: define, design, develop, and disseminate. However, this research is limited to the development stage. The test subjects in this study were two validators, material expert validators and media experts. The data collection instrument is a validated questionnaire. The results of the questionnaire obtained from this development research are as follows: (1) The validity of the physics module in the project-based operational amplifier material electronics course is declared very valid with a percentage of (85%) in terms of material aspects. (2) The validity of the physics module in the project-based operational amplifier material electronics course is declared very valid, with a percentage value of 86% in terms of media aspects. So, it can be concluded that the physics learning module in the project-based operational amplifier material electronics course is valid for use as teaching material. This study implies that the module developed can serve as a supplement to educational activities.

Keywords: operational amplifier; project-based learning; teaching materials

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INTRODUCTION

Education is paramount to cultivating high-quality human resources. The government conveyed one of the efforts that can be applied in Indonesia to enhance the quality of education, namely through the education system commonly referred to as the curriculum. As we know today, Indonesian schools use an independent curriculum. (Adeliya, 2021; Hanushek & Woessmann, 2008; Khoirurrijal et al., 2022). The independent learning curriculum is a framework intended to promote greater student autonomy (Manalu et al., 2022). Throughout the learning process, students will play a more active role in this curriculum than lecturers, who act as facilitators and mediators. In higher education, the independent learning curriculum is called an independent campus. The main objective of the

independent learning curriculum or campus is to increase independent, interactive, and collaborative learning and create high learning creativity (Collison et al., 2020; Kapur, 2014).

Teaching materials greatly affect achieving the main learning objectives on an independent campus. Using teaching materials during learning can make learning run smoothly, effectively, and efficiently toward achieving goals. (Alammary et al., 2020; Tomlinson, 2017). Without teaching materials, students have difficulty adapting during learning, and lecturers will face difficulties in increasing the effectiveness of learning (Pujaningsih et al., 2022). At the tertiary level, many types of teaching materials allow them to be used as guidelines during the learning process, one of which is very common, namely books or e-books (Rockinson et al., 2013).

The use of books or e-books as teaching materials in the current era is considered less effective and tends to be monotonous. This is because, so far, the books provided and used are limited and monotonous, not considering the abilities and needs of students (Waryanto et al., 2017; Woody et al., 2010). According to findings from interviews conducted with instructors teaching Electronics courses at the Physics Education Department of Jambi University, the teaching materials currently used are limited to textbooks or e-books and simple practicum guides, which means that lecturers do not use modules as teaching materials during learning time. This condition results in ineffective and efficient use of time during teaching and learning activities (Ratu, 2015; Tohir et al., 2015). Therefore, there are various ways that a lecturer can make the learning and teaching process successful and efficient, one is to innovate in developing educational resources appropriate for student needs.

Modules are one example of teaching materials that are suitable for students. Modules are structured and systematic to facilitate students' understanding of the concept of material or certain topics. Modules serve as key elements in facilitating the learning process by aiding students in accessing crucial information about the course materials (Parmin & Peniati, 2012). In addition, using modules as teaching materials is more practical and efficient than using other teaching materials. This is because modules can be a solution for overcoming the limitations of space, time, and sensory power to motivate students' learning spirit and allow them to learn individually according to their interests and abilities (Sadiq & Zamir, 2014).

In addition to teaching materials, choosing an appropriate learning model greatly impacts the effectiveness of the educational material. An approach that corresponds to real-life situations, such as project-based learning. Proves to be highly influential, focusing on improving students' ability to solve a problem in the form of a project that is carried out in the long term (Angreni, 2018; Sari, 2018). Project-based learning facilitates the delivery of learning concepts, makes learning more realistic, makes learning situations active and not monotonous, builds learning motivation and the ability to collaborate, and promotes student engagement in communication and reasoning skills (Mahendra, 2017; John, 2018).

Septi et al. (2019) conducted a study entitled “Development of Physics Modules with Project-Based Learning on Optical Tool Material." This indicates that the physics module developed using a project-based learning approach falls within a highly credible category and has been successfully validated, achieving an effectiveness rate of 82.35%. Although it has been done in previous studies, there are several advantages to the research

that are not in previous studies. First, previous research has not developed operational amplifier material in electronics courses. In previous studies, the modules developed were not equipped with simulation activities and direct project assignments. In contrast, in this study, the modules were developed with simulation activities and direct project assignments. The researcher is intrigued to pursue a study titled "Validity of Physics Module Development in Electronic Subject Project-Based Learning Operational Amplifier Material." Given the context outlined in the problem statement, this study aims to assess the validity of the developed module for instructional use.

METHOD

This research refers to the R&D design. The research and development methodology aims to generate a specific product, which is subsequently evaluated to assess its efficacy (Sugiyono, 2018; Akker et al., 2020). This research will produce a physics module focusing on project-based learning of operational amplifier electronics. Which was developed by Employing the 4-D development model pioneered by S. (Thiagarajan, 1974), which encompasses four stages: (1) define, (2) design, (3) develop, and (4) disseminate.

The first phase is defined, which is the initial step in determining and defining learning requirements based on examining the material's goals and constraints and collecting information related to the product being developed (Dempsey & Van Eck, 2018; Richey et al., 2019). Furthermore, the design phase involves developing a learning module according to the specified learning objectives in the previous stage that can be used in physics learning, including format selection and storyboarding (Fatikhah & Izzati, 2015; Malik & Sukiman, 2021). The third stage is the development stage. At this phase, product validation will be conducted by validators who assess the outcomes of the developed products and incorporate revisions based on feedback, suggestions, and responses from these validators (Khasanah & Sunarti, 2017). The last stage is the dissemination stage. However, this study is confined to the development phase only. Confined solely to the development phase.

The trial sample in this study consisted of two validators, consisting of material expert validators and media experts. Data collection instruments gather information or measure variables in a research study (Yusup, 2018). This study's collection instrument consisted of an initial needs questionnaire sheet, an interview sheet, and a material and media expert validation sheet.

Analysis data is a technique utilized to identify the description of data, relationships between data, data semantics, and data boundaries contained in an information system (Taherdoost, 2020). In the context of this research, following data collection, the subsequent step involves analyzing the gathered data based on the results of the questionnaire assessment. The questionnaires to be analyzed include the initial needs questionnaire and material and media validation questionnaires.

The initial needs analysis questionnaire is obtained from scoring, which refers to the assessment criteria using a Guttman scale; namely, the answer "yes" is given a score of one, while the answer "no" is given a score of zero. Table 1 shows the Guttman scale score criteria.

Table 1 Guttman scale score criteria

No	Scale of Answer	Score
1	Yes	1
2	No	0

(Sugiyono, 2018)

Material and media expert validation questionnaires. Validation questionnaires by material and media

experts produce qualitative and quantitative data. Qualitative data comprises validator assessments presented as comments and suggestions for enhancement, subsequently utilized for revising the module. Table 2 shows the quantitative data obtained from filling out the validation questionnaire for material and media experts using a Likert scale.

Table 2 Likert Scale Score Criteria

No	Scale of Answer	Score
1	Completely agree	5
2	agree	4
3	Less agree	3
4	disagree	2
5	Completely disagree	1

(Akbar, 2013)

The data from the questionnaire can be interpreted to conclude the validation of the developed module. This interpretation makes it possible to determine whether the module is categorized as highly valid, valid, moderately valid, invalid, or highly invalid, as shown in Table 3.

Table 3 Validation questionnaire interpretation criteria

No	Interval	Category
1	81-100%	Highly Valid
2	61-80%	Valid
3	41-60%	Moderately Valid
4	21-40%	Invalid
5	0-20%	Highly Invalid

(Akbar, 2013)

RESULTS AND DISCUSSION

Define phase. The defining phase aims to identify all learning requirements and gather relevant information pertaining to the product to be developed. There are five steps in the defining stage, as follows:

Analyze Front-end. The initial analysis aims to identify the basic problem as the first step in making the module to be developed. During this phase, researchers initially conducted a literature review to assess the availability of instructional materials for electronics courses in the educational process (Morrison et al., 2017). The outcomes derived from this literature review show very limited use of teaching materials in learning electronics courses. Furthermore, researchers also conducted an initial study by interviewing one of the lecturers teaching electronics courses to identify teaching materials used in learning electronics, especially amplifier operational material. From the findings of the interview with the electronics lecturer, information was obtained that in learning electronics courses, the use of teaching materials was still very limited, namely only available textbooks and simple practicum guides.

Analyze college students' characteristics. The purpose of analyzing student characteristics is to study the characteristics and experiences of students as a reference in determining media and learning approaches that suit student needs (Basu et al., 2019; Risan, 2022). During this stage, the analysis is conducted. Drawing from the results obtained from disseminating questionnaires assessing student needs. The findings from the questionnaire indicate that students encounter challenges comprehending op-amp material, and the instructional materials employed in the learning process do not adequately address the needs of students in electronics courses. in the form of modules, aiming to enhance comprehension of operational amplifier concepts and make learning more effective, interactive, collaborative, and contextual.

Analyze Task. Task analysis seeks to pinpoint the primary tasks performed by students in order to achieve minimum competencies and determine the material to be included in the module (Prasetyo & Santoso, 2018; Setiawan & Kurniawan, 2019). Task analysis is obtained according to the outcomes of the material analysis outlined in the semester learning plan. In comparison with the course

learning outcomes and sub-course learning outcomes. After the researchers analyzed the semester learning plan, the data used as a lecture plan about the amplifier operational material in lecture activities was determined. This task analysis results in researchers knowing that the material included in the module development is amplifier operational material.

Analyze Concept. Concept analysis aims to systematically identify and organize the content of materials and concepts outlined in the module. The selected material is adjusted to the semester learning plan, the course learning outcomes and sub-course learning outcomes.

Analyze the learning objective. The main purpose of analyzing learning objectives is so that module development can solve problems related to electronics courses on operational amplifier material. Learning objectives are formulated from task and concept analysis outcomes, aligning with the learning outcomes specified in the RPS of electronics lectures.

Design Phase. The design process aims to develop a prototype of the learning tool to get an initial sketch of the module product to be developed. The module is designed based on the outcomes of the preceding defining stage. The stages of the design process are as follows:

a. Format Selection

This format selection stage is divided into two categories: media format and content format. The selection of the media format aims to determine the learning media that will be developed according to student needs (Arsad, 2017; Bogard & Carr-Chellman, 2017). The media chosen to be developed is a module. The module is designed based on the defining stage, which is very relevant to the needs of students based on the analysis questionnaire. Students are distressed about grasping the material covered in the electronics course and need the development of teaching materials to support learning, which so far tends only to use ordinary textbooks. While the content format aims to design or plan learning content, in this instance, the format developed is contingent upon the employed learning model.

b. Preliminary Design

There are two stages in this initial design, namely, creating a storyboard and creating a prototype. Storyboard refers to a comprehensive depiction of learning media loaded into the application to be used as a guide or map to make it easier during the media creation. The storyboard format consists of symbols that the reader can understand. Meanwhile, the prototype is the stage of making the initial product model based on the storyboard. The results of the prototype will then be continued at the next stage, namely assessment, revision, and evaluation.

c. Development Stage

At this stage of development, the product will be validated. Validation comprises both material validation and media validation. The validation process is conducted by expert validators in both material and media fields, each specialized in their respective domains.

d. Material Expert Validation

The validation of operational amplifier material within the electronics module is conducted by lecturers who are experts in the material field. Material validation was carried out twice. The results of validation 1 and validation 2, carried out by material experts on the electronics module on operational amplifier project-based learning, are shown in Table 4.

Table 4 Result of stage 1 and 2 material validation

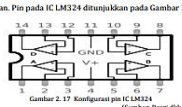
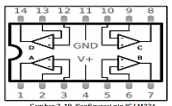
Assessed aspect	Percentage (%)	
	Validated 1	Validated 2
Feasibility of content	70	83
Learning	70	80
Presentation	77	90
Average	72%	85%
Category	Valid	Highly valid

From Table 4, the material validation in stage 1 scored 70 on the content feasibility indicator. The validator provides input that the content contained in the module is still incomplete with a systematic arrangement and sequence, not in accordance with the course learning outcomes and sub-course learning outcomes, and the suitability of the concept map with learning material still needs to be improved (Muhardini, et al., 2023). The learning indicator obtained a score of 70. On this indicator, the validator also said that the suitability of the theoretical explanation with the topic of learning material needs to be improved, the suitability of competency tests and project assignments with students' proficiency level, and the alignment of the course learning outcomes with learning objectives that require further enhancement. While the presentation indicator received a score of 77, the input, namely the presentation of images, project assignments, completeness of the table of contents, and completeness of supporting references, must be improved. Therefore, from the results of the total score of three indicators, a percentage of 72% was obtained with a valid category used with revision. So based on suggestions and comments, researchers revised the product and re-conducted validation, namely in validation 2.

In stage 2 validation, it is apparent from the average percentage obtained that it is greater than that of stage 1 validation, which reached 85% with a very valid category. In the content feasibility indicator, the validator said it was better, namely the course learning outcomes and sub-course learning outcomes, which were appropriate, and the order and arrangement of the material were complete and systematic, resulting in a total score of 83. In the learning indicator of getting a score of 80, the explanation of the theory with the topic of learning material is appropriate, the suitability of competency tests and project assignments with the level of student ability is better, and the suitability of the course learning outcomes with learning objectives is better. The presentation indicator, which includes the presentation of images, project assignments, the table of contents, and the completeness of supporting references, gets a score of 90. Based on the implementation of material validation, the ultimate outcomes from this material expert validation show that the module is valid with a percentage of 85% to be used and tested.

The outcomes of the validation conducted by the material expert validator are presented in Table 5.

Table 5 Material expert validation result

No	Description	
	Before revision	**After revision**
1.	$V_- = V_+ = 0$ Tegangan jepit pada R_1 adalah $V_{in} - V_- = V_{in}$ Tegangan jepit pada resistor R_2 adalah $V_{out} - V_- = V_{out}$ $I_{in} + I_{out} = I_- = 0$, arus masukan op amp adalah nol $I_{out} = -I_{in}$ $I_{in} + I_{out} = \frac{V_{in}}{R_1} + \frac{V_{out}}{R_2} = 0$ (2.1) Selanjutnya, $\frac{V_{out}}{R_2} = -\frac{V_{in}}{R_1}$ atau $\frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1}$ Jika penguatan atau gain didefinisikan sebagai perbandingan tegangan keluaran terhadap tegangan masukan, maka dapat ditulis: $Gain = \frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1}$ Sehingga, $V_{out} = Gain \times V_{in}$ $V_{out} = -\frac{R_2}{R_1} \times V_{in}$ (2.2) 8 | Modul Elektronika	$V_- = V_+ = 0$ Tegangan jepit pada R_1 adalah $V_{in} - V_- = V_{in}$ Tegangan jepit pada resistor R_2 adalah $V_{out} - V_- = V_{out}$ $I_{in} + I_{out} = I_- = 0$, arus masukan op amp adalah nol $I_{out} = -I_{in}$ $I_{in} + I_{out} = \frac{V_{in}}{R_1} + \frac{V_{out}}{R_2} = 0$ (2.1) Selanjutnya, $\frac{V_{out}}{R_2} = -\frac{V_{in}}{R_1}$ atau $\frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1}$ Apabila penguatan atau gain diartikan dengan rasio tegangan *output* terhadap tegangan *input*, rumus dinyatakan sebagai berikut: $Gain = \frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1}$ $V_{out} = Gain \times V_{in}$ $V_{out} = -\frac{R_2}{R_1} \times V_{in}$ (2.2) 9 | Modul Elektronika Op-Amp
2.	**Tugas Proyek** Sebelum membuat dan menyelesaikan tugas proyek, terlebih dahulu lakukan simulasi dan analisis rangkaian op-amp melalui aplikasi *proteus*. dan sebelum anda melakukan simulasi, dapat terlebih dahulu menonton video singkat melalui barcode dibawah ini **Praktik/simulasi** Sebelum melakukan simulasi pastikan anda telah menginstall aplikasi proteus pada laptop/pc! A. Tujuan 1. Mahasiswa dapat mengetahui karakteristik rangkaian komparator sebagai aplikasi dari rangkaian op-amp 2. Mahasiswa dapat membuat rangkaian komparator sebagai aplikasi dari rangkaian op-amp 41 | Modul Elektronika	**Tugas Proyek** **Pertanyaan Mendasar**  Berdasarkan ilustrasi diatas, terlihat seseorang akan menyalakan kipas. Pada umumnya, kipas akan menyala dan mati ketika tombol on/off ditekan secara manual. Akan tetapi, apabila pada suatu kondisi misalnya, terjadi peningkatan suhu yang disebabkan oleh adanya sumber panas. Apakah dengan menyalakan kipas secara manual seperti ilustrasi diatas sudah efektif dilakukan. Lalu bagaimana ketika kipas dapat menyala tanpa menekan tombol on/off melainkan secara otomatis? Oleh karena itu, buatlah sebuah proyek kipas pendingin otomatis yang dapat menyala ketika adanya sumber panas. 46 | Modul Elektronika Op-Amp
3.	4. IC LM324 Penguat operasional IC LM324 dapat bekerja seperti komparator normal, dan terdiri dari empat *op-amp* independen secara internal. IC ini dirancang dengan daya rendah, bandwidth, dan stabilitas tinggi untuk beroperasi dengan catu daya tunggal pada rentang tegangan yang luas. Kisaran tegangan operasi IC ini meliputi 3,0 V untuk rendah dan 32 V untuk tinggi. Kisaran input mode umum terutama terdiri dari suplai tegangan negatif, sehingga menghilangkan kebutuhan komponen biasing luar dalam beberapa aplikasi. Kisaran tegangan keluaran juga terdiri dari suplai tegangan negatif. IC LM324 terdiri dari 14-pin dengan empat op-amp independen dalam satu paket. Penguat tegangan elektronik ini tersedia dalam gain tinggi dengan masukan diferensial serta keluaran tunggal. Perbedaan tegangan antar terminal masukan IC sangat kecil dibandingkan tegangan keluaran. Komparator ini beroperasi dengan satu catu daya dan kebutuhan pasokan ganda dihilangkan. Pin pada IC LM324 ditunjukkan pada Gambar 2.17.  Gambar 2. 17 Konfigurasi pin IC LM324 (Sumber: Basri dkk., 2018) 29 | Modul Elektronika	Perbedaan tegangan antar terminal masukan IC sangat kecil dibandingkan tegangan keluaran. Komparator ini beroperasi dengan satu catu daya dan kebutuhan pasokan ganda dihilangkan. Gambar 2.19. memperlihatkan pin pada IC LM324.  Gambar 2.19 Konfigurasi pin IC LM324 (Sumber: Basri dkk., 2018) Berdasarkan gambar 2.19. berikut dijelaskan fungsi dari masing-masing kaki yang dimiliki IC LM324: a. Pin1 (OUTPUT1): Keluaran dari komparator pertama b. Pin2 (INPUT1-): Membalik masukan komparator pertama c. Pin3 (INPUT1+): Masukan non-pembalik dari komparator pertama d. Pin4 (VCC): Tegangan suplai positif e. Pin5 (INPUT2+): Masukan non-pembalik dari komparator ke-2 f. Pin6 (INPUT2-): Membalik masukan komparator ke-2 g. Pin7 (OUTPUT2-): Keluaran dari komparator ke-2 h. Pin8 (OUTPUT3): Keluaran dari komparator ke-3 33 | Modul Elektronika Op-Amp

e. Media Expert Validation

Media expert validation in this study was carried out three times. The results of the first, second, and third validation conducted by media experts on electronics modules on project-based learning amplifier operational material are presented in Table 6.

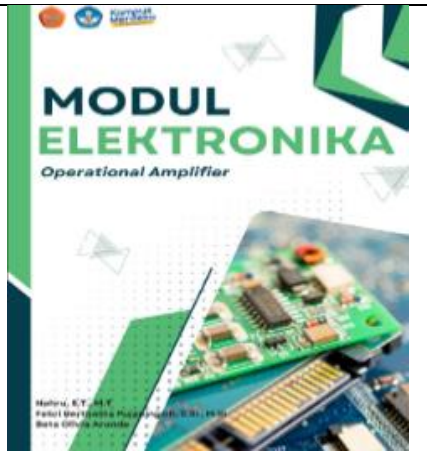
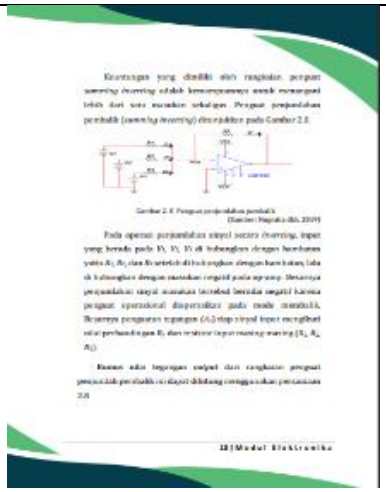
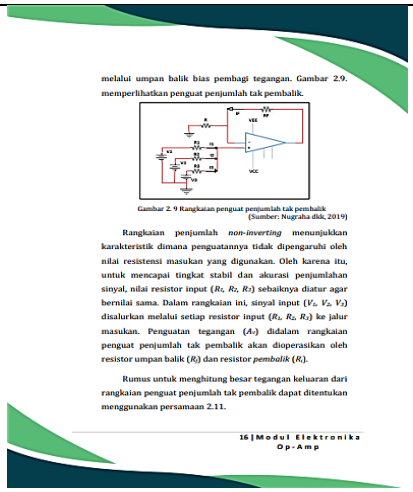
Table 6 Result of stage 1, 2 and 3 media validation

Assessed aspect	Percentage (%)		
	Validated 1	Validated 2	Validated 3
Module size	60	73	86
Module skin design	73	73	86
Module content design	60	70	85
Average	64%	72%	86%
Category	Valid	Valid	Highly valid

According to the table provided, the initial validation yields a percentage result of 64%, falling within the valid category. However, in this first validation, researchers received a lot of suggestions and input from validators, including in the aspect of module size. The level of validity received a score of 60. This is because there are still many deficiencies in both the module size, which is still not in accordance with ISO standards, the size of the margins and module paper, and the font size used, which still needs improvement. The skin design aspect of the module obtained a score of 73 with suggestions and input that the module skin illustrations that describe the content or teaching material and reveal the character of the object must be revised to make it look more attractive, the module title colour and the background colour that has not been contrasted, and the use of a combination of fonts that are not too excessive. The second validation of the module skin design score remained at 73, identical to the first validation. The validator noted that the revisions made to the skin design still lacked appeal and appeared too similar to the previous version. As a result, the validator provided further suggestions to enhance the attractiveness of the skin design for the third validation. Then, in module content design, getting a score of 60, the validator also said that improvements needed to be made to the space between lines of text arrangement, space between letters, and neatness of image location.

Derived from the outcomes of the stage 1 validation, the researcher returned to conduct a second validation, where the second validation obtained an average of 72% in the same category as the first valid validation. Furthermore, the validator again gave suggestions and input so that researchers could further improve the module regarding size, skin, and content. The revision results in the second validation were then carried out in the third validation, with the average percentage reaching 86%. Based on the outcomes of this third validation, which was categorized as highly valid, the validator stated that the module was valid without revision. The validation results conducted by the media expert validator are presented in Table 7.

Table 7 Media expert validation result

No	Description	
	Before revision	**After revision**
1.		
2.		
3.		

CONCLUSION

Based on the conducted research and data analysis, we can infer that the validity of developing physics modules for project-based operational amplifier material in electronics courses is strongly supported for educational purposes, both in material content and media format. The validity is substantiated by the percentage outcomes from two validations conducted by material and media experts, scoring 85% and 86%, respectively, falling within the highly valid category. The implications of this research are that for lecturers, the development of valid modules can be used as additional teaching materials in learning activities.

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