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Feasibility of Engineering Mechanics E-Modules Developed Using the Four-D Model

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Abstract: Technological developments demand that learning media be developed on an electronic basis. Availability of electronic modules in Engineering mechanics lessons is currently still not available. Even though students are required to solve cases in the field by mastering three concepts, namely mathematics, physics and mechanics independently. This research aims to determine the feasibility of a case-based engineering mechanics e-module. The research method uses the R&D method with a 4D development model. The stages of the 4D method are definition, design, development and distribution. The data collection technique was carried out by distributing questionnaires. Validation of the e-module was carried out by material experts, learning design experts and learning media experts who were analyzed descriptively. The research results showed that the feasibility score for material experts was 91.17% in the very good category, learning design experts 93.38% in the very good category, and learning media experts 89.83% in the very good category. Thus, it can be concluded that the case-based e-module developed is very suitable for use in learning engineering mechanics.

Keywords: E-module; Engineering mechanics; Feasibility; Four-D

Introduction

The era of industrial revolution 4.0 has had an impact on all aspects of human life, including one that has quite a big impact, namely the field of education. The industrial revolution has changed the way humans work from manual use to digitalization (Suwardana, 2018). In the era of Industrial Revolution 4.0, advances in technology are very influential and growing rapidly in human life. According to Lase (2019). This era integrates all aspects of human life with digital technology (Afrianto, 2018). Apart from that, online learning can also provide access to a wider range of learning resources, such as learning videos, electronic books and interactive digital learning platforms (Indarta et al., 2022). Through technological developments in the learning process, students will be able to face these challenges (Alimuddin et al., 2023).Learning activities using the internet provide benefits and ease of access to information in various conditions (Herliandry et al., 2020). The use of technology in learning can increase efficiency, effectiveness and quality of learning (Dito et al., 2021). The role of universities in the era of industrial revolution 4.0 is very important, especially in the development of science and technology. Therefore, higher education must support more open knowledge so that it can improve human welfare.

Universities must make various breakthroughs in producing competitive graduates (Putro et al., 2020; Rahayu et al., 2020). Universities must make various breakthroughs in producing graduates who are competitive. The college graduates needed in the era of industrial revolution 4.0 are individuals- Competent and competitive individuals in the world of work. In the era of globalization and increasingly fierce competition, students must be able to adapt to changes that occur and develop new skills in order to compete in an increasingly competitive job market (Kamaruddin et al., 2022). Therefore, every graduate must be able to master the competencies in each productive course.

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The Engineering Mechanics course is a mandatory subject in the Department of Mechanical Engineering Education, Faculty of Engineering, Unimed. Engineering Mechanics is one of the important subjects in the Building Engineering Education study program (Basito et al., 2018). Engineering Mechanics is a course with the principles of applying physics which studies the state of building structures, force systems, calculating and drawing the forces and loads that act on a construction (Santoso et al., 2020). In the Engineering Mechanics course, students must master three concepts, namely mathematics, physics and mechanics. Therefore, many students experience difficulties in engineering mechanics courses, so that the learning outcomes achieved are not optimal. Students are required to be able to solve and resolve problems in the field. Apart from that, limited media makes learning not optimal. learning engineering mechanics only uses power points and printed books. The material in the current printed books is still difficult to understand and only focuses on descriptions of the material. One factor that can influence student competence is the presentation of material that is less varied and tends to be monotonous, this is related to the teacher's readiness in carrying out the learning process in class (Mardiana et al., 2017). So students have not been able to solve problems in engineering mechanics lessons. Another problem is that teachers also tend to use conventional learning models in learning, which makes them feel bored when studying (Wulandari et al., 2020). The challenges and demands of an educator are currently increasing, and to meet curriculum demands an educator is needed who is innovative in developing the learning process (Haridza et al., 2017). Today's active students are often referred to as Generation Z who have a high interest in digitalization. Generation Z on average has the best digital skills with an average level of understanding of 61.14% about digitalization, so it would be boring if teachers were still oriented towards learning systems without a touch of digitalization (Esteve-Mon et al., 2020). The learning process must be based on science and technology, teachers can utilize digital media in the learning process to attract students' attention and interest (Chu et al., 2021). Learning media innovations that support the learning process to achieve learning goals and competencies are modules presented in digital form or e-modules (Prabasari et al., 2021; Sudiyono et al., 2022).

E-module is an electronic presentation of teaching materials that can be used independently, designed completely and systematically in certain learning units and presented in electronic format, where each learning process is connected by a link that is able to realize learning (Andermi et al., 2021; Serevina et al., 2018). The benefits of using E-modules can enable students to learn independently and have communicative language that can be accessed anytime and anywhere, making it easier for students to learn subject matter (Elvarita et al., 2020; Kimianti et al., 2019; Lestari et al., 2019; Udayana et al., 2017). Learning using electronic modules makes students' learning activities more active compared to using print media (Widalismana et al., 2017). E-modules presented electronically will make students more interactive in learning (Putri et al., 2020). To increase student competency in the era of industrial revolution 4.0, consideration is needed regarding aspects of ease of use of modules and application of technology (Abyadati et al., 2017). Modules developed by teachers themselves can be adapted to their characteristics (Tamami, 2020). So it is easier for teachers to convey or explain learning material because the module content has been mastered by the teacher and is created based on student characteristics (Masaguni et al., 2023).

Case-based e-module integrate students to solve problems and manage the learning process through electronic engineering mechanics modules. case-based learning is constructivist-oriented with active student participation so that students can form their own knowledge (Wardani et al., 2023). This is in accordance with the characteristics of engineering mechanics learning. In case-based learning, students will be given a case that must be solved interactively by studying the problem (Çimen, 2021). Cases are presented in the form of narratives that present real life problems and then discussed by students in small groups and follow-up is carried out individually or in groups through books, articles or research reports (Sato et al., 2023). The cases presented provide students with the opportunity to practice their science knowledge and connect several concepts at the same time to practice connection-related skills (Kazempour, 2014; Sato et al., 2023) Case-based learning can improve critical thinking skills, problem solving, communication skills, collaboration and creativity (Efremenko et al., 2020; Liu, 2019; Servant-Miklos, 2019; Tan et al., 2017). Apart from that, students are also able to increase knowledge and skills in solving problems and finding solutions (Cakmak et al., 2017). Students who were given cases had better learning outcomes (Huda et al., 2023). Case-based e-module development contains cases and problems that must be solved by students after students have completed the material in the Engineering Mechanics e-module. Case-based learning really needs to be integrated into engineering mechanics learning e-module. Case-based e-module development is still rarely done in engineering mechanics learning. By integrating case-based learning into e-module, students can be directly involved in solving cases in the field, think critically and are able to make decisions so that they can improve students' ability to understand the material.

In this research, case-based e-module development adapts the 4D research model developed by Thiagarajan (1974) because Thiagarajan's development model is the basis for developing learning tools (not learning systems) (Ishaq, 2017). The four-D development model consists of 4 stages, namely; define, design, develop, and deploy. The four-D moderepresents a dynamic and flexible guideline for building effective learning systems and performance support tools. Meanwhile, the advantage of developing this 4D model is that it is simpler and more suitable for module development, the description looks complete and systematic (Thiagarajan, 1974).

Based on the description above, it is considered important to develop a case-based Engineering Mechanics e-module that can increase student competence in solving cases in the field.

Method

This research procedure uses the four-D development model. This model was chosen because it has a simple procedure, has a systematic procedure in accordance with the required research development steps. This development model includes 4 stages, namely defining, designing, developing, and disseminating. The feasibility of the e-module is obtained from 3 stages, namely define, design and development. The subjects of the e-module feasibility trial were material experts in the field of engineering mechanics, learning media experts and learning design experts. The target users of the e-module are students of the Mechanical Engineering Education Department, Faculty of Engineering, Medan State University who are taking Engineering courses. The research procedure is shown in Figure 1.

Define

The define stage includes analyzing media needs, gathering information, and formulating learning objectives. Information on media needs was obtained through Focus Discussion Groups (FGD) between lecturers, students and graduate user stakeholders. Further information relates to learning needs, student characteristics, and determining learning objectives.

Design

Activities at the design stage include preparing instruments, selecting media, and initial design of learning media. The design of the e-module begins with determining the content of the engineering mechanics course material. The e-module application uses flipbook maker software.

Development

In e-module development, the development stage is carried out by the developer based on the design and content that has been collected. The development stage includes design validation, design revision, field trials, learning media data analysis, development output.

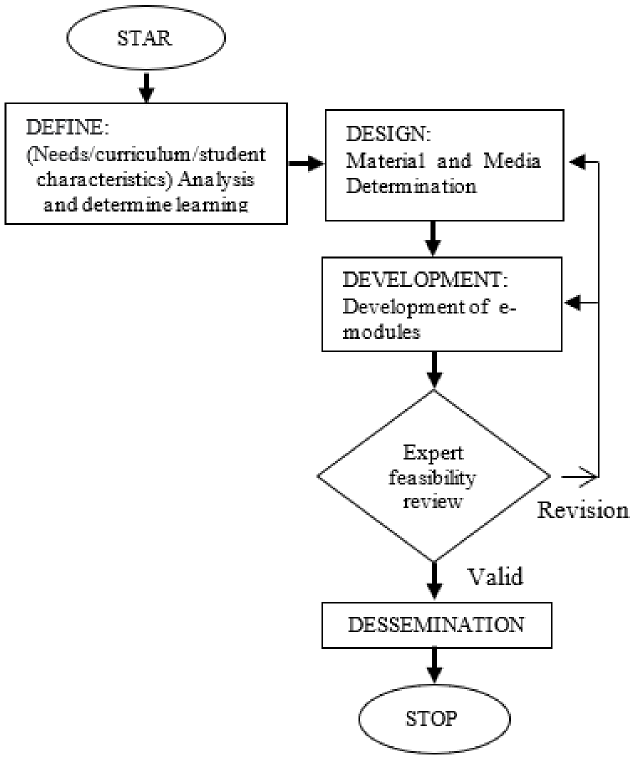


Figure 1. Research procedure

Data Collection Method

The data collection method in this study was analyzed qualitatively, and the data collection instruments used were related to each research stage, namely: in the form of a questionnaire used for observation, as well as the expert development and validation stage using a questionnaire from the Learning Object Review Instrument (LORI) version 1.5 (Nesbit et al., 2007) with a Likert Scale.

Data Analysis Technique

Data analysis was carried out using descriptive analysis techniques, namely by analyzing quantitative data obtained from expert test questionnaires and field tests which were then interpreted in a qualitative sense. After the data is obtained, the next step is to analyze the data. To analyze data from a questionnaire, by calculating the score of each subvariable with interpreted qualitatively using the Formula 1.

$$X = \frac{\sum X}{N} \quad (1)$$

Where:
X =Courseware feasibility score
∑X =Total score of each subvariable
N =Number of subvariables

Based on the above calculations, the percentage range and qualitative criteria can be determined as shown in Table 1 (Sriadhi, 2018).

Table 1. Interpretation of E-Module Feasible Score Range 0 – 5

Score Intervals	Interpretation
1.00 – 2.49	Not feasible
2.50 – 3.32	Quite feasible
3.33 – 4.16	Feasible
4.17 – 5.00	Very feasible

Feasibility Criteria

The Feasibility criteria are presented in the form of a questionnaire that is used as a source of research data. This e-module is said to be feasible if the results obtained from the questionnaire are in the criteria of "Very Good", "Good" and "Enough Good". The data assessment indicator is an important position and must be prepared before the researcher collects field data. In accordance with the feasibility interpretation with a feasibility score limit of 2.50, in e-module eligibility data stability can be stated, data processing is easier, and e-module reliability can be carried out if the resulting data analysis obtains 50% of the feasibility carried out in processing research data (Sriadhi, 2018).

Result and Discussion

This research produced a product in the form of Engineering Mechanics e-module. The three-step development model in this study was adopted from the 4-step four-D development model which includes; define, design, and development.

Define

Define, this stage is in the form of analysis of the needs required by users to obtain the latest information. Information on these needs is obtained by carrying out Focus Discussion Groups (FGD) between Lecturers, Students and graduate user stakeholders. Information obtained about curriculum needs (learning content), student characteristics, analysis and determining learning objectives. Based on the results of the analysis of learning outcomes, the learning content that will be delivered in the e-module is engineering mechanics. There are three aspects of e-module eligibility, namely learning design aspects, material content aspects and learning media aspects. The feasibility of learning design aspects includes learning objectives, learning strategies, preparation of materials and assessment tools. The feasibility of the material content aspect is assessed based on the aspects of content preparation, content presentation and assessment tools. The feasibility of learning media aspects is in the form of navigation settings, covers and visual illustrations.

Design

The design phase of the e-module begins with determining the material content of the engineering mechanics course.

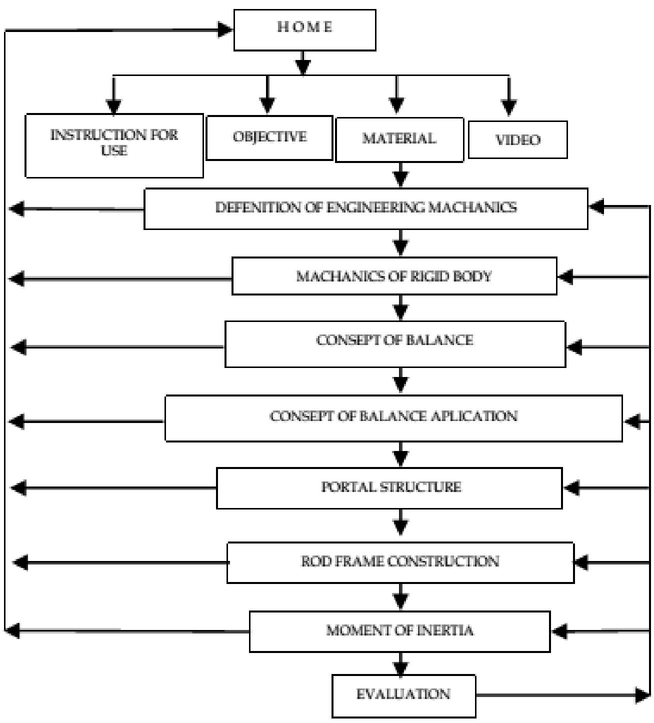


Figure 2. Schematic of mechanics e-module design

At the design stage, material is collected that is used to fill in content such as articles, videos and images related to engineering mechanics. The material is obtained from several websites or created by yourself. Application design using the help of flipbook maker software. By using flipbook maker software students will be more interested in learning because it contains a more attractive display and student learning outcomes can increase (Pornamasari, 2017).

Selection of software used to support the running of applications on digital devices and can contain the needs to be presented in the form of text, video, images and other navigation. Flipbook maker is an application for creating, modules and magazines in electronic form. The display design of e-modules that are now in great demand by the public is a three-dimensional e-module known as a flipbook, where pages can be opened like reading a book on a monitor screen (Hardiansyah, 2016).

Development

The Development stage is to realize the design that has been made before. Steps that need to be taken in developing e-modules, namely (1) the development stage is carried out by the developer based on the design and content that has been collected. Display Cover displays, navigation and instructions for using the engineering mechanics e-module can be seen in Figure 3.

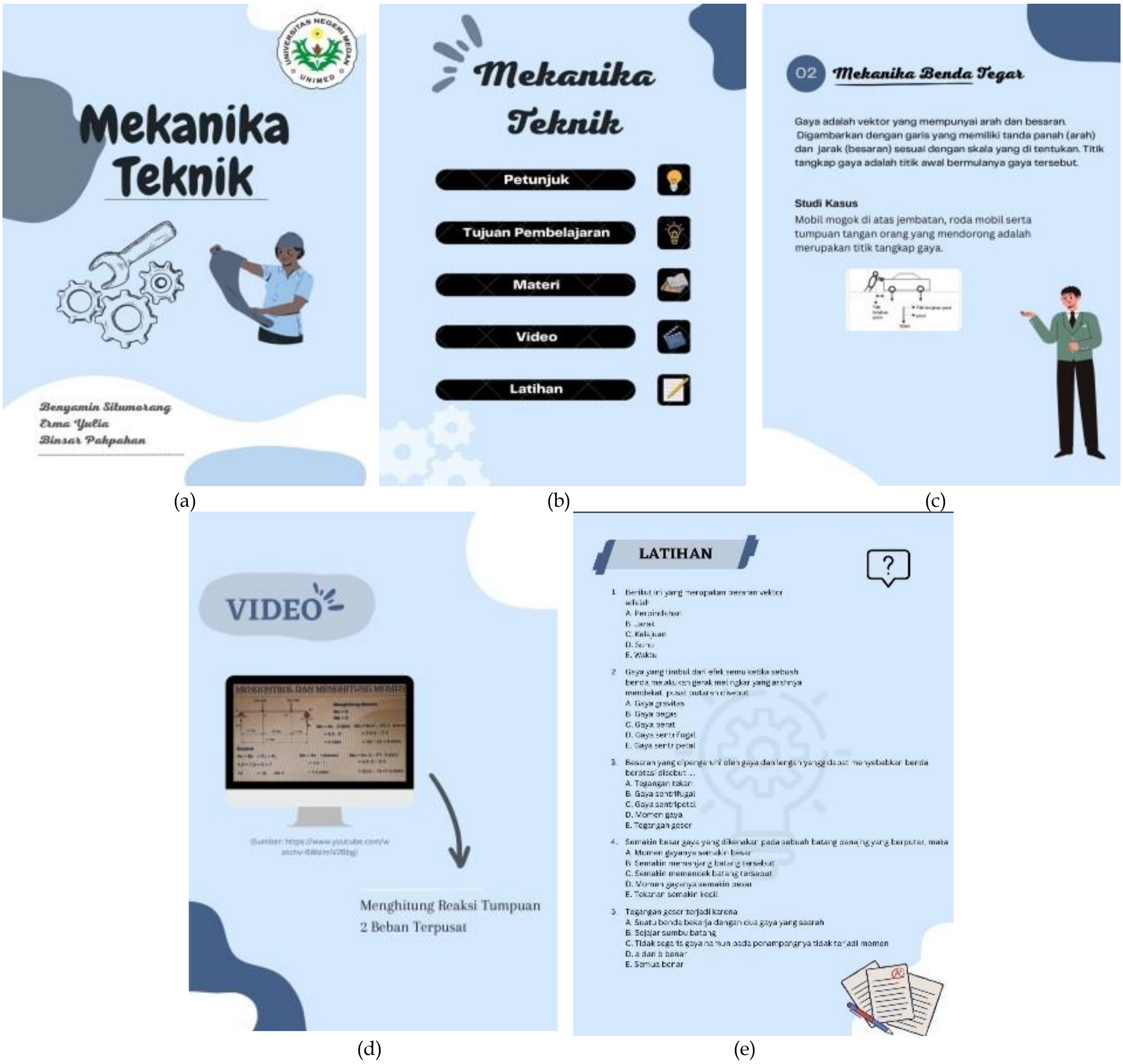


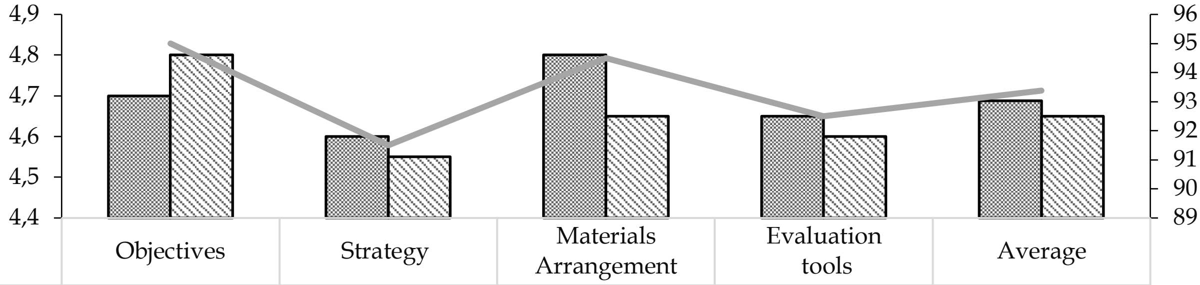
Figure 3. Display of e-module: (a) Cover display; (b) Navigation instructions for using e-modul; (c) Case study materials; (d) Video display; and (e) Exercise

Next, e-module feasibility tests were carried out by Learning Design experts, Content Experts, and Learning Media Experts.

Learning Design Expert Feasibility

The feasibility of learning design experts is divided into 4 (four) aspects, namely learning objectives, learning strategies, preparation of materials and evaluation tools. The learning design expert's assessment is shown in the diagram in Figure 4.

The average score given by Learning Design experts for 4 (four) aspects of the assessment is 4.70 or 93.37%, thus the assessment of the feasibility of learning design experts is in the very good category.

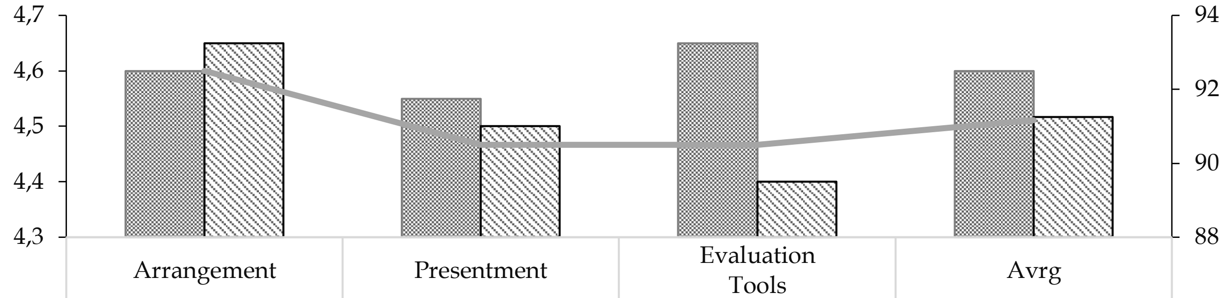


	Objectives	Strategy	Materials Arrangement	Evaluation tools	Average
Expert 1	4,7	4,6	4,8	4,65	4,7
Expert 2	4,8	4,55	4,65	4,6	4,7
%	95	91,5	94,5	92,5	93,375

Figure 4. Learning design experts feasibility results

Material Expert Feasibility

Material expert feasibility consists of 3 (three) aspects namely; preparation of learning materials, presentation of learning materials, and assessment tools. Of the three aspects assessed by material experts, the average score obtained was 4.56 or 91.17% and included in the very good category. The results obtained can be seen in Figure 5.



	Arrangement	Presentment	Evaluation Tools	Avrg
Expert 1	4,6	4,55	4,65	4,60
Expert 2	4,65	4,5	4,4	4,52
%	92,5	90,5	90,5	91,17

Figure 5. Material expert feasibility results

The feasibility of learning media experts is divided into 3 (three) aspects, namely setting, cover and visual illustration. From the validation of learning media experts, it gives an average score of 4.51 or 89.83% and is included in the very good category. The evaluation of learning media experts is shown in the diagram in Figure 6.

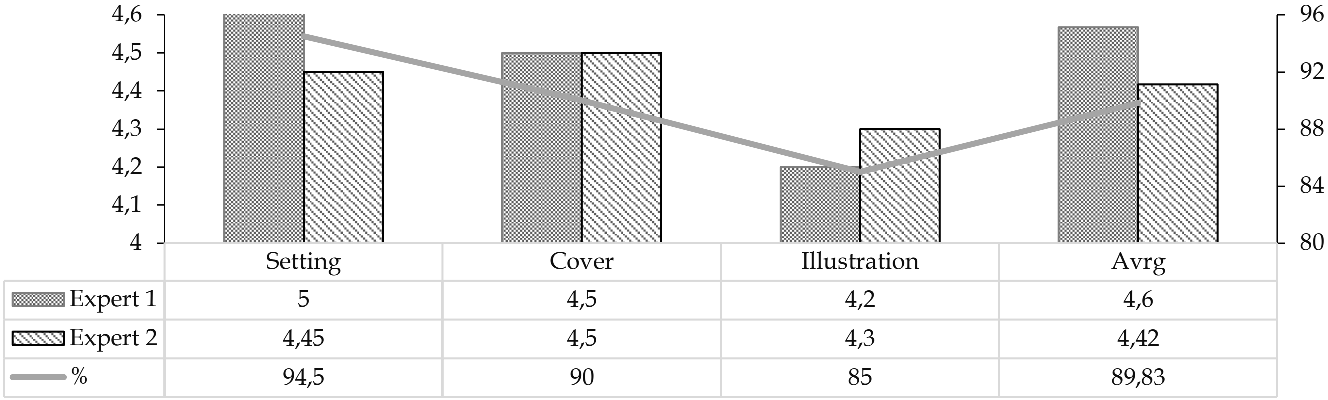


Figure 6. Learning media experts feasibility results

The feasibility results of learning design experts, material experts and learning media experts are shown in Table 2.

Table 2. Experts Feasibility Score

Expert	Average Score	Percentage (%)
Material Expert	4.56	91.17
Learning Design Expert	4.70	93.8
Learning Media Expert	4.51	89.83

From the data Table 2 it is known that the results of the material expert's assessment were 91.17% in the very good category. The results of the learning design expert's assessment were 93.38% in the very good category and the results of the learning media expert's assessment were 89.83% in the very good category for use in learning. These data indicate that the development of the Mechanical Engineering e-module using the four-D model is feasible for use in learning. This is in line with the results of research by (Supriadi et al. (2022) and Akhmadi et al. (2019) which stated that the e-module uses a four-D development model with a level of validity and feasibility in the very good category. The results obtained from the development of the e-module can be used in the learning process.

Conclusion

Based on the results and discussion in research on the development of e-module engineering mechanics, it can be concluded that this research produces case-based e-module products for learning engineering mechanics. The development method uses 4D which is limited to the stages of definition, design and development. The feasibility of the engineering mechanics e-module which has been reviewed by learning design experts, material experts, and learning media experts obtained a feasibility score for material experts of 91.17% in the very good category, learning design experts 93.38% in the very good category, and media experts learning 89.83% very good category. The e-module developed is in accordance with the conditions and needs of students in completing case studies. Thus, the case-based e-module developed is very suitable for use in learning Engineering mechanics.

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Author Contributions

Conceptualization, E. Y., B. S., B. M. P.; methodology, E. Y and B. S.; validation, B. S.; formal analysis, B. M. P.; investigation, E. Y. and B. M. P.; resources, B. S. And B. M. P.; data curation, E. Y.; writing—original draft preparation, E. Y; writing—review and editing, B. S. and B. M. P.; visualization, E. Y. and B. S. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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