ISSN 2987-4270
PLE
Physics Learning and Education
Vol. 4 No. 3 (2026)

Validation Analysis of E-Modules Fluid Dynamics Based Dual Space Inquiry to Facilitate Critical Thinking Skills of Senior High School Students

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ABSTRACT

The rapid development of technology in the 21st century has encouraged the world of education to utilize technology to improve the quality of learning. Critical thinking is one of the important skills that needs to be developed in order to face the challenges of this century. The application of the inquiry model is one effective approach to facilitate this skill. Therefore, educators or teachers need to integrate information and communication technology with the inquiry model, especially in physics learning, which requires active student involvement. In order for this integration to be balanced between online and offline activities, teaching materials that support scientific and digitally flexible learning are needed. One solution is to design a E-Module Dynamic Fluid Based Dual Space Inquiry to Facilitate Critical Thinking Skills of Senior High School Students. The design of the E-Module dynamic fluid based on Dual Space Inquiry refers to Research and Development (R&D) conducted through the ADDIE model. This research was only conducted in 3 stages of analysis, design, and development. The results of the study show that the teaching materials developed in the form of a E-Module Fluid Dynamics based Dual Space Inquiry to facilitate students' critical thinking skills are valid according to experts in terms of content feasibility, learning design, visual communication display, software utilization, Dual Space Inquiry, and critical thinking skills with a validation score of 0.96. Based on the research conducted, it can be concluded that E-Modules Fluid Dynamics based on Dual Space Inquiry to facilitate students' critical thinking skills are valid and can be used in physics learning.

Keywords: E-Modul, Dual Space Inquiry, Inquiry Learning, Critical Thinking Skills, Fluid Dynamics

I. INTRODUCTION

21st century education integrates knowledge, skills, and attitudes, as well as mastery of information and communication technology (ICT). Technological developments can be utilized to facilitate 21st century skills so that learning becomes interesting and innovative, and learning objectives can be achieved. [1]. In 21st century, students are required to have one of the competencies that must be mastered in facing the 21st century, namely critical thinking skills [2]. Critical thinking skills is a fundamental and essential intellectual asset for everyone [3]. Critical thinking skills are important for students in facing the challenge of modern society [4]. One learning method that has been proven effective in facilitating students' critical thinking skills is inquiry based learning [5][6]. Based on preliminary research conducted at SMAN 2 Batusangkar in grade XII, it was found that the physics learning process was still teacher-centered, so that learning was not innovative, resulting in the students' critical thinking skills remaining low and not reflecting the expected level of 28.38%.

The primary factor relates to the teaching materials used, which are not compatible with critical thinking indicators. This finding is evident from interviews conducted, which revealed that the teaching materials used by teachers are printed books from commercial publishers. Additionally, teachers have not fully implemented innovative learning models, resulting in student boredom during lessons. Even though students have access to technology such as smartphones, this technology is rarely utilized effectively for classroom learning. Based on observations of students, it was found that students enjoy learning that incorporates technology, as it makes learning more interactive. To overcome this imbalance, learning materials are essential to facilitate students' critical thinking skills with an innovative approach using inquiry-based learning. This learning is student-centered, involving students in direct participation such as formulating problems, collecting data, discussing, and

communicating [7]. One learning material that can facilitate critical thinking skills and is relevant to 21st-century education is the e-module [8].

E-modules are learning modules that integrate text, images, videos, simulations, animations, quizzes, and evaluations interactively [9]. The advantage of using e-modules is that students become accustomed to dealing with issues in daily life presented in e-modules, thereby training their critical thinking skills [10]. 21st century physics learning is learning that balances the use of technology with a scientific approach [8]. Dual space inquiry is a learning method that can accommodate these aspects. E-modules developed based on dual space inquiry aim to facilitate students' critical thinking skills. Dual Space Inquiry (DSI) is a learning concept designed to facilitate flexibility in physics learning [11]. Dual Space Inquiry emphasizes the integration of digital technology throughout the learning process, facilitates diverse learning styles, and facilitates collaborative learning so that students become more active and critical.

Based on the analysis of existing problems, the researcher decided to develop an e-module fluid dynamics based on dual space inquiry to facilitate students' critical thinking skills. The developed e-module covers fluid dynamics material and is designed to be interactive in order to be more interesting and relevant to the cultural context of students. In this regard, the purpose of this study is to analyze the validity of an e-module fluid dynamics based on dual space inquiry to facilitate students' critical thinking skills..

II. METHOD

The type of research conducted in this study was R&D (Research and Development) [12]. This study utilized the ADDIE research method, which consists of five stages: analysis, design, development, implementation, and evaluation [13]. he phases of this research method are illustrated in the figure 1.

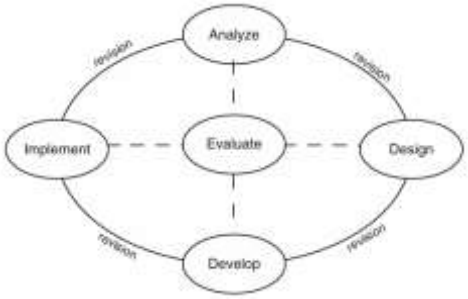

Fig 1. Ilustration of the ADDIE research model [13]

The analysis stage includes several stages, namely conducting a needs analysis to identify problems in physics learning by giving students a questionnaire, a curriculum analysis to find out the curriculum used by teachers in physics learning, a learning resource analysis to find out the learning resources used in schools, and a task analysis to identify and analyze the competencies that students must master. and document analysis aimed at collecting and analyzing data by conducting an in-depth examination of learning documents.

The design stage includes designing the E-Module to be created, including setting learning outcomes, learning objectives, learning objective flow, learning objective achievement indicators, compiling learning activities, designing learning tools, and compiling teaching materials.

The development stage includes conducting validity tests using instruments that have been validated in advance by three validators who are lecturers from the UNP Physics Department. The purpose of this validation is to produce a product, specifically an E-Module on fluid dynamics based on dual space inquiry to facilitate valid critical thinking skills in students. The results of the E-Module validity test were processed using Aiken's V formula, as follows:

$$V = \frac{\Sigma_s}{n(c-1)} \qquad (1)$$

Explanation:
$V =$ rater index of validity agreement
$s = r - I_0$
$I_0 =$ lowest validity score (e.g., 1)
$c =$ highest validity rating score (e.g., 4)
$r =$ score given by the validator
$n =$ number of validators

Validity categories based on Aiken's scores can be seen in Table 1 below:

Table 1. Aiken's V Index Criteria

Interval	Category
0,0 < 0,4	Low
0,4 < 0,8	Medium
> 0,8	Very valid

(Source: Ref [14])

III. RESULTS AND DISCUSSION

Result

The teaching material created is an e-module on fluid dynamics based on dual space inquiry to facilitate critical thinking skills in senior high school students. The validation of the design of the e-module on fluid dynamics based on dual space inquiry to facilitate critical thinking skills in students was carried out by three experts. The three validators were lecturers from the Faculty of Mathematics and Natural Sciences, University of Negeri Padang, who had expertise and experience in their respective fields. The purpose of this validation was to assess the feasibility of the teaching materials and to provide a reference for revising the teaching materials that had been prepared. The validation instrument covered six aspects of assessment, namely: 1) Material Substance, 2) Learning Design, 3) Visual Communication Display, 4) Software Utilization, 5) Dual Space Inquiry, and 6) Critical Thinking Skills.

The validity result of the first component is material substance, this component has four indicators: (1) Truth with a value of 0.97 or very valid, this shows that the truth of the material presented is in accordance with scientific principles, tested, factual, and rational; (2) Material Coverage with a value of 0.94 or very valid, indicating that the material presented is complete, exploratory, collaborative, and descriptive; (3) Timeliness with a score of 0.96 or very valid, indicating that the material presented is current, innovative, and easily accessible; and (4) ReadSkills with a score of 0.92 or very valid, indicating that the writing is in accordance with KBBI rules, easy to understand, and does not cause misunderstandings. For this indicator, the average score obtained was 0.95, categorized as very valid. The results of the validation of the material content component can be seen in Figure 2.

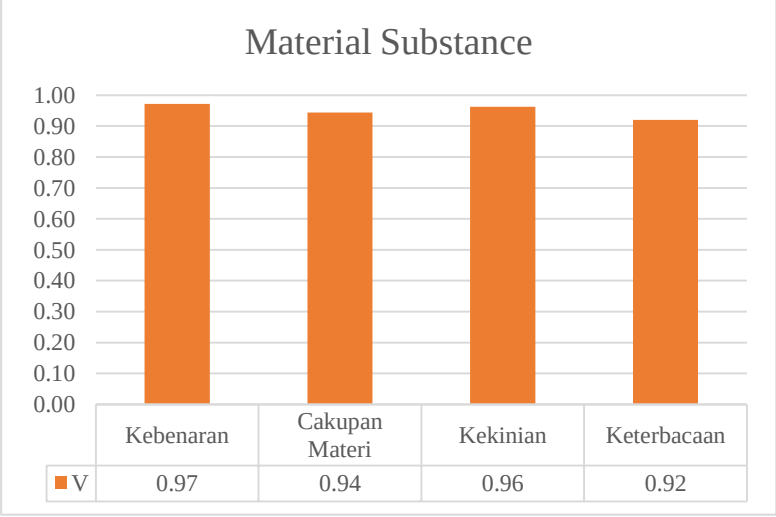

Fig 2. Material Substance Validity Results

The validity result for the second component is learning design, which has eleven indicators: (1) Title with a score of 1.0 or very valid, indicating that the title is appropriate for the content of the e-module; (2) Learning Outcomes with a score of 1.0 or very valid, indicating that there are learning outcomes in the e-module; (3) Learning Objectives with a score of 1.0 or very valid, indicating that there are learning objectives in the e-module; (4) Material with a score of 0.89 or very valid, indicating that the material is in line with the learning objectives; (5) Sample Questions with a score of 0.78 or valid, indicating that there are sample questions in the e-

module; (6) Exercises with a score of 0.78 or valid, indicating that exercises are included in the e-module; (7) Evaluation with a score of 0.89 or very valid, indicating that evaluation is included in the e-module; (8) Author with a score of 1.0 or very valid, indicating that the identity of the e-module author is included; (9) References with a score of 1.00 or very valid, indicating that there are 5 or more references used; (10) Graphics with a score of 0.89 or very valid, indicating that the colors of the layout elements are harmonious and the e-module cover illustration accurately depicts the content of the e-module. For this indicator, the average score obtained was 0.92, categorized as very valid. The validity results of the learning design components can be seen in Figure 3.

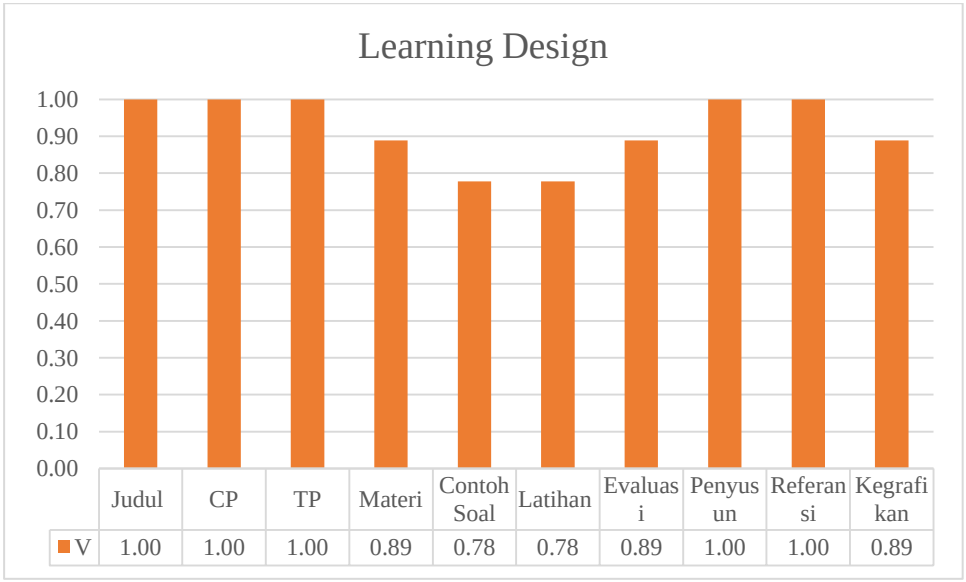

Fig 3. Learning Design Validity Results

The validity result for the third component is visual communication display. There are five indicators in this component: (1) Navigation with a score of 1.0 or very valid, indicating that there are instructions for use and that it is in accordance with basic navigation; (2) Font with a score of 0.94 or very valid, indicating that the font composition used in the e-module is proportional; (3) Media with a score of 1.0 or very valid, indicating that the e-module content includes videos, images, and animations that support learning; (4) Color with a score of 0.89 or very valid, indicating that the color combination used is appropriate; (5) Layout with a score of 0.89 or very valid, indicating that the layout of the e-module is proportional. For this indicator, the average score obtained was 0.94, which is categorized as very valid. The results of the validity of the visual communication display components can be seen in Figure 4.

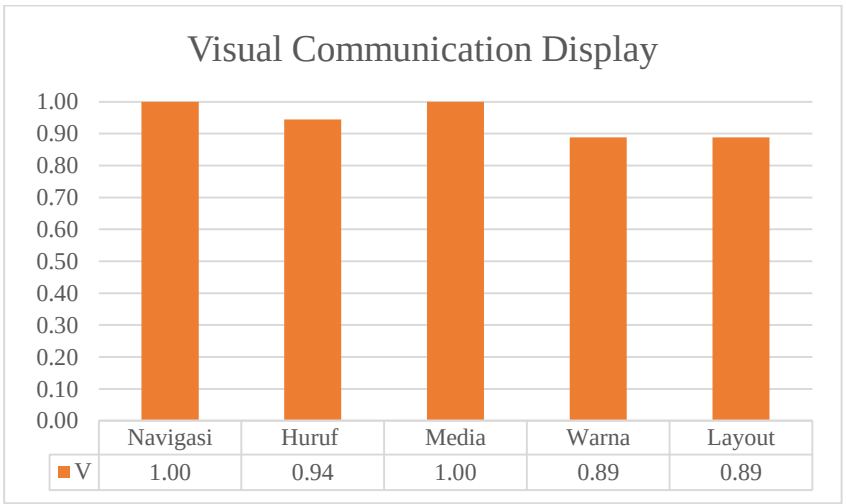

Fig 4. Visual Communication Display Validity Results

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The validity result for the fourth component is software utilization. There are three indicators in this component: (1) Interactivity with a score of 1.0 or very valid, indicating that the e-module generates interactivity in exercises and evaluations; (2) Supporting Software with a score of 0.98 or very valid, indicating that this e-module uses many supporting websites; (3) Originality with a value of 1.0 or very valid, indicating that this e-module is wholly owned by the author. For this indicator, the average value obtained was 0.99, which is categorized as very valid. The validity results for the software utilization component can be seen in Figure 5.

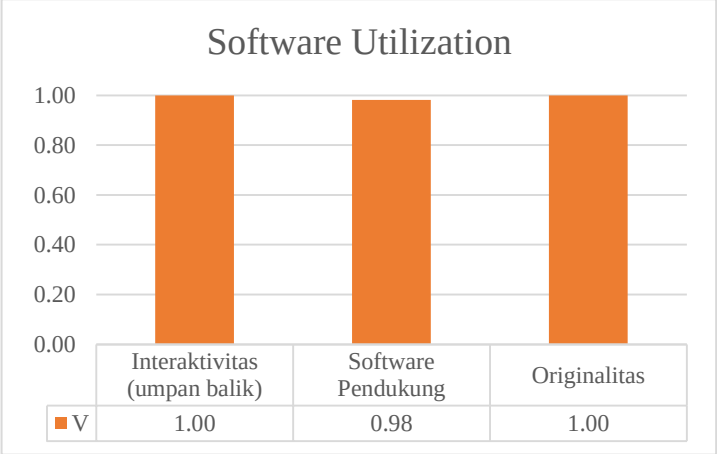

Fig 5. Software Utilization Validity Results

The validity result for the fifth component is dual space inquiry, which has six indicators: (1) DSI steps with a value of 1.0 or very valid, indicating that this e-module already contains DSI steps; (2) Orientation with a value of 0.89 or very valid, indicating that there is a phenomenon that allows students to build knowledge; (3) Conceptualization with a value of 0.89 or very valid, indicating that there are problems in the e-module and students make hypotheses; (4) Exploration with a value of 1.0 or very valid, indicating that the e-module makes students conduct experiments; (5) Conclusion and Assessment with a score of 1.0 or very valid, indicating that the e-module allows students to draw conclusions and make assessments; (6) Reflection with a score of 1.0 or very valid, indicating that there are reflection activities in the e-module. For this indicator, the average score obtained was 0.96, which is categorized as very valid. The validity results of the dual space inquiry component can be seen in Figure 6.

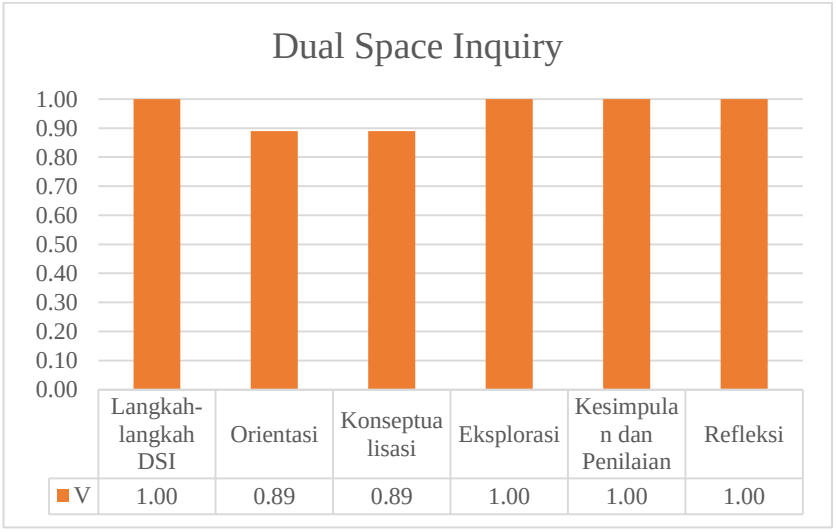

Fig 6. Dual Space Inquiry Validity Result

The validity result for the sixth component is critical thinking Skills. There are five indicators in this component: (1) Providing Simple Explanations with a score of 1.0 or very valid, which shows that the e-module facilitates students in providing simple explanations; (2) Building Basic Skills with a score of 1.0 or very valid, indicating that the e-module facilitates students in building basic skills; (3) Making Conclusions with a score of

1.0 or very valid, indicating that the e-module facilitates students in making conclusions; (4) Making Further Explanations with a score of 0.89 or very valid, indicating that the e-module facilitates students in making further explanations; (5) Strategies and Tactics with a score of 1.0 or very valid, indicating that the e-module facilitates students in making strategies and tactics related to learning concepts. For this indicator, the average score obtained was 0.98, which is categorized as very valid. The validity results for critical thinking skills can be seen in Figure 7.

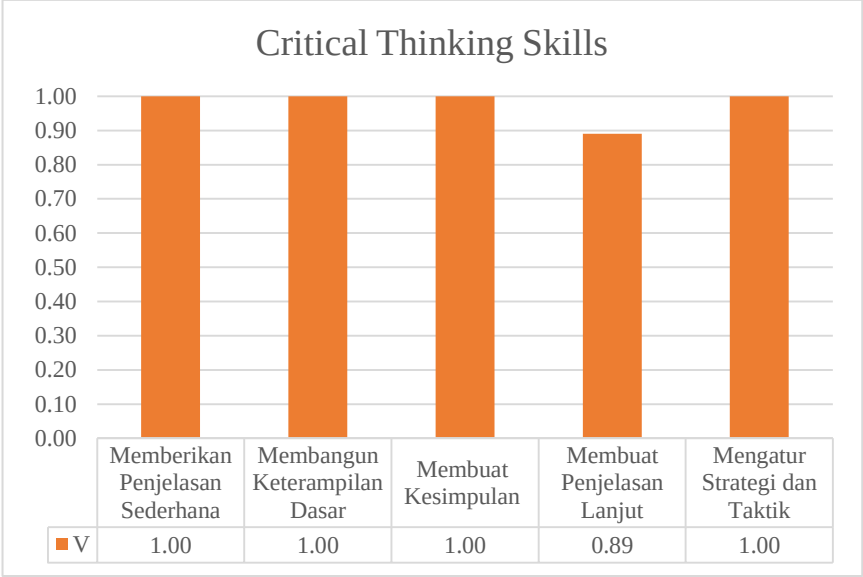

Fig 7. Critical Thinking Skills Validity Results

The validity test results for each assessment component of e-module fluid dynamics based on dual space inquiry to facilitate critical thinking skills in senior high school students, where the components are 1) Material Substance, 2) Learning Design, 3) Visual Communication Display, 4) Software Utilization, 5) Dual Space Inquiry, 6) Critical Thinking Skills. The overall validity results for each component can be seen in Figure 8.

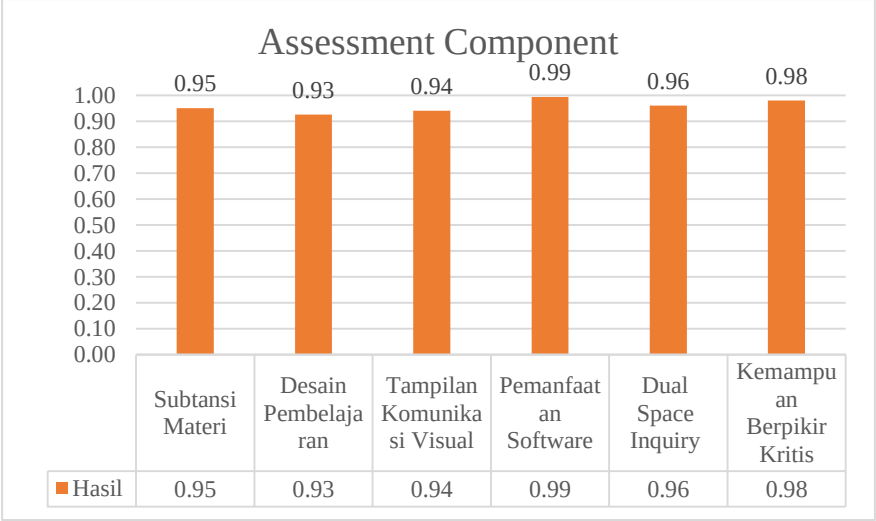

Fig 8. E-Module Validity Test

Based on the validation results conducted by several expert lecturers, the average V value obtained was 0.96, as shown in the figure. The validity criteria for Aiken's V formula state that a product is considered highly valid if the V value is greater than 0.8. Therefore, it can be stated that the Dual Space Inquiry Framework-based E-Module for facilitating students' critical thinking skills is valid with a score of 0.96, which is greater than 0.8.

Overall, this E-Module is based on dual space inquiry to facilitate critical thinking skills. This E-Module was designed using Google Sites with the aim of facilitating students in learning physics so that they can develop critical thinking skills. This E-Module was designed to be as attractive as possible to make it easier for students to learn physics. An illustration of the E-Module interface can be seen in Figure 9.

Fig 9. Illustration of the E-Module

Discussion

The validation process has confirmed the feasibility and high quality of the e-module in all aspects evaluated. During the validation process, three expert lecturers provided suggestions for follow-up actions in the form of e-module checks. There were several suggestions given by the first validator, namely to improve the animation because the UNP logo and independent curriculum were cut off on the cover, secondly to improve the concept map, thirdly to change the achievements per element to use tables, fourthly to add practice questions adjusted to critical thinking Skills indicators, and fifthly to correct incorrect words.

The material substance feasibility component (0.95) ensures that this e-module is scientifically valid. This is in line with the research by Cici et al. (2024), which states that an e-module is considered valid if it meets the content feasibility criteria tailored to student needs, the material presented is clear and systematic, and the material presented helps students understand the concepts [15]. The learning design validity component (0.92) ensures that this e-module is scientifically valid. This is in line with the research by Hasni et al. (2024), which states that learning designs must be as attractive as possible so that the learning process is interesting for students [16]. In addition, Rosminah et al. (2023) emphasize that the use of attractive designs, such as the addition of images, animations, and learning videos in e-modules, can make a good impression on readers [17]. The software utilization feasibility component (0.94) ensures that this e-module is scientifically valid. This is in line with the research by Zain et al. (2024), which states that the use of software has become a necessity in the learning process so that students have critical, innovative, and interactive thinking patterns [18]. he dual space inquiry feasibility component (0.96) ensures that this e-module is scientifically valid. This is in line with the research by Nisrina et al. (2024), which states that inquiry-based learning allows students to engage in deep learning, thereby significantly improving their competence [19]. The critical thinking Skills feasibility component (0.98) ensures that this e-module is scientifically valid. This is in line with the research by Ridlo et al. (2024), which states that e-modules that contain critical thinking indicators effectively encourage students to

be active in solving real-life problems during the learning process and are able to improve students' critical thinking skills [20].

IV. CONCLUSION

Based on the findings and analysis of the research presented, the E-Module on fluid dynamics based on dual space inquiry facilitates students' critical thinking skills. The assessment of this E-Module shows that the content component is highly valid. The learning design component is also categorized as very valid. Similarly, the visual communication display component is rated as very valid. The software utilization component is also rated as very valid. In addition, the dual space inquiry component was also rated as very valid. The critical thinking skills component was rated as very valid. Overall, the validity of the dual space inquiry-based dynamic fluid E-Module to facilitate students' critical thinking skills obtained an average score of 0.96, which is classified as very valid. These results indicate that this E-Module has been evaluated by validators and deemed feasible, allowing it to proceed to the practical feasibility testing stage with students.

ACKNOWLEDGMENT

The author would like to thank Padang State University for the opportunity given to researchers to conduct this study, as well as the Department of Physics, Faculty of Mathematics and Natural Sciences, UNP for the platform provided to publish this article. The author would also like to thank the supervising lecturer, Dr. Fuja Novitra, M.Pd, who guided the researchers in conducting this study. The researcher also thanks the lecturers of the Department of Physics who acted as validators and provided suggestions and input in the development e-modules based on dual space inquiry in fluid dynamics to facilitate critical thinking skills in high school students are valid.

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