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Development of a Computer-Based Interactive Video Formative Feedback to Improve Students' Conceptual Understanding of Static Fluid

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Abstract – *Physics education, particularly in static fluid concepts, often suffers from students' low conceptual understanding due to the limited availability of tailored formative feedback. To address this issue, this study aimed to develop and validate a computer-based interactive-video formative feedback model that supports independent learning and improves students' comprehension of static fluids. Employing the 4D Research and Development model (Define, Design, Develop, and Disseminate), the study focused on the first three stages and involved 128 high school students. The validity of the media was assessed by content and media experts, yielding high validity scores (97% for content and 93% for media). A practicality test showed an 83% approval rate, indicating strong usability and relevance for classroom and independent use. Effectiveness was further assessed through pretest and posttest analysis using the Wilcoxon and N-Gain tests. Results demonstrated a statistically significant improvement in students' conceptual understanding ($p < 0.001$), although the N-Gain value of 0.27 classified the effectiveness as low. Despite this limitation, students responded positively to the interactive format, citing increased engagement and clarity. The novelty of this study lies in integrating isomorphic questions with animated feedback and audio explanations in an interactive video format tailored to students' interests. This research contributes to physics education by offering a practical, validated digital tool that enhances formative assessment practices and provides a foundation for future improvements in instructional media for abstract topics like static fluid.*

Keywords: *computer-based learning; formative feedback; interactive video; physics education; static fluid*

I. INTRODUCTION

Formative feedback plays a crucial role in enhancing the quality of learning by improving students' understanding and identifying areas for improvement (Peter & Uwamahoro, 2023). It enables students to receive corrective guidance on their progress, allowing for the development of a well-rounded and comprehensive understanding. Furthermore, formative feedback helps guide students toward achieving their learning objectives (Ole & Gallos, 2023). These objectives are constructed from various improvements made throughout the student's learning journey. The application of formative feedback can also enhance students' self-efficacy and learning interests (Rakoczy et al., 2019). Additionally, formative feedback offers an opportunity to review students' progress before advancing to the next learning phase (Sasmita et al., 2023).

Despite its benefits, the implementation of formative feedback in learning faces several challenges. Not all students receive the necessary feedback, often due to the large class sizes, which make it difficult for teachers to address the individual needs of every student (Pishchukhina & Allen, 2021). The effectiveness of formative feedback is also influenced by students' attitudes and willingness to engage. Students perceive formative feedback as more impactful when it is delivered in a friendly and supportive manner (Kyaruzi et al., 2019). Previous studies have indicated that students often feel frustrated when they receive unclear or ambiguous written feedback (Hyland, 2013), primarily due to a lack of specificity (Aslam & Khan, 2020). To address this issue, there is a need for engaging, complete, and specific feedback media. In science learning, students often encounter various difficulties and comprehension challenges that necessitate diverse formative feedback approaches (Novianti et al., 2022).

Several factors must be considered when implementing feedback in the learning process. Student involvement is a critical component in the practical application of formative feedback (Adarkwah, 2021). Zhang and Hyland (2022) noted that few studies have emphasized the role of students in providing feedback to improve learning outcomes. Feedback should be detailed and specific to ensure that students can easily comprehend it and benefit from it effectively (Henderson et al., 2021). This involves providing feedback that is clear, direct, relevant, and accompanied by specific suggestions for improvement (Dawson et al., 2019). The interactive feedback model, which includes purposeful formative assessment, can support iterative learning (Mohan et al., 2024). Additionally, students' preferences regarding feedback should be taken into account to enhance its effectiveness (Agricola et al., 2020). Wancham & Tangdhanakanond (2022) identified four components influencing the effectiveness of feedback: focus (people, tasks, and processes), comparison (norms and criteria), function (descriptive and evaluative), and valence (positive and negative).

In recent years, various computer-assisted formative feedback innovations have been developed to support students' learning. Research by Khusaini et al. (2025) demonstrated that computer-assisted formative feedback enhances students' conceptual understanding. This feedback model incorporates both text and graphics, enabling students to engage in independent learning. Previous studies, such as that of Kusairi (2020), explored web-based formative feedback with isomorphic questions using Tryout and Webvoting applications. Suryadi & Kusairi (2021) also developed computer-assisted formative feedback in physics education. However, a formative feedback model linked to students' interest in learning has yet to be fully explored.

To develop an appropriate formative feedback model, it is necessary to study students' interests and learning needs. Initial analysis revealed that students have a high interest in the interactive-video formative feedback model. Interactive multimedia provides a promising opportunity to innovate formative feedback models with significant potential impact. Sasmita et al. (2023) noted that formative feedback should be delivered both verbally and non-verbally. Therefore, the developed feedback model includes audio explanations to accompany the feedback provided.

Interactive multimedia offers numerous advantages in learning environments. It provides easy access both online and offline (Yulianci et al., 2021). The features and benefits of interactive media can be tailored to meet the needs of students who are familiar with technological advancements (Sahronih et al., 2019). Moreover, interactive media can effectively support the development of students' understanding of abstract concepts, fostering innovative learning (Rahim et al., 2022). For instance, interactive simulations in physics have been shown to improve students' conceptual understanding (Rutten et al., 2012). Additionally, the results of the needs analysis confirm that both teachers and students demand and need interactive formative feedback models in physics education.

Therefore, this research aims to develop a computer-based interactive video formative feedback model to support students' independent learning and enhance their conceptual understanding of static fluid. Specifically, the objectives are to: (1) design and develop an interactive video formative feedback model; (2) assess the validity and practicality of the model; and (3) evaluate its effectiveness in improving students' understanding. This study addresses the urgent need for innovative formative assessment tools tailored to students' cognitive challenges and learning preferences in physics education.

II. METHODS

This study employed a Research and Development (R&D) approach using the 4D model to develop an interactive video formative feedback model. The 4D model consists of four main stages: define, design, develop, and disseminate (Thiagarajan et al., 1974). This research primarily focused on the Define, Design, and Develop stages, with the Disseminate stage involving limited testing to assess the practicality and effectiveness of the developed formative feedback model. The model was developed explicitly for teaching static fluid.

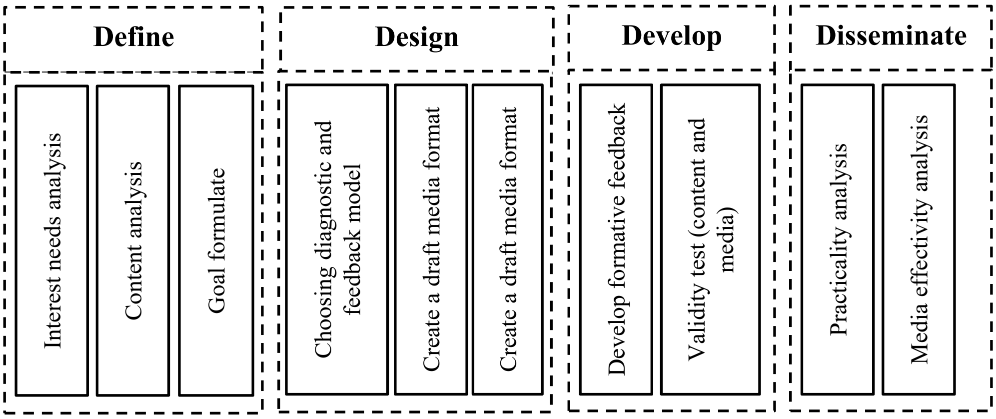

Figure 1. Scheme of formative feedback development with 4D model

The research began with the Define stage, which aimed to explore the interests and needs related to formative feedback, analyze the form and objectives of the feedback model, and establish the foundation for development. Data were collected through questionnaires from students and teachers to gauge their interest in different formative feedback models. This stage provided the necessary background for the subsequent development process. In the Design stage, the initial framework for the formative feedback model was created. This process involved selecting the format, drafting the content, and developing a prototype for further analysis. Discussions with media and content experts were held to refine the prototype before moving on to the next stage. The development stage was the core of the study, focusing on the production of computer-based formative feedback that aligned with students' interests and needs. The developed media format is shown in Figure 2. This stage involved two key tests: content validation and media validation. Content validation assessed the feasibility, presentation, and language aspects, while media validation evaluated the suitability of visual, audio, video, and content elements. The dissemination stage involved a limited trial of the formative feedback media aimed at measuring its practicality and effectiveness in enhancing students' understanding.

The Development stage primarily focused on validating the content and media through expert lecturers. Feedback from the validity tests was used to improve and revise the developed formative feedback model. The Practicality test utilized a questionnaire administered to 128 respondents, all of whom were high school students majoring in science majoring in science, selected using a random sampling method. The results of the validity and practicality tests were analyzed by calculating percentages and categorizing them according to predefined criteria, as shown in Table 1 and Table 2. These results were then used to refine and enhance the interactive-video formative feedback model further. The validation criteria followed the guidelines set by Sunismi and Fathani (2016), while the practicality test adhered to the criteria outlined by Saputra et al. (2020).

Further testing was conducted to assess the effectiveness of the formative feedback model through statistical analyses. The media was trialed and disseminated to students to determine its impact on their conceptual understanding. Data were collected through pretest and posttest results using a concept understanding test. The pretest data were collected prior to students using the formative feedback media, while posttest data were gathered afterward. The test instrument consisted of 10 multiple-choice questions designed to assess students' understanding of the concepts. The data were analyzed using statistical methods. Since the data did not meet the assumptions of normality and homogeneity, the Wilcoxon test was employed to compare the pretest and posttest scores. The Wilcoxon test was used to evaluate the difference in student's conceptual understanding between the two tests. Additionally, the N-Gain test was used to measure the effectiveness of the computer-based interactive video formative feedback model.

III. RESULTS AND DISCUSSION

Interactive video formative feedback media has been developed for students learning static fluid. The primary function of this media is to assist students in understanding and improving their knowledge of static fluid. Interactive learning aids in the retention of material by enabling students to visualize and experience fluid concepts in motion, making abstract ideas more tangible (Rosendahl & Wagner, 2024). Students are expected to grasp the laws of static fluids and apply them to real-life situations. The feedback provided in the media includes text supported by relevant graphics and audio explanations. In practice, students can use the media independently or in groups, utilizing laptops or computers with Microsoft PowerPoint installed. Teachers can also integrate this system into their teaching as a support tool for both classroom instruction and independent learning, aligning with constructivist learning theories.

Define

The results of the interest and needs analysis indicated that the most preferred media by students was an interactive video model with isomorphic problems. The media was developed using PowerPoint, with the selected learning material focusing on static fluid, a topic where students' understanding tends to be low. The goal of the development was to create a learning medium that facilitates independent learning and enhances conceptual understanding.

Design

The design of the computer-based formative feedback media was developed in accordance with a predetermined mechanism. The process for using the interactive-video formative feedback model is illustrated in Figure 2.

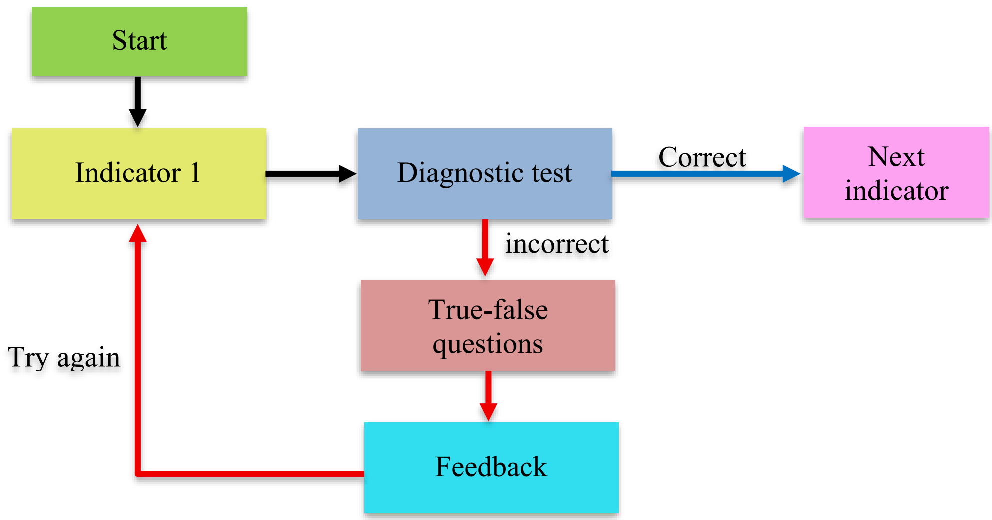

Figure 2. Mechanism of using the interactive-video formative feedback model

Develop

The formative feedback media begins with isomorphic questions comprising three items for each learning indicator. Each problem within an indicator has the same level of difficulty and applies the same theoretical solution, but it is presented in a different format. Students are required to solve all three isomorphic items correctly. If students fail to answer all three questions correctly, they are categorized as not fully understanding the concept. The use of isomorphic questions was selected because they effectively and precisely identify the depth of student understanding (Kusairi et al., 2022). These questions have been validated by physics experts to ensure their appropriateness for assessing students' conceptual understanding.

Students who answer all three isomorphic questions correctly can proceed to the next indicator. However, students who fail to answer the questions correctly will receive feedback. The feedback process begins with true-false questions that correspond to the isomorphic questions but are presented in a simplified format to further scaffold students' understanding. The number of true-false questions is adjusted according to the depth of material covered in each indicator. This approach aligns with the constructivist principle of scaffolding, offering progressively less support as students' competence improves. Figure 3a and Figure 3b illustrate the display of isomorphic and true-false questions.

Each true-false question provides feedback for both correct and incorrect answers. Correct-answer feedback serves to reinforce student understanding, while incorrect-answer feedback guides the student toward the correct concept. The feedback is presented as text slides accompanied by appropriate animations or illustrations. Furthermore, the feedback includes audio explanations to reinforce the material being discussed. Students can engage with the feedback by reading the text, observing the illustrations, and listening to the audio explanations. Figure 3c and Figure 3d show the feedback interface where students can access these resources. After reviewing the feedback, students are redirected to solve the isomorphic problems again in the corresponding indicator. This iterative process continues until students are able to answer all three isomorphic items correctly.

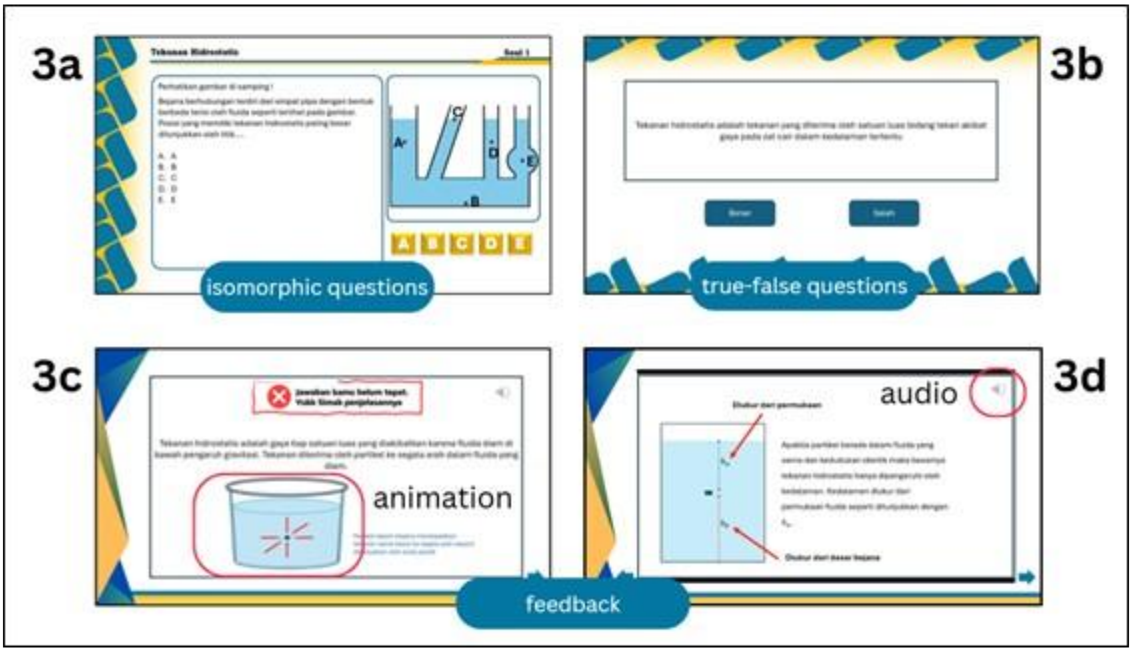

Figure 3. Various features of formative feedback interactive-video model

During the development phase, validation tests were conducted by content experts and media experts. The content validation test showed that the formative feedback media developed was in the "very valid" category, with a percentage of 97%. Similarly, the media validation results were also classified as "very valid," with a percentage of 93%. The feedback from validators led to minor revisions in the formative feedback media. Table 1 presents the revisions made based on the feedback provided by the validators.

Table 1. Expert and media validation results

Category	Content validation	Media validation
Result	Very valid (97%)	Very valid (93%)
revisions	Improve the writing of equations $\rho = \frac{m}{V}$	Provide more detailed and specific feedback
	Adding vector symbols to some equations.	Adjusting the audio volume on some parts of the feedback provided

Disseminate

The practicality test was conducted to assess the feasibility of the formative feedback media as a self-learning tool for students. This test comprised three main indicators: visual communication, operational aspects, and learning design. The practicality test was administered to 128 students, and the results are presented in Table 2.

Table 2. Practicality test results

No	Aspect	Percentage (%)			
		Strongly agree	Agree	Disagree	Strongly disagree
1	Visual communication (84%)	41.41	53.57	4.80	0.22
2	Operational (83%)	37.50	58.98	3.52	0.00
3	Study design (81%)	31.86	60.24	7.64	0.26

Table 2 indicates that the formative feedback media falls into the "very practical" category, with an overall score of 83%. The results for the three aspects were quite similar, with percentages ranging from 81% to 84%, and the majority of respondents selected the "Agree" option. This indicates that the formative feedback media is practical and meets the necessary requirements for helping students learn independently. The media was found to be visually attractive, easy to use, and supportive of the learning process.

Open-ended questions were included in the practicality test to capture respondents' perceptions of the formative feedback media. Some responses are as follows:

- *"Interesting and helps with learning in a new way, so it's not boring and quite helpful in understanding physics."*
- *"Learning with this method is more engaging and easier to understand; we feel like we're playing a game, not studying, making the learning process very effective, fun, and exciting."*
- *"The explanations are easier to understand through images, even though the questions are difficult."*
- *"Very interesting and informative. The feedback provided is complete and helps improve understanding."*
- *"The computer-based formative feedback is interactive and responsive, providing fast, structured feedback that directly addresses students' deficiencies, making learning more effective."*

The responses indicate that students positively received the computer-based formative feedback media, suggesting that the developed media is well-suited for self-directed learning. Statistical tests were conducted to determine the effectiveness of the computer-based interactive-video formative feedback media. The effectiveness was assessed using the Wilcoxon test because the data did not meet the requirements for parametric statistical analysis. Pretest and posttest results were compared to evaluate students' conceptual understanding in one research class. The pretest and posttest results are shown in Figure 4.

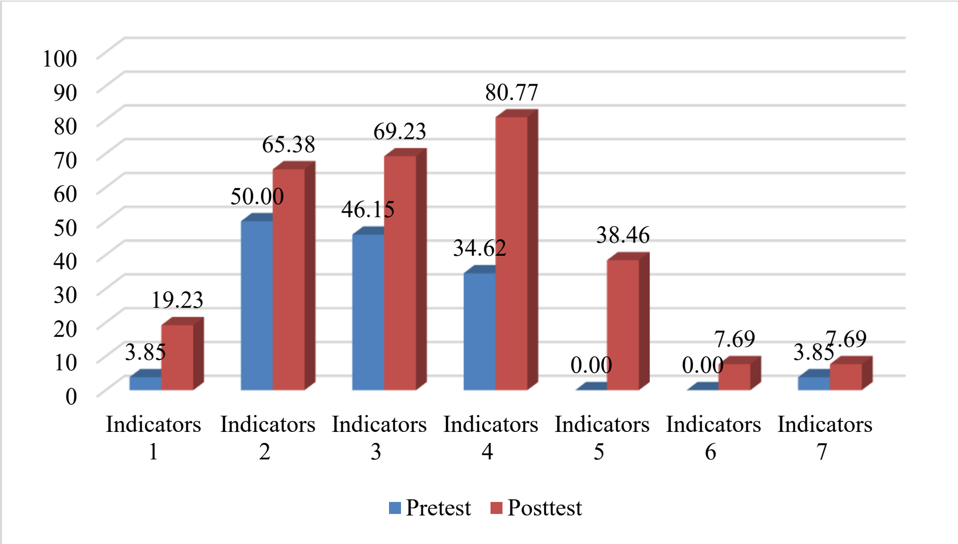

Figure 4. Students' concept understanding on pretest and posttest

The average pretest score was 19.8, while the average posttest score was 41.2, indicating an average increase of 21.4 points. Further analysis showed that indicator 2 had the highest pretest score, while indicator 4 had the highest posttest score. Indicators 5 and 6 had the highest scores on the pretest, whereas indicators 6 and 7 had the lowest posttest scores. The Wilcoxon test results are presented in Table 3.

Table 3. Wilcoxon test analysis results

Ranks				
		N	**Mean rank**	**Sum of rank**
Pretest - Posttest	Negative ranks	2[a]	4.00	8.00
	Positive ranks	21[b]	12.76	268.00
	Ties	3[c]		
	Total	26		
Pretest < Posttest				
Pretest > Posttest				
Pretest = Posttest				

The table 3 reveals that out of 26 students in the research sample, two students experienced a decrease in scores after using the formative feedback media, while three students maintained the same score. However, the majority of students (21 respondents) experienced an increase in scores, with an average improvement of 12.76 points. The Wilcoxon test results show a p-value of less than 0.001, indicating a significant difference in students' conceptual understanding before and after using the media. Further analysis with the N-Gain test yielded an average gain of g = 0.27, which falls within the low category. This suggests that while computer-based interactive video formative feedback has a significant impact on students' conceptual understanding, its level of effectiveness is relatively low.

Discussion

The interactive video formative feedback media has been successfully developed, validated, and tested on a limited basis. The model has been found to be both valid and feasible for application in the learning process. The results from the limited trial suggest that the interactive-video formative feedback model can enhance students' conceptual understanding, albeit with limited effectiveness. These findings align with the work of Khusaini et al. (2025), who suggested that the use of formative feedback in physics learning can help reduce student misconceptions. Similarly, Suryadi & Kusairi (2021) reported that computer-based formative feedback can enhance students' understanding of concepts.

The development of computer-based interactive-video formative feedback holds considerable potential in supporting educational practices. The media developed has undergone expert validation and practicality testing, ensuring that it is suitable for integration into the learning process. The feasibility of the formative feedback media developed in this study shows results comparable to those of previous media-based studies. For instance, Pratami et al. (2023) developed an educational game to support English language learning, which received 89% validity from experts and was deemed highly feasible for educational use. Similarly, Wahyudi & Amir (2022) developed video-based learning media, which was successfully applied in the learning process, following expert revisions and suggestions.

The methodology employed in the development of formative feedback media adhered to the 4D model framework, which has been widely recognized and successful in the creation of various learning support media. For example, Susilawati et al. (2021) used the 4D model to develop learning media based on the guided inquiry model, improving students' concept understanding and creativity. The 4D model has also been used effectively in developing practical modules for physics education, as evidenced by Said et al. (2021).

Despite the significant impact of the interactive video formative feedback media on students' understanding, the results presented in Figure 4 indicate that students' understanding remained low in indicators 6 and 7, which focus on comparing the buoyancy of objects in a liquid. Previous research has shown that students tend to struggle with these indicators, which may explain the low performance in this area. These results suggest that the developed media meets the criteria of having an attractive visual appearance, ease of use, and the ability to support the learning process effectively (Wardaningsih & Supriyatman, 2021; Kusairi et al. 2021). The difficulty in understanding these indicators is likely due to misconceptions related to Archimedes' Law and Pascal's Law. Research by Saputra et al. (2019) found that students often struggle to understand these principles, particularly in distinguishing between the buoyant force and the gravitational force acting on sinking and floating objects (Wicaksono et al., 2019). Additionally, students frequently misunderstand the application of Pascal's law in practical contexts (Estianinur et al., 2021; Irma et al., 2022).

The application of computer-based formative feedback plays a critical role in improving the quality of classroom teaching and helping students enhance their understanding. Formative assessment is integral to the learning process (Leenknecht et al., 2021) and has a direct influence on the quality of education. Garira (2020) explained that the quality of education is determined by three key aspects: input, process, and output. Thus, providing formative feedback to students is essential for improving both the learning process and outcomes. Teachers can utilize this media during lessons or as a self-learning tool for students.

This study contributes to the field of physics education by offering an empirically tested and student-centered digital learning tool that addresses common conceptual challenges in static fluid instruction. The integration of formative feedback through interactive videos aligns with modern pedagogical trends that emphasize technology-enhanced, inquiry-based, and personalized learning. For future research and practice, the findings suggest the need to enhance the design of digital feedback to target specific misconceptions more effectively, particularly in areas identified as persistently difficult. Additionally, broader implementation across diverse student populations is recommended to validate scalability and to refine the tool based on varied learning contexts. Ultimately, the model developed in this study serves as a foundation for the continued evolution of interactive instructional media in physics education, supporting deeper conceptual understanding and promoting independent, feedback-driven learning.

IV. CONCLUSION AND SUGGESTION

This study successfully developed a computer-based interactive-video formative feedback model aimed at improving students' conceptual understanding of static fluid concepts. The model, built using the 4D (Define, Design, Develop, Disseminate) development framework, demonstrated high content and media validity (97% and 93%, respectively) and was found to be very practical (83%) based on student feedback. Statistical analysis revealed a significant improvement in students' conceptual understanding after using the media, as shown by the Wilcoxon test ($p < 0.001$). However, the N-Gain score of 0.27 indicates a low level of effectiveness. Despite this, the media received positive responses from students regarding its clarity, engagement, and support for self-directed learning, confirming its potential as a supplemental tool in physics education.

Nevertheless, the study had several limitations. The small and localized sample size limits the generalizability of the findings, and some static fluid indicators particularly those related to buoyant force and pressure remained challenging for students even after using the media. Future research should involve larger and more diverse populations across different educational contexts and regions. Additionally, further refinement of the media is needed to address conceptual difficulties through clearer animations, improved content scaffolding, and more targeted feedback. This study contributes to the field of physics education by demonstrating how interactive, computer-based formative feedback can foster self-learning, support conceptual development, and offer an innovative approach to diagnosing and addressing misconceptions in abstract science topics.

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