Current STEAM and Education Research
Volume 3, Issue 2, August 2025

DOI: doi.org/10.58797/cser.030205

Developing and Evaluating 'Fluid Mission': A Case-Based E-Learning Game for Teaching High School Fluid Mechanics

Lila Zalika

Industrial Engineering and Management, Chengqing Rd No. 840, Niaosong District, Kaohsiung City 83347, Taiwan

Email: M1406604@gcloud.csu.edu.tw

Abstract

This study explores the design, development, and evaluation of Fluid Mission, a game-based e-learning tool aimed at enhancing the understanding of fluid mechanics for high school students. The game integrates game-based learning (GBL) with case-based learning (CBL), providing students with interactive, real-world scenarios to bridge the gap between abstract concepts and practical applications. The study involved 36 high school students from Jakarta, Indonesia, who engaged with the game and completed quizzes designed to assess their comprehension of fluid mechanics concepts. Results showed a significant improvement in student performance, with average quiz scores increasing from 60.36% before the game to 83.51% after. Expert evaluations indicated that the game met high standards for content accuracy, media design, and usability. Student feedback also revealed increased engagement and motivation to learn fluid mechanics. The findings suggest that Fluid Mission is an effective tool for enhancing student learning in fluid mechanics and demonstrate the potential of combining GBL and CBL to improve education in complex scientific subjects.

Keywords: case-based learning (CBL), e-learning game, fluid mechanics, game-based learning (GBL)

Received: 19 March 2025
Revised: 6 May 2025
Accepted: 7 May 2025
Published: 8 May 2025
Issued: 30 August 2025

Current Steam and Education Research e-ISSN: 3025-8529

INTRODUCTION

A basic field of physics, fluid mechanics poses significant challenges for students particularly in understanding complex ideas including hydrostatics, the Bernoulli principle, and fluid dynamics. Along with their reliance on advanced mathematical models, the abstract attributes of these subjects may cause difficulties for understanding (Minichiello et al., 2020; Shi et al., 2023). For students to understand, the Bernoulli principle, which relates to the interaction of velocity, pressure, and

elevation in fluid dynamics, is sometimes paradoxical and difficult (Minichiello et al., 2020). Consequently, the lack of useful applications in traditional classroom settings causes students to often experience dissatisfaction and disengagement (Brown, 2016; Martínez, 2021).

Conventional educational approaches, which mostly rely on lectures and textbooks that do not actively involve students, it is the challenges in learning fluid mechanics. Virtual simulations and project-based learning approaches have been investigated to some extent, but they usually fall short in linking theoretical knowledge with useful application (Shi et al., 2023; Baldock & Chanson, 2006; Natarajan, 2024). Lack of practical experience limits students's ability to visualize fluid dynamics, therefore affecting their grasp and memorization of abstract ideas (Fleischmann & Manoharan, 2022). The lack of experience learning has created demand for innovative pedagogical approaches combining academic knowledge with pragmatic problem-solving techniques.

To overcome these issues, game-based learning (GBL) and case-based learning (CBL) have emerged as potential pedagogical strategies (Ruipérez, 2022). By incorporating interactive simulations, GBL creates a dynamic environment in which students can engage directly with fluid mechanics ideas through problem-solving and experience learning. This immersive method of learning has been found to improve conceptual understanding and student motivation, particularly in complicated disciplines such as fluid mechanics (Minichiello et al., 2020; Khine et al., 2024). GBL deliver rapid feedback and contextual rewards will increases deeper engagement by assisting students in developing mental models that connect theoretical knowledge to real-world applications (Shi et al., 2023; Vázquez-Calatayud et al., 2024).

CBL improves learning by integrating abstract concepts into real-world circumstances. By analyzing relevant case studies, such as the sinking of the KRI Nanggala (Yahya & Asril, 2022) submarine or the lift force on an aviation wing, students can gain a greater understanding of how fluid mechanics principles apply in real-world circumstances. Combining GBL and CBL results in a full learning experience that engages students not just in theory but also in practical, real-world scenarios. This fusion has shown significant promise in enhancing student involvement and knowledge, offering a comprehensive approach to learning fluid mechanics (Afonso et al., 2024; Skjelbred & Daus, 2022). Interactive and immersive experiences resulting from GBL facilitate deeper understanding by enabling students to apply theoretical concepts in realistic scenarios, thus reinforcing their learning through practice Using the online education planned based on anderson's theory to facilitate the practice learning experiences of nursing students: A phenomenological study. This experiential approach helps learners to visualize and contextualize abstract fluid dynamics concepts, making them more tangible and relatable (Ulazia & Ibarra-Berastegi, 2020). The use of games encourages collaboration and communication among students, fostering a community of learners who can share insights and strategies, thereby enriching the educational experience (Lee et al., 2025).

Although CBL and GBL have been extensively investigated in a variety of educational settings, their implementation, particularly for fluid mechanics training, remains underutilized. Many research have investigated how gamification can promote student knowledge and engagement in

fields such as biology, medicine, and engineering (Minichiello et al., 2020; Khine et al., 2024). However, research into how GBL can be combined with case-based learning to address the unique challenges of teaching fluid mechanics is limited. Fluid mechanics is sometimes regarded as a particularly difficult topic due to its abstract ideas and mathematical complexity; current teaching tools, such as virtual simulations, while useful in visualizing fluid dynamics, typically lack real-world case studies that connect theory to practice. This disagreement in the literature highlights the need for more research into how a dual technique combining GBL and CBL can aid in the understanding of fluid mechanics.

Furthermore, current research on gamification in fluid mechanics education is typically focused on short-term outcomes, such as instantaneous engagement or satisfaction, with little consideration given to long-term effects on students' conceptual retention or ability to apply knowledge in useful contexts. Although some research has shown that simulation tools may accurately simulate fluid behavior, they do not always provide the depth of context that case-based learning does. Case studies, or real-world applications, are crucial in helping students understand the practical applicability of theoretical principles. Further research is needed to determine how the integration of game-based simulations with case-based scenarios might bridge this gap and provide a comprehensive learning experience that not only engages students but also improves their ability to apply fluid mechanics concepts in real-world settings.

The primary goal of this study is to create and assess Fluid Mission, a game-based learning tool that teaches fluid mechanics using both case-based and game-based approaches. This e-learning game combines abstract concepts with real-world case studies and interactive activities to increase students' understanding of fluid mechanics. The study will look at how well this gamified approach enhances students' ability to connect theoretical concepts with practical applications, addressing a major shortcoming in traditional teaching approaches. The findings of this study will contribute to the existing body of information on gamification in education and provide an informed analysis of creative ways for teaching complicated scientific concepts.

METHOD

This study follows a Research and Development (R&D) approach, utilizing the ADDIE model (Analyze, Design, Development, Implementation, Evaluation) as its guiding framework (Branch & Varank, 2009). The ADDIE model is widely used in educational research for developing and testing educational products, ensuring a systematic approach to the creation and evaluation of the e-learning game, *Fluid Mission*.

The first phase involved identifying the learning challenges and determining the educational goals for the fluid mechanics curriculum. This stage included a review of the existing literature on teaching fluid mechanics, with a focus on the limitations of traditional instructional methods and the need for interactive and engaging learning tools. The game's structure, including its missions, reward system, user interface, and integration with Learning Management Systems (LMS), was designed to align with the educational goals identified in the analysis phase. This design phase also

took into account the pedagogical needs of the target audience (high school students), ensuring that the content and format were suitable for their cognitive level. The development phase involved creating the Fluid Mission game using the Genially platform, which allows for the creation of interactive, multimedia-rich educational content. The game was designed to simulate real-world fluid mechanics cases, such as the sinking of the KRI Nanggala submarine and the concept of lift on an airplane wing. It was integrated with Moodle LMS to track student progress and provide assessment through quizzes and rewards. Once developed, the game was implemented in a real-world educational setting. A pilot test was conducted with 36 students from five different high schools in Jakarta, Indonesia. The students were tasked with using the game, followed by a quiz on Moodle to assess their understanding of the fluid mechanics concepts covered. The evaluation phase involved collecting feedback from both students and experts (content, media, and software experts). This feedback was used to assess the effectiveness of the game in enhancing student engagement, understanding, and retention of fluid mechanics concepts. Revisions were made based on the feedback to improve the game's content, usability, and educational value.

The participants in this study were 36 high school students from five different schools in Jakarta, Indonesia. These students were selected using purposive sampling based on the following criteria: They were enrolled in a physics class and had a basic understanding of fluid mechanics concepts; They were willing to participate in the study and provide feedback on the game.

In addition to the students, a number of experts were involved in evaluating the game. These included:

1. Subject Matter Experts (SMEs): Faculty members from the Department of Physics Education at Universitas Negeri Jakarta, responsible for evaluating the content validity of the game.
2. Media Experts: Professionals from PT. MJI, who assessed the media and instructional design of the game.
3. Software Engineers: Faculty members from Jakarta Global University, who evaluated the technical functionality and software integration of the game.

The primary tool used in this study was the e-learning game Fluid Mission, which was developed using the Genially platform. The game was designed to be compatible with Learning Management Systems (LMS), specifically Moodle, to facilitate tracking of student progress and provide assessment through quizzes.

1. Platform: Genially was used for creating the interactive game, which included puzzles, missions, and case-based scenarios related to fluid mechanics.
2. LMS: Moodle was used to host the game and track student performance, as well as deliver quizzes and surveys.
3. SCORM Package: To integrate the game with Moodle and enable tracking of scores and progress, a SCORM package was generated in Genially and uploaded to the Moodle platform.

The procedure for this study involved several structured steps designed to evaluate the effectiveness of the *Fluid Mission* game. Initially, students were provided with a pre-implementation

briefing, where they were introduced to the Moodle platform and explained how to engage with the *Fluid Mission* game. This briefing ensured that students understood the objectives of the game and the fluid mechanics concepts it aimed to teach. Once the briefing was completed, students accessed the game through Moodle, where they were required to complete various missions focused on fluid mechanics. These missions involved activities such as solving puzzles, identifying relevant fluid dynamics principles in real-world case studies, and completing corresponding quizzes. Each mission was structured to reinforce key concepts such as hydrostatics, Bernoulli's principle, and fluid dynamics. Upon finishing the game, students took a post-game quiz on Moodle to assess their understanding of the material covered. Data collection occurred after the game through surveys and expert evaluations. Students provided feedback via pre- and post-game perception surveys to evaluate changes in their engagement, understanding, and motivation towards the subject. Simultaneously, subject matter experts, media experts, and software engineers assessed the game's content, usability, and technical quality, providing valuable insights into the game's effectiveness.

The data collected from the student feedback, expert evaluations, and quiz results were analyzed using both quantitative and qualitative methods. Quantitatively, pre- and post-game quiz scores were compared to determine if the students demonstrated a significant improvement in their understanding of fluid mechanics concepts. Student engagement, understanding, and motivation were also measured through Likert scale items on the student perception surveys.

Table 1. Feasibility Instrument by Subject Matter experts

Aspect
Material Coverage Aspect
Presentation Technique Aspects
Linguistic aspect

Table 2. Feasibility Instrument by Media experts

Aspect
Design Aspects
Aspect of Use
Linguistic aspect

Table 3. Feasibility Instrument by Software Expert

Aspect
Compatible Aspect
Aspect of Inoperability
Aspect of Use

Maintenance Aspects

Table 4. Teacher Perception Instrument

Aspect
Material Coverage Aspect
Presentation Technique Aspects
Aspect of Use
Structural Aspect

Table 5. Student Perception Instrument

Aspect
The appearance of the learning game Fluid Mission
Presentation of the material is easy to understand.
The language used is easy to understand.
Arrange the content layout proportionally and consistently.
Increasing curiosity

Table 6. Likert Scale Description

Percentage	**Description**
$\mathbf{81\% \leq \bar{x} \leq 100\%}$	Very Feasible
$\mathbf{61\% \leq \bar{x} \leq 80.5\%}$	Feasible
$\mathbf{41\% \leq \bar{x} \leq 60.5\%}$	Feasible Enough
$\mathbf{21\% \leq \bar{x} \leq 40.5\%}$	Not Feasible
$\mathbf{\bar{x} \leq 20.5\%}$	Very Not Feasible

for each indicator, it is calculated using the following formula:

$$\bar{x} = \frac{\Sigma \text{ score obtained}}{\Sigma \, maximum \, score} \, x \, 100\% \quad (1)$$

The Likert scale data from these surveys, along with expert evaluation forms, were analyzed to assess the overall effectiveness of the game. For qualitative analysis, open-ended responses from both students and experts were examined thematically. This analysis helped identify key strengths and areas for improvement in the game, such as aspects of content accuracy, design, and technical functionality. By triangulating both the quantitative quiz data and the qualitative feedback, the

study aimed to draw comprehensive conclusions regarding the impact of the *Fluid Mission* game on student learning.

This study utilized several instruments to collect data and assess the effectiveness of the *Fluid Mission* game. The primary tool for gauging student engagement and learning outcomes was the Student Perception Survey, which included questions designed to measure students' motivation, interest, and understanding of fluid mechanics before and after interacting with the game. The survey used a Likert scale to assess changes in these areas, providing quantitative data that was analyzed to determine the impact of the game. Additionally, Expert Evaluation Forms were used to gather feedback from subject matter experts, media experts, and software engineers regarding the game's content, instructional design, and technical functionality. These forms allowed for a comprehensive evaluation of the game's educational effectiveness. Finally, Game Performance Metrics such as mission completion rates, time spent on each task, and quiz scores were tracked and analyzed to measure students' progress and achievement in the game. Together, these instruments provided a robust framework for evaluating both the educational quality and the user experience of the *Fluid Mission* game.

Ethical approval for the study was obtained from the relevant academic bodies. Informed consent was collected from all participants, including students and experts, prior to their involvement in the study. All personal information was kept confidential, and participants were assured that their feedback would be used solely for the purpose of this research.

RESULTS AND DISCUSSION

The results of this study provide strong evidence for the effectiveness of the *Fluid Mission* game in enhancing students' understanding of fluid mechanics and increasing their engagement with the subject. Pre- and post-game quiz results indicated a significant improvement in student learning outcomes. The average pre-game quiz score was 60.36%, while the post-game quiz score increased to 83.51%, demonstrating a 23.15% improvement in students' conceptual understanding of fluid mechanics. This increase suggests that the *Fluid Mission* game was successful in helping students grasp abstract fluid mechanics concepts, such as hydrostatics, Bernoulli's principle, and fluid dynamics. These findings align with previous research that supports the positive impact of game-based learning (GBL) on student comprehension of complex topics (Minichiello et al., 2020; Shi et al., 2023).

After the product development is completed, the product is then tested for feasibility by material experts, media experts, and software experts. The purpose of this feasibility test is to determine the viability of the developed product and then trial it with teachers and students. The feasibility test is conducted by providing a Google Form to subject matter experts, media experts, and software experts. The results of the feasibility test include assessments, critiques, and suggestions from the experts, which are then used to make improvements based on the findings.

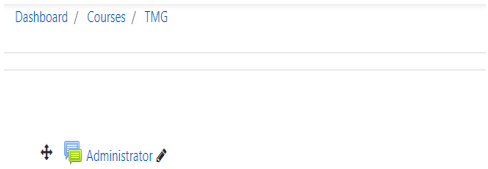
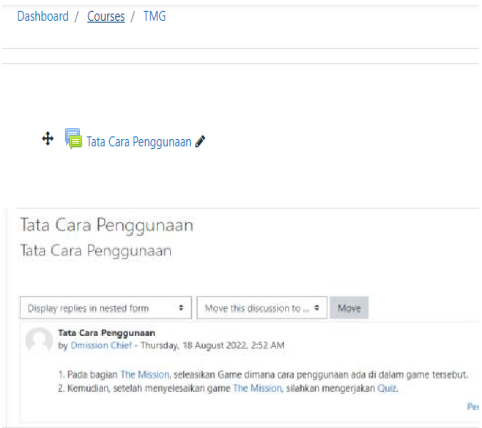
Table 7. Feasibility Test Results by Subject Matter Experts

Aspect	Percentage	Interpretation
Material Coverage Aspect	95.83%	Very Feasible
Presentation Technique Aspects	92.85%	Very Feasible
Linguistic aspect	87.50%	Very Feasible
Average of All Aspect	**92.06%**	**Very Feasible**

The feasibility test for the subject matter experts is conducted online where a Google Form is provided to the subject matter experts.The feasibility test by the material experts includes 3 aspects: the scope of the material, presentation, and language. For the aspect of material coverage, there are 6 questions. Then, for the presentation aspect, there are 7 questions.Then finally, the Language aspect with 2 questions.

The subject matter expert also suggested reviewing the physics concepts in the e-learning to see if they are already included.For the developed e-learning, there are physics concepts in fluid cases used in the game, along with explanations of the relationship between those cases and fluids. Then, the subject matter expert suggested adding a sequence of case-based learning syntax in the Fluid Mission product and a user manual or usage instructions for the Fluid Mission product.

Table 8. Revision from the Subject Matter Expert

Before Revision	After Revision
 There are no usage guidelines for e-learning.	 Usage instructions have been added.

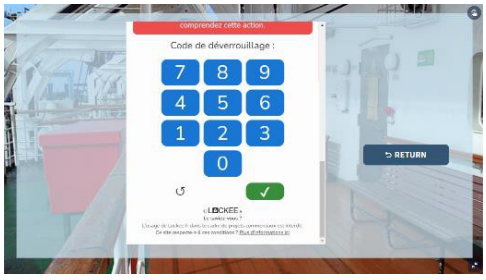
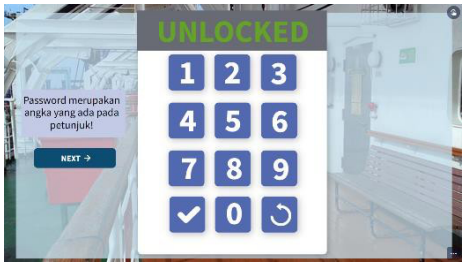
The feasibility test for media experts is conducted online where a Google Form is provided to the media experts.The feasibility test by media experts includes 3 aspects: design, usability, and language. For the design aspect, there are 9 questions.Then, for the aspect of usage, there are 9 questions. Then finally, the linguistic aspect with 4 questions.

Table 9. Feasibility Test Results by Material Experts

Aspect	Percentage	Interpretation
Design Aspects	90.63%	Very Feasible
Aspect of Use	100%	Very Feasible
Linguistic aspect	100%	Very Feasible
Average of All Aspect	**96.88%**	**Very Feasible**

Learning media experts suggest that the letters used in the game should be more consistent and some words in the game are also obstructed by images or unclear. In addition, there are also parts related to other websites that need to be fixed.

Table 10. Revision from the Media Expert

Before Revision	After Revision
	
There are no usage guidelines for e-learning.	Usage instructions have been added.

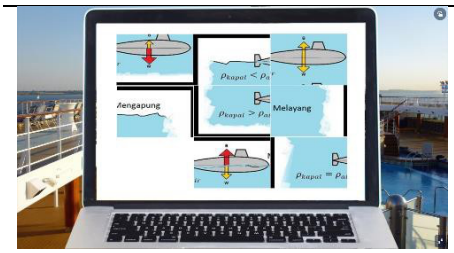
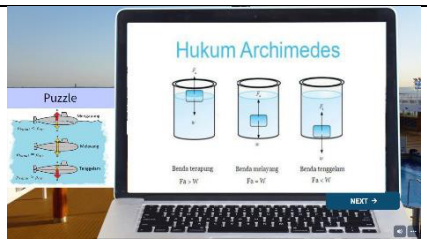
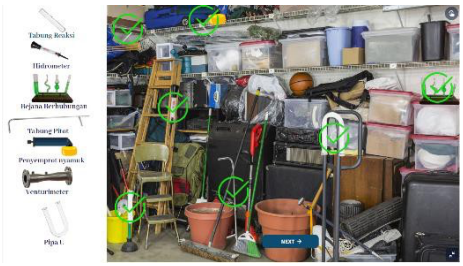
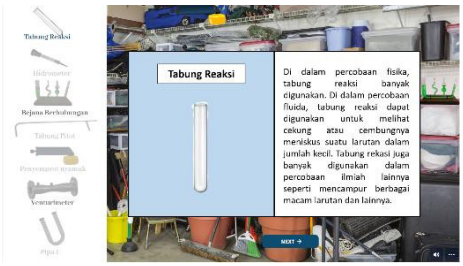
The feasibility test for software experts is conducted online where a Google Form is provided to the software experts. The feasibility test by software experts includes 4 aspects: the usability aspect with 9 questions, the maintenance aspect with 3 questions, the compatibility aspect with 2 questions, and the inoperability aspect with 1 question.

Table 11. Feasibility Test Results by SoftExperts

Aspect	Percentage	Interpretation
Compatible Aspect	100%	Very Feasible
Aspect of Inoperability	100%	Very Feasible
Aspect of Use	88.80%	Very Feasible
Maintenance Aspects	100%	Very Feasible
Average of All Aspect	**97.20%**	**Very Feasible**

The software expert explained that the interface is already consistent and the learning content is good. The software expert also suggested placing more emphasis on the learning content rather than the game itself and incorporating educational points at various stages of the e-learning game.

Table 12. Revision from the Software Expert

Before Revision	**After Revision**
	
After successfully completing puzzle no feedback	After successfully completing the table, there is information regarding floating, sinking, and Floating
	
After the user finds the requested item, there is no feedback.	After the user finds the item, there is information about the item.

Expert evaluations were also highly positive, confirming the game's educational value. The content was rated 92.06 % by subject matter experts (SMEs), indicating that the fluid mechanics principles presented in the game were accurate and aligned with the learning objectives. Media experts rated the game's design at 96.88%, highlighting the engaging visuals, clear animations, and interactive elements that facilitated student learning. Software engineers gave the game a usability rating of 97.2%, praising the smooth integration with Moodle LMS and its compatibility with various devices. These expert evaluations validate the game's design and functionality, suggesting that it is both an effective and user-friendly tool for teaching fluid mechanics.

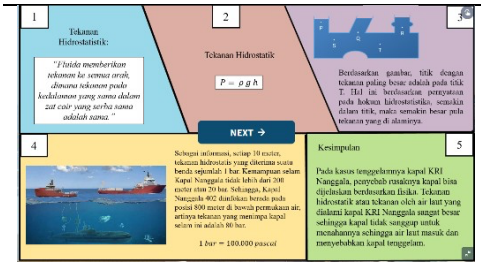
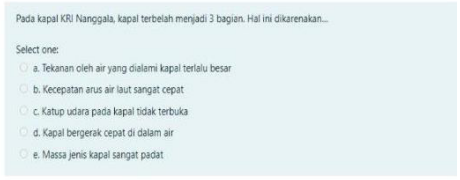
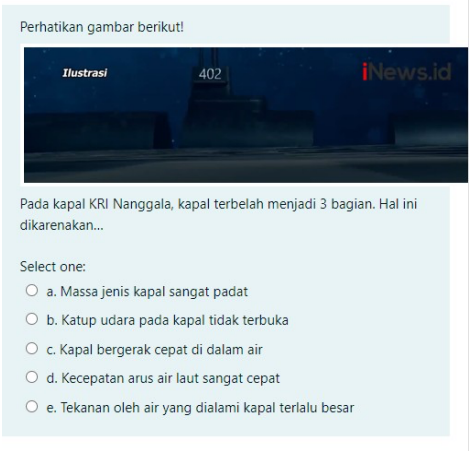
The product trial by the teacher was conducted. The instrument for testing the use of the product is in the form of a questionnaire. The product usage trial instrument for teachers includes 4 aspects: the material coverage aspect with 5 questions, the appearance aspect with 5 questions, the usability aspect with 8 questions, and the structure aspect with 3 questions.

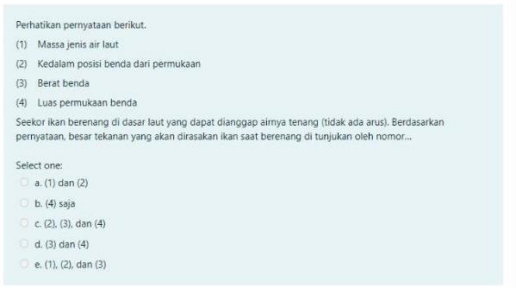
Table 13. Results of the Product Trial by the Teacher

Aspect	Percentage	Interpretation
Material Coverage Aspect	95%	Very Feasible
Presentation Technique Aspects	100%	Very Feasible
Aspect of Use	93.75%	Very Feasible
Structural Aspect	100%	Very Feasible
Average of All Aspect	**97.19%**	**Very Feasible**

Based on the results of the trial usage by teachers, the average percentage for all aspects was 97.19%, so it can be concluded that the e-learning game Fluid Mission is considered very suitable for use as a learning medium. From the results of the teacher's usability test, there were not many changes to the game, where suggestions were received such as improving the formulas, where explanations should be provided for the formulas. Next, in the final quiz of the e-learning game, the teacher suggested adding images to some questions so that students could better illustrate the questions. Next, the answer options for the questions are adjusted and not randomized.

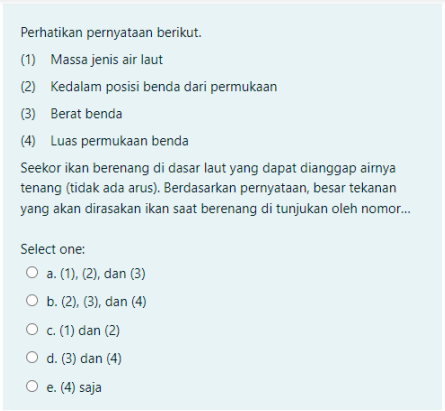
Table 14. Revision from the Product Trial by Teacher

Before Revision	After Revision
	
There are no explanations for the formulas in the game.	An explanation has been added to the formula in the game.
	
There is no image regarding the question.	

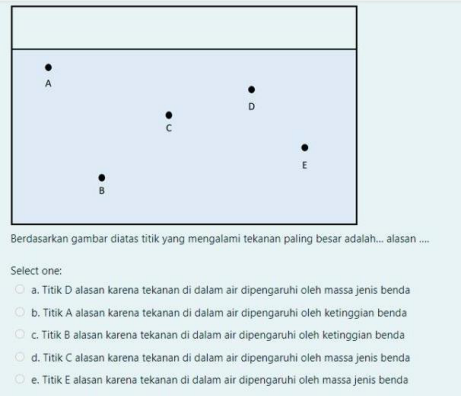


Answer options are not in order.

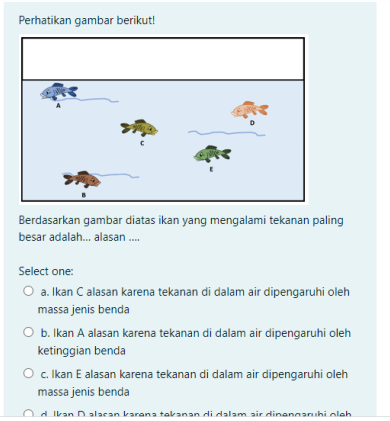
An image has been added to complete the question.



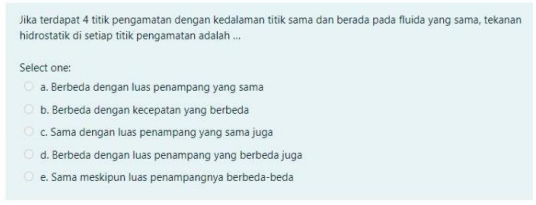
The answer options have been corrected to be sequential.



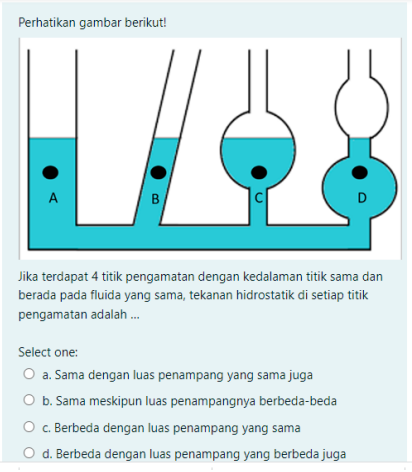
The image is confusing because it uses a dot.



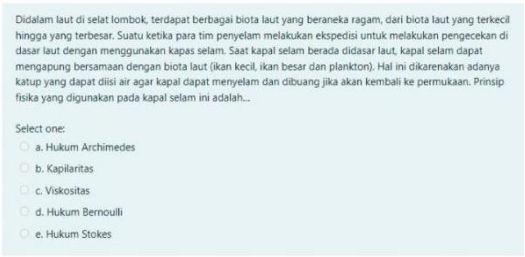
The image was corrected to a fish image to explain the question.



There is no image to clarify the question.

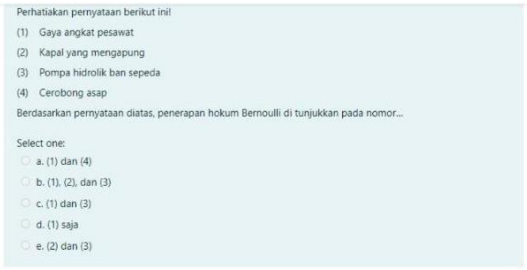


An image has been added to clarify the question.

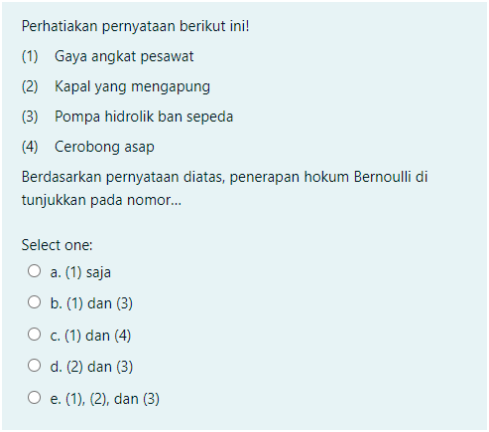


There are no pictures to help students visualize the situation.

An image has been added to clarify the question.



Answer options are not in order.



The answer options have been corrected to be sequential.

Student feedback was similarly positive, with significant improvements in engagement and motivation. The pre-game survey indicated that students had a moderate interest in learning fluid mechanics (60.36%), but this increased to 83.51% after playing the game, demonstrating a substantial boost in student engagement. Additionally, the game received an average usability score of 88.34%, with students praising its interactive features and real-world case studies, which helped them connect theoretical concepts with practical applications. The feedback suggests that the game not only improved understanding but also fostered a more engaging and enjoyable learning experience compared to traditional methods.

The substantial improvement in student performance, from pre-game to post-game quizzes, highlights the game's effectiveness in promoting active learning. The interactive and immersive nature of the game enabled students to apply fluid mechanics principles to real-world scenarios, such as the sinking of the KRI Nanggala submarine and the dynamics of airplane lift. This case-based learning approach provided students with contextualized examples that helped them visualize abstract concepts in action, making the material more tangible and relatable. This aligns with previous findings that demonstrate the advantages of case-based learning in enhancing students' critical thinking and problem-solving skills (Brown, 2016; Vázquez-Calatayud et al., 2024).

Despite the positive findings, the study also encountered several limitations. One notable limitation was the relatively small sample size of 36 students from five high schools. While the results are promising, a larger sample size would provide more robust data and help generalize the findings. Furthermore, the study focused on the short-term impact of the game, with assessments conducted immediately after students completed the game. Future research could examine the long-term retention of fluid mechanics concepts to determine whether the improvements in understanding persist over time. Additionally, while the game proved effective in enhancing engagement and learning outcomes, its reliance on internet connectivity could pose challenges for students in areas with unstable or limited internet access. Future iterations of the game could explore offline capabilities or optimize it for lower-bandwidth environments to enhance accessibility.

From a practical perspective, the results of this study suggest that *Fluid Mission* has significant potential as a supplemental tool in fluid mechanics education. By combining game-based learning with real-world case studies, the game provides an engaging way for students to explore complex scientific concepts. The success of this approach highlights the value of integrating gamification into STEM education, where active learning, interactivity, and real-world applications are essential for fostering deeper understanding. Moreover, the positive feedback from students and experts suggests that *Fluid Mission* could be adapted and applied to other scientific disciplines that involve complex theoretical concepts, such as thermodynamics or aerodynamics.

In conclusion, the results from this study indicate that the *Fluid Mission* game is a highly effective tool for enhancing student learning in fluid mechanics. The significant improvement in quiz scores, combined with high ratings for engagement and usability, demonstrate the potential of gamified learning experiences to make complex subjects more accessible and engaging for students. However, further research with a larger sample size, as well as long-term follow-up studies, would provide a more comprehensive understanding of the game's impact on student learning. Future enhancements to the game, including additional content, multiplayer features, and offline accessibility, could further extend its educational reach and effectiveness.

CONCLUSION

The findings from this study provide strong evidence for the effectiveness of the Fluid Mission e-learning game in enhancing students' understanding of fluid mechanics and increasing their

engagement with the subject. The significant improvement in quiz scores, from an average of 60.36% before the game to 83.51% after, demonstrates the game's ability to foster a deeper conceptual understanding of complex fluid dynamics topics. Expert evaluations further validated the quality of the game, with high ratings for content accuracy, media design, and software usability. Additionally, the positive feedback from students regarding the game's interactivity and real-world case studies highlights its potential to bridge the gap between theoretical concepts and real-world applications.

While the study's limitations, such as the small sample size and the focus on short-term outcomes, suggest areas for further research, the results indicate that gamified learning, particularly when combined with case-based scenarios, can significantly enhance student engagement and understanding in complex subjects like fluid mechanics. The Fluid Mission game offers an innovative approach to teaching fluid mechanics, making abstract concepts more accessible and engaging for students. Future studies should explore the long-term retention of the material and assess the effectiveness of the game in a broader range of educational settings.

REFERENCES

Afonso, M., Lopes, R., Andrade, E., & Pereira, L. (2024). Game-based learning enhances students' understanding of endocrine physiology in veterinary medicine. Ajp Advances in Physiology Education, 48(2), 155-163. https://doi.org/10.1152/advan.00182.2023

Baldock, T. and Chanson, H. (2006). Undergraduate teaching of ideal and real fluid flows: the value of real-world experimental projects. European Journal of Engineering Education, 31(6), 729-739. https://doi.org/10.1080/03043790600911837

Bayram, A., Bayram, S. B., & Özsaban, A. (2024). Using the online education planned based on anderson's theory to facilitate the practice learning experiences of nursing students: A phenomenological study. *Education and Information Technologies*, *29*(16). https://doi.org/10.1007/s10639-024-12692-1

Branch, R. M., & Varank, İ. (2009). *Instructional design: The ADDIE approach* (Vol. 722, p. 84). New York: Springer. https://doi.org/10.1007/978-0-387-09506-6

Brown, A. (2016). Engaging students as partners in developing online learning and feedback activities for first-year fluid mechanics. European Journal of Engineering Education, 43(1), 26-39. https://doi.org/10.1080/03043797.2016.1232372

Fleischmann, S. and Manoharan, S. (2022). Lessons learned: hands-on fluids lab in remote delivery mode. International Journal of Mechanical Engineering Education, 50(4), 923-954. https://doi.org/10.1177/03064190221078257

Khine, P., Thein, W., Lim, S., Ponnupillai, A., Lim, Y., Sirisinghe, R., … & Kumwenda, B. (2024). The effectiveness of gamebook teaching-learning approach in undergraduate mbbs course in comparison with the conventional teaching-learning approach. Education in Medicine Journal, 16(Supp.1), 79-90. https://doi.org/10.21315/eimj2024.16.s1.9

Lee, C., Lee, C., Lai, H., Chen, P., Chen, M., & Yau, S. (2025). Emerging trends in gamification for clinical reasoning education: a scoping review. BMC Medical Education, 25(1). https://doi.org/10.1186/s12909-025-07044-7

Martínez, F. (2021). Dificultades cognitivas asociadas a la solución de un ejercicio de mecánica de fluidos en un contexto de aprendizaje virtual. Formación Universitaria, 14(1), 121-134. https://doi.org/10.4067/s0718-50062021000100121

Minichiello, A., Armijo, D., Mukherjee, S., Caldwell, L., Kulyukin, V., Truscott, T., … & Bhouraskar, A. (2020). Developing a mobile application-based particle image velocimetry tool for enhanced teaching

and learning in fluid mechanics: a design-based research approach. Computer Applications in Engineering Education, 29(3), 517-537. https://doi.org/10.1002/cae.22290

Natarajan, R. (2024). A project-based learning (pbl) on gas dynamic concepts using hydraulic analogy technique. International Journal of Mechanical Engineering Education, 53(2), 277-292. https://doi.org/10.1177/03064190231224339

Ruipérez, J. A. (2022). Unveiling the Potential of Learning Analytics in Game-Based Learning. *Advances in Human and Social Aspects of Technology Book Series*, 524–544. https://doi.org/10.4018/978-1-7998-9732-3.ch023

Shi, P., Fu, X., Yang, J., & Dai, L. (2023). Development and evaluation of a virtual simulation experiment system for the course of fluid mechanics. International Journal of Mechanical Engineering Education, 52(2), 109-125. https://doi.org/10.1177/03064190231176130

Skjelbred, S. and Daus, S. (2022). Satisfaction is insufficient: insights from a randomized, controlled trial of a marketing simulation game. Journal of Computer Assisted Learning, 38(6), 1686-1702. https://doi.org/10.1111/jcal.12703

Ulazia, A. and Ibarra-Berastegi, G. (2020). Problem-based learning in university studies on renewable energies: case of a laboratory windpump. Sustainability, 12(6), 2495. https://doi.org/10.3390/su12062495

Vázquez-Calatayud, M., García-García, R., Regaira-Martínez, E., & Gómez-Urquiza, J. (2024). Real-world and game-based learning to enhance decision-making. Nurse Education Today, 140, 106276. https://doi.org/10.1016/j.nedt.2024.106276

Yahya, A. N., & Asril, S. (2022, April 21). *Setahun tenggelamnya KRI Nanggala, duka dan rumitnya kelola pertahanan negara*. Kompas.com. https://nasional.kompas.com/read/2022/04/21/06433791/setahun-tenggelamnya-kri-nanggala-duka-dan-rumitnya-kelola-pertahanan-negara?page=all