

Needs Analysis of Interactive Learning Media for Teaching Heat Transfer in Physics: Students' and Teachers' Perspectives

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ABSTRACT

Heat transfer material in physics is known to be abstract. This study specifically analyzes the conceptual difficulties, and visualization needs specific to this material, which is different from the analysis of physics needs in general. This analysis does not only look for the need for traditional media but explicitly looks for the need for interactive media (simulation, animation, virtual laboratory). Therefore, this study aims to identify the need for interactive learning media in physics education, specifically in the teaching of heat transfer, from the perspective of students and teachers in West Java, Indonesia. Using a quantitative descriptive survey, data were collected from 66 students and 9 teachers through an online questionnaire. The results showed that most students had difficulty understanding the concept of heat transfer using only textbooks, while students and teachers showed a strong interest in using interactive digital media. Furthermore, teachers supported the integration of collaborative learning and the POGIL approach. These findings emphasize the need for constructivist-based media to enhance understanding and engagement.

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INTRODUCTION

The incorporation of technology in 21st-century education is vital to facilitate contextual, engaging, and learner-centered experiences that correspond with the traits of digital-native students (Bao & Koenig, 2019; Kim et al., 2019). In physics education, the implementation of technologies like simulations, modeling, and dynamic visualizations has demonstrated an enhancement of students' cognitive abilities and facilitated their comprehension of abstract concepts (Yurchenko et al., 2023). Interactive digital media enhances motivation and learning engagement, offering students expanded opportunity to meaningfully study scientific topics (Faresta et al., 2024). The success of this integration primarily hinges on instructors' preparedness and the congruence of digital information with the instructional context (Shintya et al., 2025; Verawati & Nisrina, 2025).

Heat transfer is routinely identified as a tough subject for both students and educators among diverse physics topics. This subject encompasses the principles of conduction, convection, and radiation. Prior research has demonstrated that students' conceptual comprehension of heat and temperature is moderate, with numerous pupils harboring misconceptions, especially about heat capacity and thermal equilibrium (Trisnasari & Oksiana, 2024). Mahsunah et al. (2024) discovered that merely 47.32% of students accurately comprehended the idea of heat and its transport, while the remainder exhibited confusion or misconceptions. This finding illustrates the topic's abstract nature and the challenges associated with its direct observation in quotidian contexts.

Subsequent study indicates that the greatest rates of mistake arise in the comprehension of temperature and the characteristics of heat transfer, rendering it one of the most conceptually challenging subjects in secondary physics education (Saparini et al., 2020; Sherly Eka Putri Damayanti et al., 2023). Findings from Sari et al. (2022) indicate that many pupils lack comprehension of heat transfer characteristics and exhibit significant misconceptions regarding the idea



of temperature. Moreover, physics educators acknowledge heat transfer as one of the most abstract and intricate subjects, necessitating more effective pedagogical innovations to facilitate student comprehension of the idea (Razak et al., 2024).

Interactive learning media present a viable answer to these issues by elucidating physical processes via dynamic representations and simulations (Mansour et al., 2025). Instruments like animations and virtual simulations have demonstrated efficacy in depicting abstract physical phenomena in a more tangible and comprehensible manner. Interactive simulations enable students to perform virtual experiments, adjust parameters, and watch system responses instantaneously. This method enhances their comprehension of intricate concepts that are challenging to witness firsthand, such as thermal energy transfer or wave dynamics (McElhane et al., 2015; Mutiawani et al., 2022; Piacsek, 2018; Suyatna et al., 2017).

Articulate Storyline is a frequently utilized platform for creating interactive digital learning experiences (Saadah et al., 2022; Daryanes et al., 2023). This authoring tool allows educators to create simulations, scenario-based learning experiences, and interactive quizzes. An increasing amount of research substantiates its viability and educational significance. Research indicates that media based on Articulate Storyline are both valid and practical for classroom application (Suherman et al., 2020), as well as effective in improving learning outcomes (Adawiyah et al., 2024), fostering learning autonomy (Nita et al., 2023), and developing students' problem-solving abilities (Wahyuni et al., 2024). Furthermore, these technologies have garnered favorable responses from students, exhibiting continuously elevated levels of engagement and satisfaction (Mustikawati & Isdaryanti, 2024).

Although these findings underscore the platform's educational potential, its implementation must be firmly based on a comprehensive understanding of classroom requirements and student attributes. Performing a needs analysis before development is crucial to guarantee that the resultant media is contextually pertinent, pedagogically robust, and effectively incorporated into the learning process. The utilization of interactive media not only offers instructional advantages but is also closely associated with the tenets of STEM (Science, Technology, Engineering, and Mathematics) education. This method prioritizes interdisciplinary integration, technology-driven instruction, and the development of 21st-century competencies, including critical thinking, creativity, teamwork, and problem-solving.

Numerous studies indicate that STEM-oriented interactive media, including digital multimedia and Android applications, enhance learning outcomes and conceptual comprehension while also improving students' technological literacy and creative thinking abilities (Ahzari & Asrizal, 2023; Hidayah & Sutarto, 2023; Khairani et al., 2023). Moreover, these tools are deemed practical and pertinent to 21st-century education due to their user-friendliness for both educators and learners, as well as their adaptability to technological advancements and contemporary educational requirements (Husniyah & Ramli, 2023; Widya et al., 2024; Yulyani et al., 2023). Technology-based learning media enhance students' cognitive abilities while fostering active participation, knowledge retention, and more profound learning experiences. The incorporation of interactive media in physics education can substantially enhance the quality of adaptive and sustainable science instruction (Abouhashem et al., 2021; Ahzari & Asrizal, 2023; Widya et al., 2024).

Prior to creating educational media, it is imperative to perform a comprehensive needs assessment from the viewpoints of both students and educators. This stage guarantees that the resultant media is genuinely pertinent, efficient, and congruent with the actual learning situation. This study seeks to examine the requirements for interactive learning media pertaining to heat transfer in physics education, informed by perspectives from both students and educators. This study's results are anticipated to establish a basis for creating constructivist-oriented digital media that facilitates active learning and enhances the efficacy and innovation of physics instruction in secondary education.

METHOD

Research Design

This study employed a descriptive survey method with a quantitative approach. The method aims to describe the tendencies of a particular phenomenon within a defined population (Zheng et al., 2020). The survey was used to identify and describe the needs for interactive physics learning media based on students' and teachers' perceptions of heat transfer. This approach enabled systematic data collection on preferences, experiences, and expectations related to technology-based interactive media, especially those developed using Articulate Storyline.

Participant, Data Collection Instruments, and Procedures

The participants of this study consisted of high school physics teachers and students in West Java, Indonesia. A total of 66 students and 9 teachers participated in the study. Participants were selected using purposive sampling, considering their active engagement in physics learning and their willingness to participate. This technique was considered appropriate as it involved individuals with direct experience relevant to the research objective (Fowler, 2014). The collected data were analyzed using descriptive quantitative techniques. The analysis focused on identifying trends in the responses and

formulating practical recommendations for the development of relevant learning media based on the observed needs in the field.

Research Limitations

This study has several limitations. First, the sample was restricted to selected schools in West Java, which may not represent all high school students and physics teachers across Indonesia. Second, the data relied entirely on self-reported responses, which may introduce potential response bias. Nevertheless, the findings offer helpful observations about the actual needs for interactive learning media in physics education from both student and teacher perspectives.

RESULTS AND DISCUSSION

Results from Students' Perspective

This study aimed to identify students' needs, readiness, and interest in using interactive learning media based on Articulate Storyline in the context of heat transfer materials. The data were obtained through questionnaires distributed to students who had previously studied the topic in class. The key findings are presented below.

Learning Experience and Conceptual Difficulties

Figure 1 shows that most students (98.5%) reported having previously studied the topic of heat transfer in class. This indicates that the concept was not new to them and is therefore relevant for further exploration.

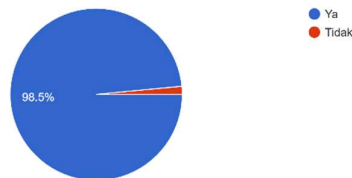


Figure 1. Students' Experience in Learning Heat Transfer

However, as presented in Figure 2, a substantial proportion of students (75.8%) admitted that they found it difficult to understand the concept of heat transfer solely by reading textbooks. This finding suggests that conventional instructional approaches may not be fully effective in facilitating students' deep conceptual understanding.

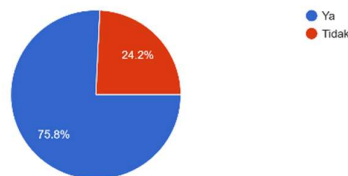


Figure 2. Difficulty in Understanding Heat Transfer Concepts

Instructional Media Used by Teachers

Based on their learning experiences, students identified various types of instructional media that their teachers had used to deliver heat transfer content. As shown in Figure 3, the most frequently mentioned media were simulations or virtual labs (59.1%), followed by images (42.4%), PowerPoint presentations (40.9%), and videos or animations (37.9%). A smaller proportion of students also reported the use of e-modules (25.8%), while 7.6% stated that they had never received instruction using such media.

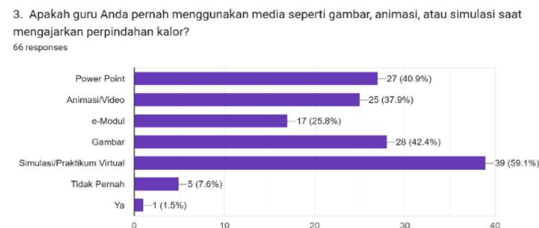


Figure 3. Instructional Media Used by Teachers

This variety of media indicates an effort by teachers to incorporate visual representations into instruction, although such implementation appears to be uneven and inconsistent across classrooms.

Technological Readiness and Access to Interactive Media

Regarding device readiness, Figure 4 shows that a large majority of students (90.9%) owned a smartphone or tablet that could be used to access interactive learning media. However, only 69.7% had used their devices to study heat transfer materials.

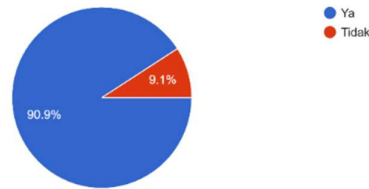


Figure 4. Ownership of Smartphones or Tablets

This finding highlights a significant opportunity to develop digital media based on technologies already commonly owned by students, even though their usage for academic purposes has not yet been fully optimized.

Interest in Visual and Interactive Media

Figure 5 illustrates that most students (95.5%) believed that heat transfer concepts would be easier to understand if presented in visual formats such as images, animations, or simulations. Consistent with this view, Figure 6 shows that 93.9% of students expressed interest in learning through interactive media accessed via smartphones or tablets.

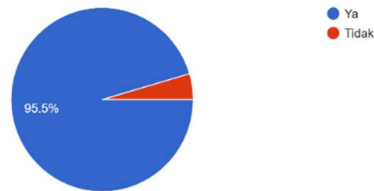


Figure 5. Students' Interest in Visual Media

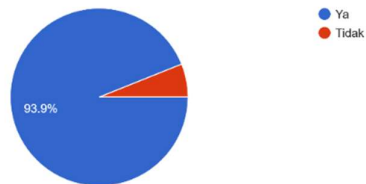


Figure 6. Students' Interest in Using Interactive Media

This interest was further reinforced by students' enthusiasm for specific types of media. As shown in Figure 7, 97% of students responded positively to the idea of using interactive visualizations of microscopic processes such as conduction, convection, and radiation. This indicates that concepts which are difficult to explain through conventional methods hold great potential for representation through digital simulations.

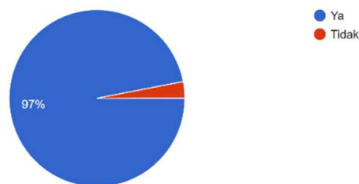


Figure 7. Students' Interest in Microscopic Process Visualization

Awareness and Response to Articulate Storyline

Although many students (72.7%) were unfamiliar with the Articulate Storyline platform, Figure 8 shows that 81.8% expressed interest in learning heat transfer concepts using media developed with this tool. This suggests that while the platform is not yet widely recognized among students, it holds considerable potential for acceptance, especially if well-designed and aligned with student needs.

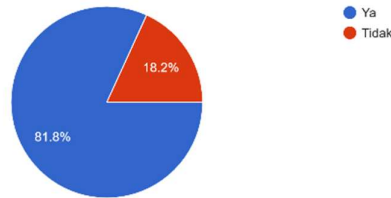


Figure 8. Students' Response to Articulate Storyline

Students Expectations for Features and Learning Strategies

Students also expressed strong interest in specific features of learning media. As shown in Figure 9, 97% were attracted to interactive practice questions, while Figure 10 shows that 95.5% believed interactive learning would help improve their conceptual understanding.

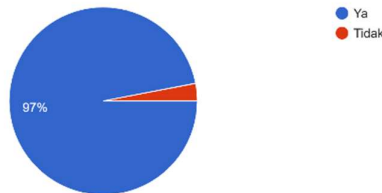


Figure 9. Students' Interest in Interactive Practice Questions

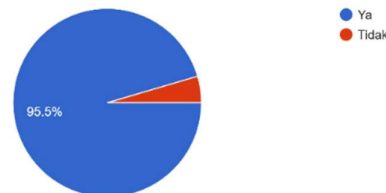


Figure 10. Students' Belief in the Effectiveness of Interactive Learning

Furthermore, Figure 11 shows that 89.4% of students were interested in a learning model that combined group discussion and independent exploration. Although not all students were accustomed to group discussions, 83.3% reported that they understood the material better when learning collaboratively with peers. These findings emphasize the importance of incorporating structured cooperative learning strategies into the design of interactive learning media.

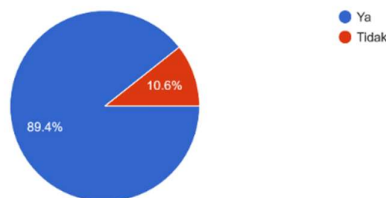


Figure 11. Students' Interest in Group Discussions and Independent Exploration

Preference for Discovery-Based Learning

Students also responded positively to learning approaches that are active and constructive. As shown in Figure 12, 87.9% of students expressed a preference for instructional methods that guide them to discover concepts on their own

through structured steps. In addition, 92.4% enjoyed learning processes that required them to think actively and solve problems collaboratively with peers.

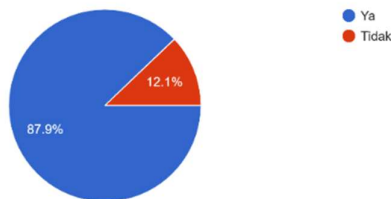


Figure 12. Students' Preference for Structured Learning Approaches

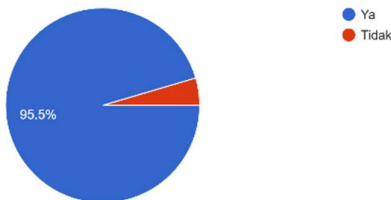


Figure 13. Students' Preference for Interactive Media that Supports Teamwork

Finally, when asked whether interactive media that supports teamwork and independent exploration would make physics learning more enjoyable, 95.5% of students agreed, as shown in Figure 13. This is a strong indication that students need learning media that not only delivers content but also supports their social and cognitive engagement during the learning process.

Results from Teachers' Perspective

To strengthen the mapping of needs in developing interactive learning media, this study also explored physics teachers' perspectives and experiences in teaching heat transfer. Several teachers from various high schools responded to the online questionnaire. The results are outlined below.

Dependence on Textbooks and the Need for Supplementary Media

Table 1 shows that all participating teachers (100%) stated that they use textbooks as the primary resource for teaching heat transfer. However, all respondents also agreed that textbooks alone are insufficient to help students fully understand the concepts. Furthermore, every teacher (100%) emphasized the importance of using supplementary instructional media to support the delivery of heat transfer content.

Table 1. Teachers' Perspective on Textbook Use and the Need for Supplementary Learning Media

No.	Questions	Percentage "Yes"
1	Do you use textbooks as the primary resource for teaching heat transfer?	100%
2	Do you think textbooks alone are insufficient to help students fully understand heat transfer concepts?	100%
3	Do you believe it is important to use supplementary instructional media when teaching heat transfer	100%

These findings indicate that while textbooks remain the main reference in classroom instruction, there is a strong perceived need among teachers for additional media to support conceptual understanding. The complete agreement on this point highlights the urgency of integrating alternative and more effective learning tools into physics education.

Use and Effectiveness of Interactive Media

Figure 14 shows that 77.8% of teachers had used interactive media such as images, animations, videos, or simulations when teaching heat transfer. However, as presented in Figure 15, only 44.4% of them considered these media effective in explaining the differences between conduction, convection, and radiation, while 55.6% felt that the media were not sufficiently effective.

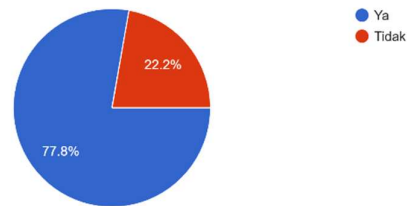


Figure 14. Teachers' Use of Interactive Media

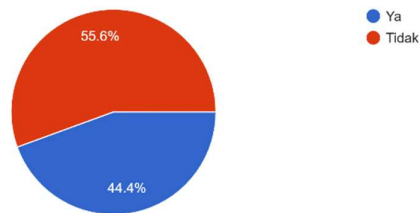


Figure 15. Perceived Effectiveness of Interactive Media

This discrepancy between the frequency of use and the perceived effectiveness indicates the need for more targeted and conceptually aligned interactive media. There is a demand for resources capable of clearly representing microscopic phenomena, which are often difficult to explain through traditional methods.

Awareness and Interest in Articulate Storyline

When asked about the Articulate Storyline platform, Figure 16 shows that 66.7% of teachers were not familiar with it, while only 33.3% reported having some familiarity. Despite this limited awareness, all respondents (100%) expressed interest in trying out interactive learning media developed using Articulate Storyline for teaching physics, as shown in Figure 17.

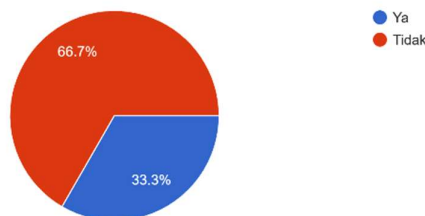


Figure 16. Teachers' Familiarity with the Articulate Storyline Platform

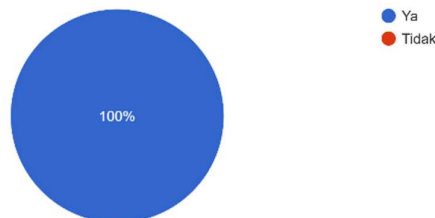


Figure 17. Teachers' Interest in Articulate Storyline

These findings suggest that although knowledge of the platform is still limited, there is strong enthusiasm among teachers to adopt promising digital learning tools that support more engaging and effective instruction.

Understanding and Interest in the POGIL Learning Approach

Regarding the Process Oriented Guided Inquiry Learning (POGIL) approach, Figure 18 shows that many teachers (88.9%) had never implemented this model, and only 33.3% were familiar with its core principles. Nevertheless, as shown in Figure 19, all teachers (100%) expressed interest in applying the POGIL model to teach the topic of heat transfer.

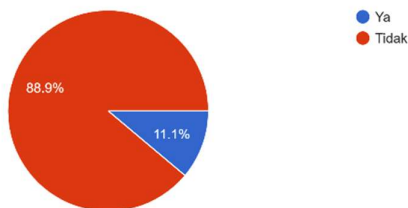


Figure 18. Teachers' Understanding of the POGIL Model

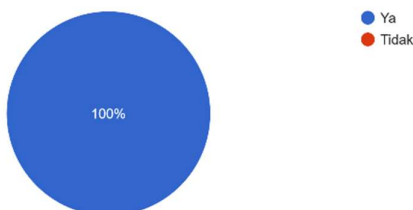


Figure 19. Teachers' Interest in the POGIL Approach

These results indicate a strong interest in active and discovery-based learning approaches. However, they also point to the need for further training or orientation so that teachers feel adequately prepared to implement such methods effectively.

Integration of Interactive Media with the POGIL Approach

All teachers (100%) agreed that interactive media could effectively support the implementation of the POGIL model. They also believed that group discussions and conceptual exploration through interactive media would enhance students' understanding of heat transfer concepts. In addition, all respondents supported the development of interactive learning media based on the POGIL approach.

Table 2. Integration of Interactive Media with the POGIL Model

No.	Questions	Percentage "Yes"
11	Do you think the use of interactive learning media can support the effective implementation of the POGIL approach?	100%
12	Do you agree that students will better understand heat transfer concepts if they engage in group discussions and explore concepts through interactive media?	100%
13	Do you support the development of interactive learning media based on the POGIL approach to improve students' understanding of heat transfer?	100%

These findings reinforce the idea that integrating active pedagogical approaches with educational technology is both anticipated and considered highly relevant by teachers.

Teachers' Expectations for Media Features

Teachers were asked to select which components they believed should be included in the interactive learning media. As illustrated in Figure 20, their responses provide valuable guidance for designing the content and features of the media to align with instructional needs and expectations.

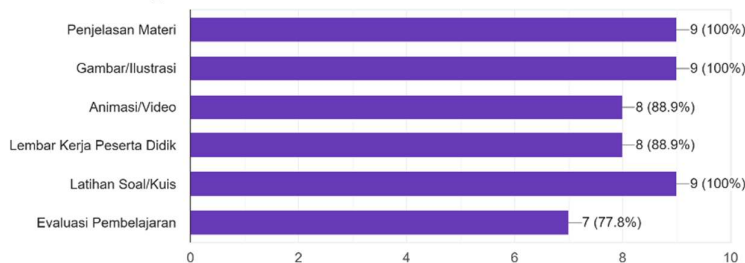


Figure 20. Desired Features in Interactive Learning Media

These findings provide a practical foundation for designing learning media content that aligns with teachers' instructional expectations and pedagogical needs.

Discussion

Both students and teachers agree that interactive learning media helps students understand heat transfer fundamentals. Students want engaging, accessible media, while teachers want structured, effective tools for active learning like POGIL. These shared viewpoints support meaningful and relevant learning media design.

The Urgency for Interactive Media in Teaching Heat Transfer

Student and teacher questionnaires showed that interactive media helps students comprehend heat transfer. Even though 98.5% of students had studied this material, 75.8% struggled with textbooks. 100% of teachers used textbooks, although they agreed that they were not enough to enhance conceptual understanding.

This emphasizes the requirement for a combined visual-verbal learning method. Previous research has shown that verbal explanations and visual representations improve student memory and capacity to recognize instructional topic pieces (Glaser & Schwan, 2020). Multimodal techniques improve academic communication abilities (Chen, 2025) and understanding and memory retention (Alyahya, 2023). For heat transport, abstract and microscopic concepts like conduction, convection, and radiation need vivid visuals.

Support for Interactive Media and Simulation Use

Both students and teachers liked interactive learning material. 95.5% of students said visuals like photos, animations, and simulations would make studying simpler, and 93.9% wanted to use smartphones or tablets. However, 100% of teachers said pupils need extra media, and 77.8% had used cartoons or simulations.

This high level of attention emphasizes the need for simulation-based interactive media in physics training. Simulations help dispel traditional learning myths by visualizing abstract physical processes. Digital simulations improve physics concept comprehension, scientific process skills, student engagement, and problem-solving (Krobthong & Thovicha, 2020; Haryadi & Pujiastuti, 2020; Kefalis et al., 2025). Computer simulations outperform direct experiments in teaching complex scientific topics (Krüger et al., 2022). Integration of simulations with proper learning models maximizes effectiveness (Ali et al., 2022). Thus, technology-enhanced physics learning relies on interactive simulations as both supplements and tactics.

Awareness and Response to Articulate Storyline

Most students (72.7%) and teachers (66.7%) were unfamiliar with Articulate Storyline, however their replies showed strong interest after its capabilities were exposed. 81.8% of students and 100% of teachers wanted to learn heat transfer with Articulate Storyline/interactive media. This passion underlines the potential for multimedia-based e-learning that integrates narration, animation, simulations, and quizzes.

Previous studies show that Articulate Storyline improves student engagement and learning at elementary (Furkan & Yanti, 2023) and secondary levels (Khairina & Rais, 2024) levels. The platform has also shown excellent design and content delivery feasibility (Toni et al., 2024) and favorable teacher and student reactions in multimedia development initiatives.

Thus, introducing Articulate Storyline into heat transfer training may help overcome conceptual problems and improve learning.

Integrating the POGIL approach into interactive learning

Process Oriented Guided Inquiry Learning (POGIL) emphasizes collaborative and exploratory learning, which students and teachers enjoyed. 89.4% of students chose group discussion and self-exploration using simulations, while 87.9% preferred formal direction. Even though 88.9% of teachers had never used POGIL, 100% were willing to use it in heat transfer education with interactive media.

These findings indicate that instructors and students are ready to use constructivist methods like POGIL, which increase higher-order thinking and problem-solving (Singh & Rao, 2025). POGIL has improved learning outcomes (Rodriguez et al., 2020), promoted positive science learning perceptions across cultures (Tregust et al., 2020), and been adaptable for distance learning with appropriate modifications (Maciel et al., 2024). Thus, POGIL and interactive media can alter physics training.

Expectations for the Development of Learning Media

Teachers gave great media development advice in the questionnaire's last section. They preferred basic, engaging, easy-to-use, contextual, and interactive media like quizzes, instructional games, and diverse practice activities. These proposals match student preferences: 97% preferred microscopic heat transfer process representations, 97% interactive exercises, and 92.4% collaborative, problem-based learning.

These findings show that interactive media should promote scientific reasoning, active involvement, and social connection in learning as well as aesthetics. Critical thinking, creativity, collaboration, and communication are the 4Cs of 21st-century education. Students' critical thinking skills improve greatly with inquiry-based multimedia (Hasanah, 2023), and contextual, problem-based audiovisual media improves higher-order thinking and scientific attitudes (Ginting et al., 2024). Socially interactive digital media improves science literacy in the digital age (Hadianto et al., 2023) and student engagement and learner satisfaction (Alalwan, 2022).

CONCLUSION

The findings of this study indicate that although most students have previously studied the topic of heat transfer, many still face difficulties in understanding the concepts when relying solely on textbooks. As a result, students highly value the use of visual and interactive learning media. Likewise, teachers acknowledge the limitations of textbooks and support the integration of supplementary materials, particularly those capable of presenting conduction, convection, and radiation processes in a more concrete and microscopic way. While many teachers are not yet familiar with the POGIL approach or the Articulate Storyline platform, they have shown strong enthusiasm to implement both in physics instruction. These findings demonstrate a clear need and strong interest among both students and teachers in developing interactive learning media grounded in the POGIL approach that can enhance conceptual understanding, support exploratory activities, and promote collaborative learning in the context of heat transfer.

As a suggestion, conduct research and development (R&D) to create interactive learning media (e.g., computer-based simulations, e-modules, or smartphone applications) according to the needs specifications that have been identified from the perspective of students and teachers. The development must strictly visualize abstract concepts in heat transfer (conduction, convection, and radiation) and facilitate the understanding of misconceptions found. Conduct research to test the validity, practicality, and effectiveness of the developed interactive media in improving cognitive learning outcomes and higher-order thinking skills of students in the Heat Transfer material. Further research can expand the focus by linking media needs with other learning variables.

AUTHOR CONTRIBUTIONS

All authors participated in the conceptualization, design, data collection, analysis, interpretation, writing, and revision of the article. All authors approved the finalized manuscript.

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pursue graduate-level research in the field of physics education. The authors also extend their gratitude to the participating schools, teachers, and students whose valuable input contributed to the success of this study.

CONFLICT OF INTEREST STATEMENT

The author asserts no conflicts of interest exist in publishing this paper. This research and results were not influenced by financial, personal, or other affiliations, and supervisors performed their professional duties. We did our best to perform and deliver the research with integrity and transparency.

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