JIPF (JURNAL ILMU PENDIDIKAN FISIKA)
p-ISSN: 2477-5959 | e-ISSN: 2477-8451 *Vol. 9 No. 1, January 2024, Page 95-104*

Mobile Learning Simulation (MLS) for Learning Physics in Heat Transfer Concept

Siti Hastin Nur Indarwati [1], Firmanul Catur Wibowo [2*)], Iwan Sugihartono [3], Beken Arymbekov [4]
Universitas Negeri Jakarta, Indonesia[1,2,3], Al-Farabi Kazakh National University, Republic of Kazakhstan[4]
[*)]Corresponding E-mail: fcwibowo@unj.ac.id

Received: September 2nd, 2023. Revised: October 31st, 2023. Accepted: November 3rd, 2023

***Keywords** :*
Mobile Apps; Heat Transfer; Physics Education; Simulations

ABSTRACT
This research aims to develop Mobile Learning Simulation (MLS) media that is valid for learning the concept of heat transfer. The method used in this research is the Research and Development method with the ADDIE model (Analyze, Design, Develop, Implement and Evaluate). MLS was developed to make it easier for students to learn the concept of expansion and increase their understanding of the microscopic nature of heat transfer. MLS can display six 2D simulations, namely the processes of length expansion, area expansion, volume expansion, and heat transfer by conduction, convection, and radiation. The product effectiveness test was carried out with correspondents of 35 students in one of the schools in western Indonesia, obtaining an average score of 84.3% and was in the very good category. Based on the test results, the MLS application is efficient and suitable for use as a physics learning medium in high school.

INTRODUCTION

Physics is a subject that has an essential role in everyday life [1], health [2] and technology [3]. Therefore, students must adequately understand the basic concepts of physics at school. The Physics learning model recommended by many experts is learning that is instilled in students [4]. Apart from that, the physics learning process must be familiarized with experimental activities [5]. Besides that, the rapid emergence and advancement of mobile technology have opened new opportunities for teaching and learning in the classroom [6] [7].

An increasing number of mobile devices, such as tablets and smartphones, have become part of practical learning activities [8] [9] [10] [11] [12]. To extend the benefits of mobile technology, educational applications play an essential role in enhancing positive learning outcomes [13] [14]. However, compared to research on computer-based educational software and simulations, the number of studies on developing educational applications for mobile devices still needs to grow [15]. Several researchers also reported the results of their research related to the study of temperature and heat, as found in the literature. Students need help with the concept of temperature; students assume that temperature has the properties of materials or instruments for measuring heat [16].

Physics has had a lot of exciting research on misconceptions, especially in topics such as motion and thermodynamics [17]. The concept of thermodynamics is not easy to understand [18] and is considered by students to be abstract and complex. Many real-life applications and situations also relate to basic thermal concepts [19]. Students tend to form thermal concepts based on everyday experience and intuition, often generating beliefs that are very much at odds with scientific theories [20].

In addition, several simulation media developments on the concepts of temperature and heat have been carried out several times, including the development of Virtual Microscopic Simulation (VMS) simulation media to remediate misconceptions about the concept of heat transfer [21], simulation of the concept of heat energy transfer in liquids, and solids (phet.colorado.edu), simulation of the effect of a barrier between 2 different metals on the rate of transfer of particles (thephysicsaviary.com), the concept of heat energy transfer in liquids and solids (phet.colorado.edu), the concept of heat effect to object temperature (kemdikbud.go.id), the concept of a calorimeter (amrita.olabs.edu.in), the concept of material structure with kinetic energy, potential energy and temperature and the concept of heat transfer in metal rods (labxchange.org) and the concept of long expansion (compadre.org).

Mobile Learning has different meanings, depending on how each community defines it. However, in general, mobile learning is mobile learning that utilizes mobile technology so that students can learn anywhere without time and place restrictions [22][23]. There are several advantages of using mobile learning, including the following. Cost savings can be made because it can reduce costs for technical matters commonly used, such as conventional learning, such as providing writing instruments and boards, consumption for teachers, projectors, and others. Mobile learning can make users adjust the time and place of learning [24]. They can insert learning in their free time and different areas [25]. Flexibility in learning speed because each learner has another ability to absorb lessons; some are fast, and some are slow [26]. Mobile learning can overcome this because the learning speed depends on each student. Of the several virtual media that have been developed, not all of the virtual press needed for physics learning related to abstract and microscopic phenomena are available; there are still many virtual media related to microscopic physics material that have not yet been developed, such as simulations of changes in substances, simulations of displacement mechanisms heat, and simulation related to the expansion of substances. Based on these problems, researchers are interested in researching the development of Mobile Learning Simulation (MLS) learning media on heat and its transfer.

METHOD

Participant
The correspondents in this research were 35 students at a school in eastern Indonesia. The selected correspondents were male and female students aged 16-17 years.

Procedure
The method used in this research is the Research and Development method. Media development refers to the ADDIE (Analyze, Design, Develop, Implement, and Evaluation) development model. The analysis was conducted to determine the need for Physics learning in schools. The analysis included a literature study, student needs analysis, and teacher needs analysis. The media developed in this research is smartphone-based Mobile Learning Simulations (MLS) media. The simulation media developed is an application on smartphones so that students can access it anywhere and anytime. The software used to develop MLS is CorelDraw and Unity 2D. The student response survey was conducted on 35 students at one of the high schools in western Indonesia. The ADDIE model development scheme can be seen in Figure 1.

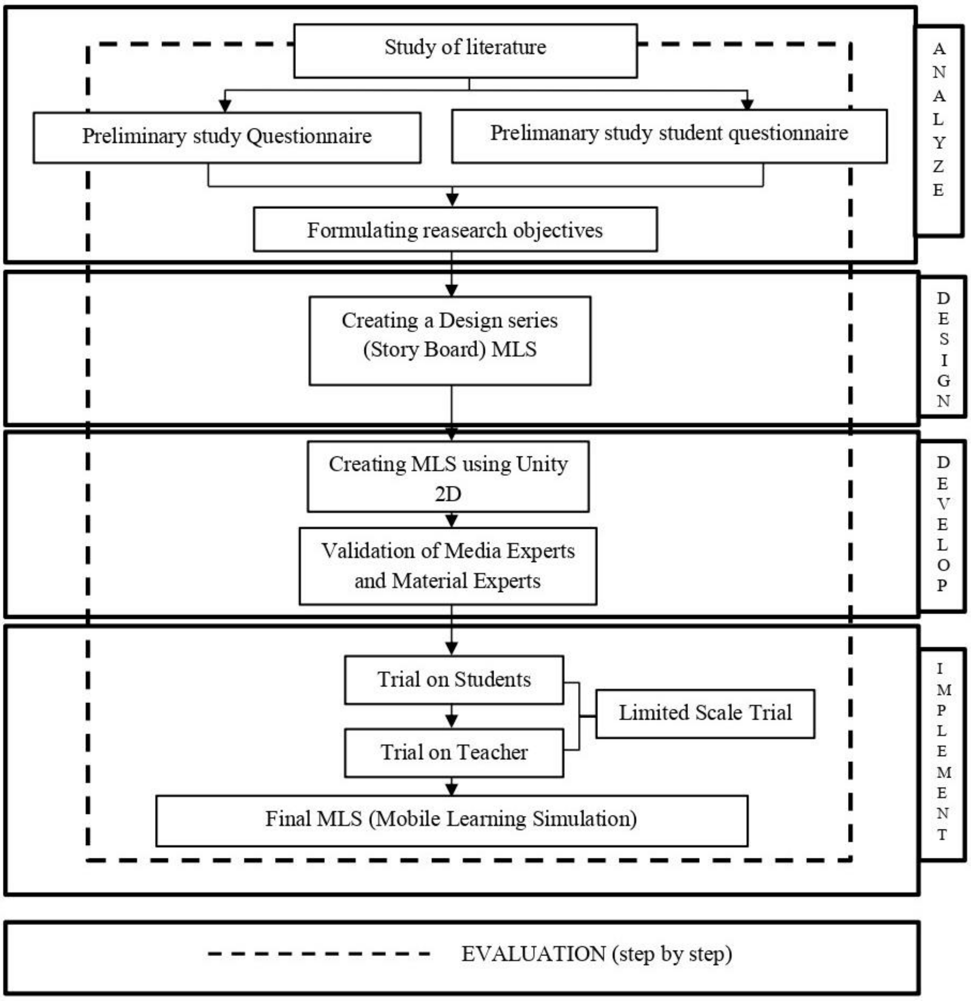


Fig 1. *Method Research of MLS*

Instruments

The instrument used in this study was a questionnaire distributed to correspondents who had used Mobile Learning Simulation (MLS) media in learning physics. Level To determine the criteria for the percentage of students at each level of understanding, the guidelines in Table 1 are used.

Table 1. Criteria Percentage of MLS

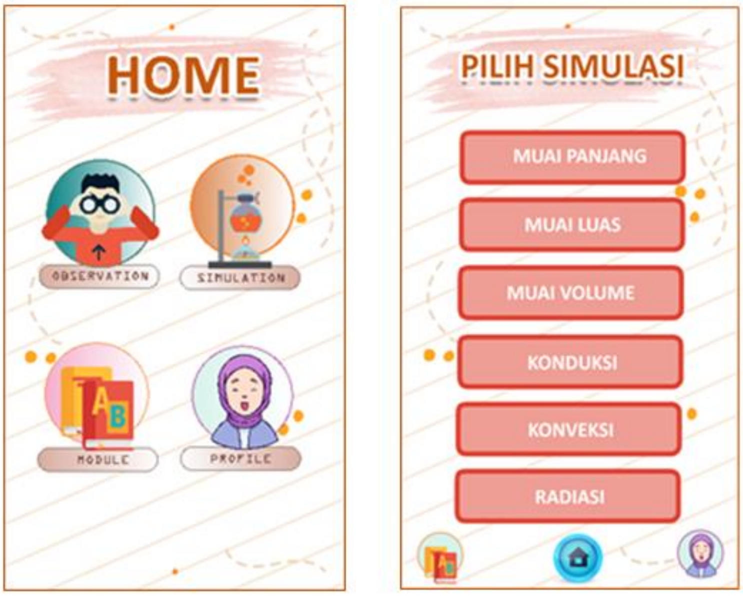
Interval	**Criteria**
0% - ≤ 20%	Very bad
≤ 20% - ≤ 40%	Not good
≤ 40% - ≤ 60%	Enough
≤ 60% - ≤ 80%	Good
≤ 80% - 100%	Very good

From this table, learning media is said to be good if it is at intervals ≤ 60% - ≤ 80% or very well on the interval ≤ 80% - 100%.

RESULTS AND DISCUSSIONS

Mobile Learning Simulation

MLS makes it easier for students to learn the concepts of expansion, temperature, and heat and their microscopic properties in the heat transfer process. MLS aims to visualize abstract concepts in heat transfer, such as the microscopic properties of particles during the processes of conduction, convection, and radiation. In addition, the ability of MLS to display objects will help improve the quality of learning. MLS can show six 2D simulations, namely the processes of conduction, convection, and radiation, and the concept of expansion, namely the expansion of length, area, and volume. Users can change the value of a variable on the simulation screen and observe its effect on other variables' simulation screen Main Menu Display (Figure 2a). This screen is the home screen when the simulation application is opened. This screen has several menu choices, namely the observation, simulation, module, and profile menus. On this page, the user can choose one of the menus above; when they have chosen, the user will be directed to the next simulation view. Where the observation menu will contain content related to apperception material, this content will be filled in the form of a video or a story. The simulation menu will be filled with several simulations, as shown in (Figure 2b).



(a) (b)

Fig 2. *(a) Main Menu Display, (b) Simulation Menu*

Displays of MLS Temperature and Heat simulation screen. This screen is the main screen when the simulation application is opened (Figure 2a). On this screen, there are several simulation options related to expansion concepts, such as length expansion, area expansion, volume expansion, and heat transfer. The user can select one of the simulation modules above on this page. Once selected, the user will be directed to the next simulation display.

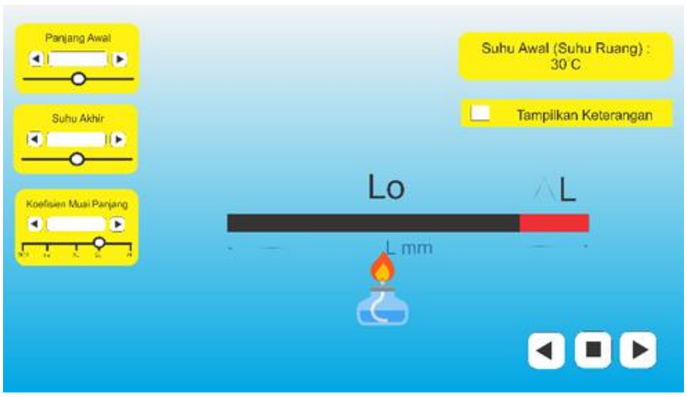


Fig 3. *Long Expansion Simulation Display*

Long Expansion simulation screen. In the simulation of long expansion on this screen, the variables are the coefficient of long expansion, final temperature, and initial length. In the initial length and final temperature menus, the user can enter a value or adjust the scrollbar to provide a value. As for the coefficient of long expansion, besides the user being able to enter the desired value, the user can also choose the coefficient of long expansion based on the type of material that the developer has provided, namely SiO_2 (Glass), Fe (Iron), Au (Gold), Cu (Copper), Al (Aluminum). Then, in this view, there is a menu option displaying information where, if this menu is checked, a description will appear in the form of symbols of magnitude and value on the simulation screen. For the initial temperature variable, the developer sets a temperature of 30^oC as the room temperature.

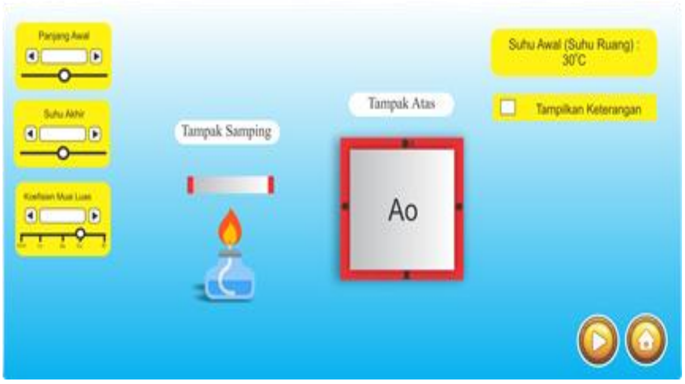


Fig 4. *Display of Area Expansion Simulation*

On the surface expansion simulation screen, the variables are the area expansion coefficient, final temperature, and initial length. In the initial area and last temperature menu, the user can enter a value or adjust the scrollbar to provide the value. Meanwhile, for the area expansion coefficient, apart from the user being able to enter the desired value, the user can also choose the area expansion coefficient based on the type of material that the developer has provided, namely SiO_2 (Glass), Fe (Iron), Au (Gold), Cu (Copper), Al (aluminum). Then, in this view, there is a menu option displaying information where if this menu is checked, a description will appear in the form of symbols of magnitude and value on the simulation screen. For the initial temperature variable, the developer sets a temperature of 30^oC as the room temperature.

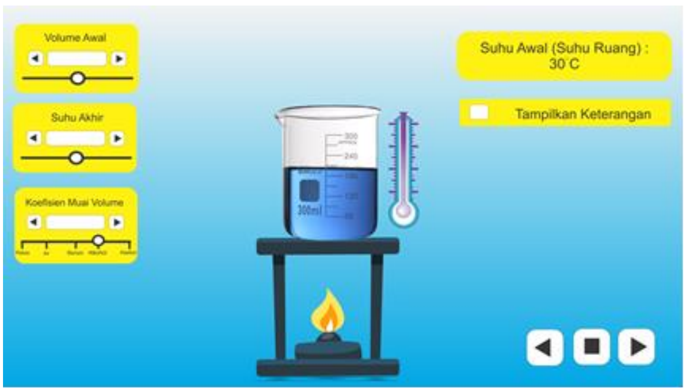


Fig 5. *Display of Volume Expansion Simulation*

On the screen display of the simulation of volume expansion, the variables are in the form of volume expansion coefficient, final temperature, and initial volume. In the initial volume and final temperature menus, the user can enter a value or adjust the scrollbar to provide a value. Meanwhile, for the volume expansion coefficient, apart from the user being able to enter the desired value, the user can also choose the volume expansion coefficient based on the type of material the developer has provided, namely mercury, water, gasoline, alcohol, and acetone. Then, this display has a menu option in the form of displaying information. The data will appear as quantity and value symbols on the simulation screen if this menu is checked. For the initial temperature variable, the developer sets a temperature of 30^{o}C as the room temperature.

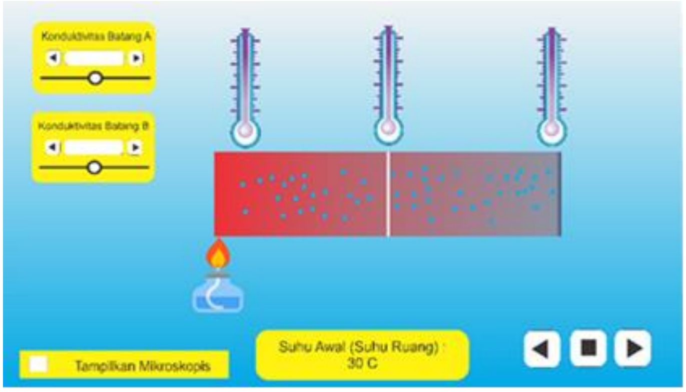


Fig 6. *Conduction Simulation Display*

The forms of simulation (Figure 6) that can be carried out on this screen are simulating heat transfer when one end of the rod is heated using a stove and simulating heat transfer between two rods. In addition, there is a material conductivity scroll button that functions to adjust the material conductivity value. The conductivity of this material will affect the temperature that will be read on the thermometer. Microscopic display, which serves to display the microscopic state of the material. In this microscopic view, if the temperature of the rod is high, the speed of the particles in the rod will move fast, and if the temperature is low, the speed of the particles in the rod will move slowly.

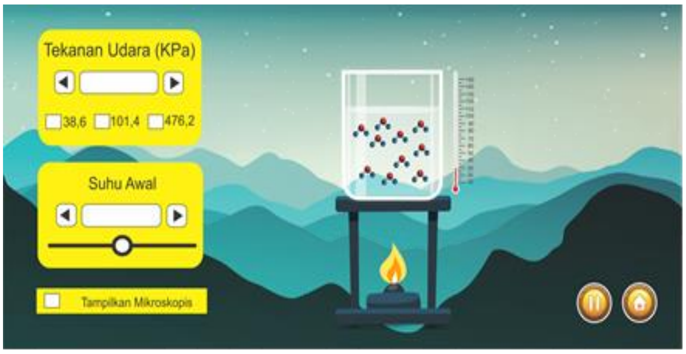


Fig 7. *Display of the Convection Concept Simulation in the Highlands*

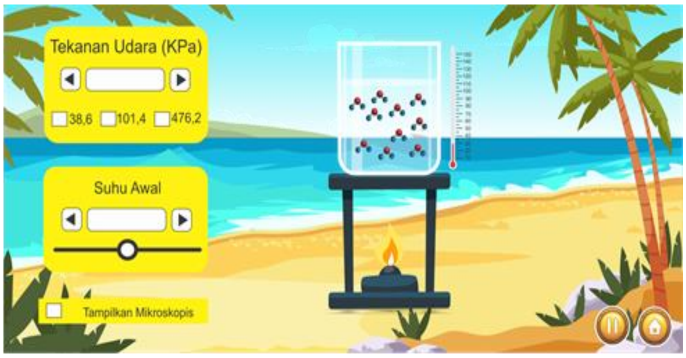
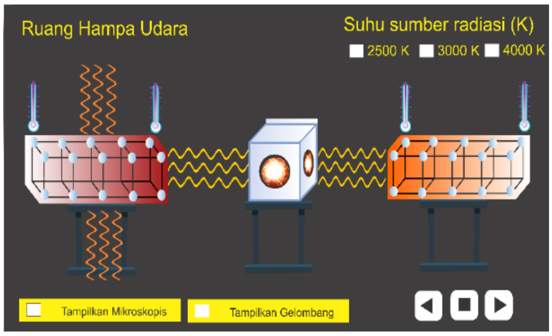


Fig 8. *Simulation view of the concept of convection in the lowlands*

This screen is a simulation for the convection concept. Convection in this simulation has two concepts, namely, the concept of convection on the mountain and the beach. When students choose the simulation on the mountain, the simulation that appears is shown in Figure 7. On this screen are images of a vessel filled with water, a thermometer, a stove, and a furnace. The ship containing water can be moved to the top of the furnace to carry out the simulation. This water cooking convection simulation aims to show microscopically the heat transfer process by convection when boiling water.

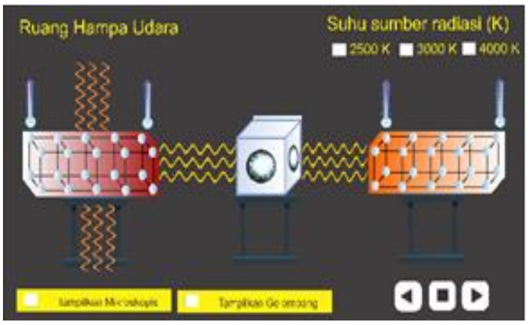
In this simulation, the user can light a fire first. At this stage, the user can also set the initial water temperature on the initial temperature button. To see changes in water temperature due to heat transfer by convection, users can also see it on a thermometer. The initial water temperature the user sets can also be observed via a thermometer installed near the vessel. In the next stage, to make it easier for the user to understand the process of heat transfer by convection, the user can display the microscopic state of the water molecule by clicking the "view microscopic" button on the screen.

The initial state of the water molecule before being heated is to have the kinetic energy shown in the motion/vibration of the particles, which is proportional to the initial temperature of the water. Apart from that, there is an air pressure menu. This menu regulates air pressure; in this process, the air pressure will affect the boiling point of water. The boiling point of water is proportional to the air pressure. The air pressure options have been set to 101.4 Kpa, 38.6 Kpa, and 12.35 Kpa. In this screen display, the air pressure has been set at 38.6 Kpa so that the boiling point of water is obtained at a temperature of 75^{0}C.



(a)

(b)



©

Fig 9. *Radiation Simulation Display (a) 250^{0}K temperature radiation display, (b) 300^{0}K radiation display, (c) 400^{0}K temperature radiation display*

Satisfaction with Using the Mobile Learning Simulation (MLS) the application MLS development products that have been developed are then tested on a limited scale so that the effectiveness and satisfaction of using MLS can be determined. This research uses a questionnaire on student responses to the MLS application to assess student responses after using MLS media in learning about heat and its transfer. Student responses based on the survey results can be seen in Table 2.

Table 2. Results of Student Response Questionnaire on the Effectiveness of Mobile Learning Simulation (MLS) Media

No	Aspect	Percentage
Relevance		
1.	Learning using MLS-based learning media is a new learning application in our school.	80,00%
2.	MLS learning media makes it easier for me to understand the concept of heat and its transfer	87,14%
3.	The MLS learning media used in physics learning has further increased my motivation to study the concept of Heat Transfer	84,29%
Confidence		
4.	I feel that the MLS learning media used in learning is easy to use and easy to understand	86,43%
5.	MLS learning media in physics learning can help me understand the concept of heat transfer	83,57%
6.	I feel happy and enthusiastic about using MLS learning media	87,14%
Satisfaction		
7.	I feel that the MLS learning media used in learning is interesting and easy to understand	85,36%
8.	I enjoy using learning media based on mobile learning applications and hope it can be used in other materials.	86,19%

Based on the results of the student response survey that has been conducted, there are several assessment criteria, including aspects of relevance, aspects of self-confidence, and aspects of satisfaction. Regarding the relevance aspect of the MLS media, the percentage is 83.83%, the student's self-confidence is 85.71%, and the element of satisfaction with the MLS media is 85.78%. So, the average score obtained from all aspects is 84.3% and is included in the very good category. The Mobile Learning Simulation Application (MLS) has fulfilled the requirements and is suitable as a medium for learning physics on temperature and heat material on the concept of heat and its displacement for high school students. MLS solves the problems experienced by students, including (1) the abstract nature of the heat transfer process, (2) visualizing the expansion process, namely expansion in length, expansion in area, and expansion in volume, and (3). The process of heat transfer by conduction, convection, and radiation. MLS can visualize and concretize the abstract concept of the heat transfer process.

CONCLUSION AND SUGGESTION

MLS succeeded in simulating the processes of expansion and heat transfer by conduction, convection, and radiation and was able to visualize the microscopic properties of abstract particles in the concept of heat transfer. Using 2D visualization, MLS can provide a more realistic expression of heat transfer processes. MLS can make it easier for students to learn the concept of temperature and heat and can give effectiveness to students' creative thinking abilities. In addition, MLS is suitable for use as a medium for learning physics on the concept of temperature and heat.

ACKNOWLEDGMENTS

Thank you to Ministry of Education, Culture, Research and Technology, Indonesia, Penelitian Kompetitif Nasional Penelitian Tesis Magister No. 51/UN39.14/PG.02.00.PL/VI/2023.

REFERENCES

[1] Jusup, M., Holme, P., Kanazawa, K., Takayasu, M., Romić, I., Wang, Z., ... & Perc, M. (2022). Social physics. *Physics Reports*, *948*, 1-148.

[2] Luharia, A., Mishra, G., Saroj, D., Sonwani, V., & Dhoble, S. J. (2022). The role of physics in modern radiotherapy: Current advances and developments. *Photophysics and Nanophysics in Therapeutics*, 139-162.

[3] Harefa, A. R. (2019). Peran ilmu fisika dalam kehidupan sehari-hari. *Warta Dharmawangsa*, *13*(2).

[4] Intania, E. V., & Sutama, S. (2020). The role of character education in learning during the COVID-19 pandemic. *Jurnal Penelitian Ilmu Pendidikan*, *13*(2), 129-136.

[5] Gilbert, J. K., & Reiner, M. (2000). Thought experiments in science education: potential and current realization. *International Journal of Science Education*, *22*(3), 265-283.

[6] Motiwalla, L. F. (2007). Mobile learning: A framework and evaluation. *Computers & education*, *49*(3), 581-596.

[7] Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & education*, *62*, 41-49.

[8] El-Gayar, O., Moran, M., & Hawkes, M. (2011). Students' acceptance of tablet PCs and implications for educational institutions. Journal of Educational Technology & Society, *14*(2), 58-70.

[9] Enriquez, A. G. (2010). Enhancing student performance using tablet computers. *College teaching*, *58*(3), 77-84.

[10] Falloon, G. (2013). Young students using iPads: App design and content influences on their learning pathways. *Computers & Education*, *68*, 505-521.

[11] Murray, O. T., & Olcese, N. R. (2011). Teaching and learning with iPads, ready or not?. *TechTrends*, *55*(6), 42-48.

[12] Zydney, J. M., & Warner, Z. (2016). Mobile apps for science learning: Review of research. *Computers & Education*, *94*, 1-17.

[13] Kucirkova, N., Messer, D., Sheehy, K., & Panadero, C. F. (2014). Children's engagement with educational iPad apps: Insights from a Spanish classroom. *Computers & Education*, *71*, 175-184.

[14] Schneps, M. H., Ruel, J., Sonnert, G., Dussault, M., Griffin, M., & Sadler, P. M. (2014). Conceptualizing astronomical scale: Virtual simulations on handheld tablet computers reverse misconceptions. *Computers & Education*, *70*, 269-280.

[15] Wang, J. Y., Wu, H. K., & Hsu, Y. S. (2017). Using mobile applications for learning: Effects of simulation design, visual-motor integration, and spatial ability on high school students' conceptual understanding. *Computers in Human Behavior*, *66*, 103-113.

[16] Hidayat, D. S., Rakhmat, C., Suryadi, A., Rochyadi, E., Nandiyanto, A. B. D., & Maryanti, R. (2022). Wheat flour as a thermal insulator for learning media for students with hearing impairment. *Journal of Engineering Science and Technology*, *17*(1), 0085-0094.

[17] Stylos, G., Sargioti, A., Mavridis, D., & Kotsis, K. T. (2021). Validation of the thermal concept evaluation test for Greek university students' misconceptions of thermal concepts. *International Journal of Science Education*, *43*(2), 247-273.

[18] Löffler, P., Pozas, M., & Kauertz, A. (2018). How do students coordinate context-based information and elements of their own knowledge? An analysis of students' context-based problem-solving in thermodynamics. *International Journal of Science Education*, *40*(16), 1935–1956.

[19] Gunawan, G., Harjono, A., Hermansyah, H., & Herayanti, L. (2019). Guided inquiry model through virtual laboratory to enhance students'science process skills on heat concept. *Jurnal Cakrawala Pendidikan*, *38*(2), 259-268.

[20] O'Brien, T. C., Palmer, R., & Albarracin, D. (2021). Misplaced trust: When trust in science fosters belief in pseudoscience and the benefits of critical evaluation. *Journal of Experimental Social Psychology*, *96*, 104184.

[21] Darman, D. R., Suherman, S., & Hidayat, S. (2017, December). Virtual Microscopic Simulation (VMS) to promote students' conceptual change: A case study of heat transfer. In *Asia-Pacific*

Forum on Science Learning & Teaching (Vol. 18, No. 2, pp. 1-12). The education university hongkong.
[22] Grant, M. M. (2019). Difficulties in defining mobile learning: Analysis, design characteristics, and implications. *Educational Technology Research and Development*, *67,* 361-388.
[23] Almaiah, M. A., Hajjej, F., Lutfi, A., Al-Khasawneh, A., Alkhdour, T., Almomani, O., & Shehab, R. (2022). A conceptual framework for determining quality requirements for mobile learning applications using Delphi Method. *Electronics*, *11*(5), 788.
[24] Chao, C. M. (2019). Factors determining the behavioral intention to use mobile learning: An application and extension of the UTAUT model. *Frontiers in psychology*, *10*, 1652.
[25] Alturki, U., & Aldraiweesh, A. (2022). Students' perceptions of the actual use of mobile learning during COVID-19 pandemic in higher education. *Sustainability*, *14*(3), 1125.
[26] Aisyah, S., & Afrizal, A. (2022). Research Trends in Mobile Learning: A Systematic Literature Review From 2011-2021. *Journal of Educational Technology and Instruction*, *1*(1), 49-61.