Penerbit Akademia Baru

Journal of Advanced Research Design

Journal homepage:
https://akademiabaru.com/submit/index.php/ard
ISSN: 2289-7984

Designing and Implementing Interactive Digital Module: Innovation for a Technology-Enable Mathematics Literacy in Calculating Heat Transfer

Laely Farokhah[1,2,*], Tatang Herman[1], Wahyudin[1], Muhammad Zulfadhli[3], Zaenal Abidin[4]

[1] Universitas Pendidikan Indonesia, Bandung, Jawa Barat, Indonesia
[2] Universitas Negeri Jakarta, Jakarta, Daerah Khusus Jakarta, Indonesia
[3] Universitas Bhayangkara Jakarta Raya, Jakarta, Daerah Khusus Jakarta, Indonesia
[4] Universitas Negeri Surabaya, Surabaya, Jawa Timur, Indonesia

ARTICLE INFO

Article history:
Received 3 March 2025
Received in revised form 28 April 2025
Accepted 15 July 2025
Available online 8 August 2025

Keywords:
Interactive digital module; fractions; heat transfer; mathematics literacy; technology

ABSTRACT

Various technology-based products have emerged as an impact of advances in technology reform. Although much research has been conducted to study technology-based products, few studies have developed innovation of interactive module and how these discussions support or hinder a technology-enable mathematics literacy, especially in calculating heat transfer. This research is aimed to design and implement Interactive Digital Module (IDM) of fractions to fostering a technology-enable mathematics literacy. This research employed design-based research (DBR) to obtain an overview regarding to design and implement the IDM. The subjects of this research were students, teachers, and experts. The results revealed that the IDM was designed and developed using Flipbook design. The contents covered how to do fraction operations completed with materials of fractions, student worksheets, exercise of mathematics literacy tests, interactive videos, and evaluations related to the need of students. The interactive and user-friendly design empower students to explore fractions and relation to the mathematics literacy. According to the validation by experts, the IDM was quite effective in Flipbook design for students. For the implementation, the IDM of fractions can enhance mathematics literacy of students. This research has implications for using IDM as an innovation to improve student's mathematics literacy of fractions.

1. Introduction

Technology in digital era has significantly changed the way of people life around the world. The existence of sophisticated technology has led humans to the better quality and standards of living system [1]. One of the impacts of technological developments is the diverse influence on human work productivity, which varies from one period to the next due to the use of technology. Various technology-based activities have emerged as a result of advances in information technology, such as electronic government (e-government), electronic commerce (e-commerce), electronic education (e-education), electronic medical services (e-medicine) and so on. Technology in education plays a role

* *Corresponding author*
E-mail address: laelyfarokhah@unj.ac.id

https://doi.org/10.37934/ard.141.1.90116

as a part of the curriculum, as a learning delivery system, as a learning aid, and as a tool to improve the learning process [2]. Digital technology within educational settings encompasses a range of software and devices designed to assist students with specific accessibility requirements [3].

Technology has a significant role in the educational process in the 21st century. Digital learning promotes creativity and empowers a sense of achievement in students, thereby motivating further learning through innovative approaches beyond conventional methods [3]. Moreover, teachers utilize technology to facilitate connections among individuals and to access new information, ideas, and perspectives [4]. Through the continuous advancement of online tools and applications, educators have the opportunity to enhance their efficiency and expertise in utilizing technology [5]. Additionally, they can empower students with the skills to effectively utilize 21st-century technology in their academic and professional aspects.

Technology used in mathematics classroom is very diverse, such as digital media, digital learning materials and digital assessments. Previous research showed that the use of digital tools influences the development of skills, mathematical knowledge, as well as students' attitudes and tendencies in using mathematics critically [6]. Students enjoy using technology in the classroom and most of them access more learning material through technology [7]. In addition, the essential aspects contributing to the effectiveness of digital technology in mathematics education encompass the development of the digital tool and related tasks to maximize its pedagogical possibilities, the teacher's involvement and the educational setting [8].

Digital module is learning material that are available in digital form and can be accessed easily through digital devices such as computers, laptops or smartphones [9]. Digital module is learning material in digital form designed so that students can learn independently [10]. Digital module aims to supply learning materials that align with curriculum requirements while considering students' needs and their social background [11]. The module has undergone a transformation from a printed format to an electronic format known as a digital module or electronic module. Digital module presents learning materials digitally, using various media such as interactive video, audio, images and animation, with the aim of increasing student interest and abilities [12]. Digital module helps students face the weaknesses of traditional learning and can also increase student motivation to learn independently [13].

Interactive Digital Module (IDM) has several characteristics related to the nature of digital module consisted of (1) self-paced, allowing learners to take control over their learning time and place according to their individual learning needs and pace, (2) self-instruction, facilitating independent learning by providing a variety of learning activities, (3) independent, organizing the entire series of learning activities in one package, and (4) modular or chunking, with material separated into smaller, in-depth sections [14]. The element of digital module consists of competencies and learning objectives, usage guidelines, necessary tools and materials, descriptions of materials, summaries, exercises and tasks, interactive forums and provided answers enabling self-assessment [15]. In the context of IDM or e-module, there is two-way or more communication, allowing interaction between the learner and the materials, as well as the possibility of interaction between learners.

Student's activities and autonomy who learned with IDM significantly different with students who learned using printed module [16]. Moreover, the learning outcomes of students who use digital module can obtain comprehension scores in the very good achievement category [17]. Another previous research showed that the interactive electronic tax-based website module is categorized as highly effective in enhancing learning outcomes [18]. The use of e-module in learning was proven to increase students' self-efficacy, motivation and learning outcomes [15].

Mathematics literacy is an ability in formulating, using, and interpreting mathematical concepts in various contexts. Mathematical literacy is the ability to understand how mathematics plays a role

in everyday life and apply it to solve various problems that arise in daily [19]. Mathematics literacy not only includes the ability to apply the quantitative aspects of mathematics, but also involves understanding mathematics in a broader sense [20]. There are seven core competencies in mathematics literacy including mathematical reasoning and thinking, mathematical argumentation, mathematical communication, modelling, problem solving, representation, symbols and tools and technology [21]. Mathematics literacy relates to mathematical proficiency such as conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition [22]. Through mathematics literacy, an individual can reflect on his mathematical logic to be utilized in his life, community and society [23]. Mathematics literacy aims to increase students' awareness and understanding of the relevance and role of mathematics in the context of the modern world [24].

Although mathematics literacy is an important ability, the studies showed that the achievement of students' mathematics literacy has not maximum. In this case, mathematics literacy of students especially in elementary school is still in the low category [25-28]. The previous research results show that the low mathematical literacy is caused by students not being trained in problem solving activities on mathematical literacy questions and still being used to solving routine and procedural questions [29]. Moreover, another research results showed that there are students' difficulties in solving contextual problems contained in mathematics literacy questions [30]. Figure 1 shows the network visualization of research on mathematics literacy in elementary school. Data was obtained from our previous study [31]. The connection between mathematics literacy and elementary school cannot be seen clearly. The publication of research in mathematics literacy in elementary school is still limited to be researched [32,33].

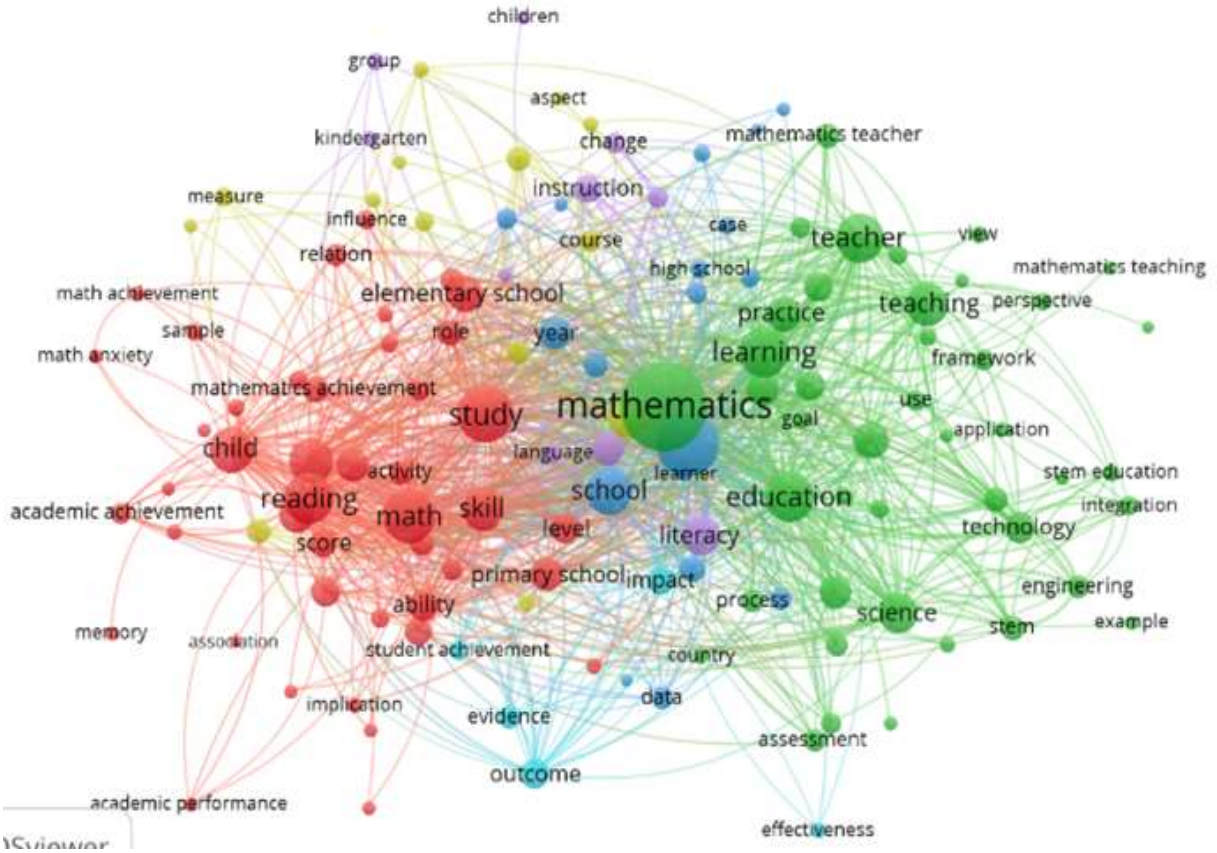


Fig. 1. Network visualization based on co-occurrence of terms [32]

Learning supports such as digital modules can also help students understand mathematics concepts at the elementary school level and improve their basic mathematics skills [34]. A comprehensive overview of prior research of technology for mathematics learning is presented in Table 1.

Table 1
Previous studies on technology for mathematics learning

No.	Title	References
1.	Digital technology in learning mathematical literacy, can it helpful?	[35]
2.	Examining the Relationship between Secondary Mathematics Teachers' Self-Efficacy, Attitudes, and Use of Technology to Support Communication and Mathematics Literacy	[36]
3.	A Systematic Review of Technological Impact on Math Literacy in the Postsecondary Classrooms	[37]
4.	Development of Mobile-Based Digital Learning Materials in Blended Learning Oriented to Students‟ Mathematical Literacy	[38]
5.	Effectiveness of Desmos Application Integrated with PjBL in Multimedia Mathematics Learning in Terms of Mathematical Literacy Skills	[39]
6.	E-LKPD based on Problem Based Learning (PBL) Approach to Measure Mathematics Literacy Ability of Elementary Students	[40]
7.	Development of Teaching Materials for E-learning-Based Statistics Materials Oriented Towards the Mathematical Literacy Ability of Vocational High School Students	[41]
8.	Development of Animated Video-based Mathematics Learning on The Three-dimensional Material of Class XII SMA to Improve Mathematical Literacy	[42]
9.	The Effect of GeoGebra-Assisted Problem-Based Learning on Students' Mathematical Literacy Skills and Learning Motivation	[43]
10.	Designing a Digital Teaching Module Based on Mathematical Communication in Relation and Function	[44]

Several previous studies have been conducted regarding technology-based products for increasing mathematics literacy, including research on mobile-based digital learning for mathematics literacy [38,39], research on digital learning materials for mathematics literacy [40,41,45] and research on the digital learning media for mathematics literacy [42,43]. However, these previous studies still focused on digital learning products in general. Different from other studies, our research gap is highlighted the need for research that addresses personalized digital tools and innovative technological applications, ensuring more effective strategies for improving mathematics literacy in calculating heat transfer. This research is aimed to design and implement IDM of to fostering a technology-enable mathematics literacy in calculating heat transfer. The novelties in this research are (i) this study design the IDM using Flipbook design (ii) this study implement the IDM for empowering mathematics literacy in calculating heat transfer completed with literature review, bibliometric and experiments for students and (iii) this study finds the next future research.

2. Literature Study

2.1 Technology-Based Products in Education

The existence of technology and information provides easy access for everyone to obtain the widest possible educational opportunities. Technology has started to transform education, influencing the way students develop the skills necessary for college and career readiness, as well as how educators incorporate digital instructional strategies into the teaching and learning process [46]. As the impact, technology has the power to create new opportunities and connections by improving access to high-quality education, enhancing communication among educators, students and families, and reducing challenges in various educational settings, from early childhood to adult learning [47].

The use of technology-based products in education are varied including digital learning, digital media, digital learning materials and digital assessment. Digital learning materials are one of the technology-based products that is widely use in education. The use of digital learning materials is effective in classroom learning [48]. Table 2 showed the previous research of digital learning materials in education practices.

Table 2
Analysis of previous study

No.	Title	Results	References
1.	What is the impact of e-books on students' mathematics performance? A qualitative systematic review	Motivation, technological progress, information technology, learning goals, digital application resources, technology-related challenges, traditional teaching methods, and visual information all significantly impact students' mathematical learning.	[49]
2.	The development of e-module mathematics Based on contextual problems	The e-module for mathematics, which focuses on contextual problems, proved effective in enhancing student learning outcomes related to set theory. The improvement in student performance was significant, driven by their active engagement with mathematical concepts through digital scenarios grounded in real-life contexts.	[50]
3.	Development of Electronic Handouts Using Numerical Literacy-Based Mathemagics Methods for Learning in the Digital Era	These findings suggest that the electronic Mathemagic handout, designed to enhance numeracy literacy, satisfies the ideal validation standards. This research proposes creating an engaging mathematical learning tool through game-based approaches to boost students' numeracy skills.	[51]
4.	Development of Mathematics E-Books in Improving Mathematical Literacy and Entrepreneurial Spirit	According to the findings, the media is valid for teaching mathematics with linear programming content and is effective in enhancing both mathematical literacy and entrepreneurial spirit.	[52]
5.	Numeracy E-Module with Edugame As A Support For Mathematics Learning for Sixth-Grade Elementary School Students	This e-module was highly appropriate as a supplementary resource for sixth-grade elementary mathematics education, receiving validation scores of 90.7% from media experts, 86.7% from material experts, and a 100% user satisfaction rating.	[53]

2.2 Interactive Digital Module (IDM)

A learning module is a set of resources collected to support students in their independent study throughout a specific learning process. A module is a set of learning programs that are planned and designed to facilitate students in achieving learning goals [54]. Moreover, a module is an instructional material that is organized systematically to facilitate students in mastering the subject matter [55]. A module serves as a unit of learning activity intended to aid individual students in reaching their educational objectives [11].

Digital module or electronic module, are instructional tools designed systematically and attractively to encompass materials, methodologies, constraints and evaluation methods electronically [56]. The e-module is designed to be interactive, facilitating navigation by featuring images, text, and videos and includes tests with automatic feedback [57]. The advantage of e-modules as an electronic learning resource is their ability to present material and practice questions

in various formats, not only text but also contained with images and videos that support the learning process [58].

Fig. 2. The characteristics of module [59]

Figure 2 shows the characteristic of module. Characteristics that need to be considered for module development include (1) self-instructional, meaning that the module can facilitate students to learn independently and not depend on other people, (2) self-contained, meaning the module contains all the required learning material, (3) stand alone, meaning the module does not depend on other teaching materials, (4) adaptive, meaning that the module is able to adapt to developments in science and technology, and (5) user friendly, meaning that the module can be used easily and is friendly to students [59]. Based on the characteristics of the module, it is clear that the module is a teaching material that has special characteristics compared to other teaching materials. This characteristic can be utilized in optimizing learning, including mathematics learning for empowering mathematics literacy.

2.3 Development of IDM using Flipbook Design

Digital teaching materials has been widely used in educational practice. Teachers believe that digital learning materials will be more engaging, easier to comprehend, practical, cost-effective, diverse and better suited to capturing students' interest in the digital era [60]. Digital module as the innovation of printed module is one of teaching materials that provides resources combined with multimedia tools such as video, pictures, and others. The instructional material presented as an E-Module offers benefits such as greater effectiveness and efficiency, along with easy accessibility [61]. The digital module can enhance students' autonomy in learning since it isn't limited to classroom use [44].

Currently, the digital module has been presented in various design. Flipbook is a form of digital book that combines text, photos, audio and video in one platform [62]. Flipbooks as a digital learning platform will include various types of media such as text, images, and videos that support learning materials [63]. The interactive features of flipbooks can be an additional advantage because this electronic media utilizes multimedia properties, which include a combination of text, narration, video, practice questions and integration with various learning approaches [64]. Flipbook as a

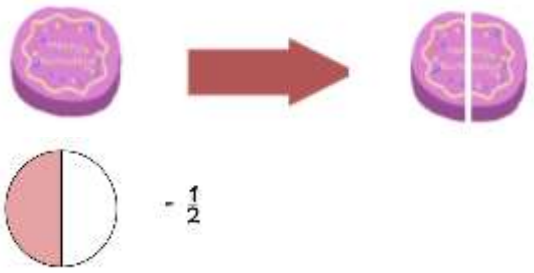
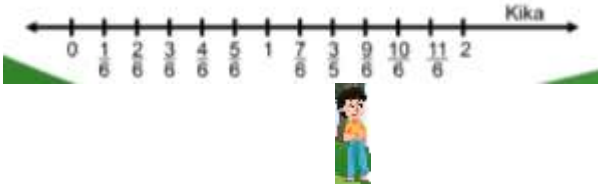
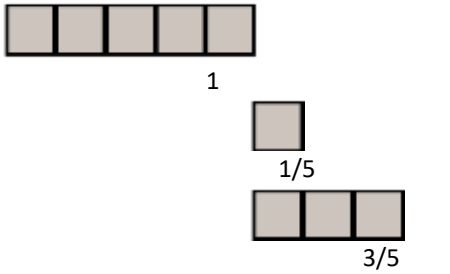
learning media facilitates students' better understanding of the material presented and offers an attractive learning presentation, which increases students' interest and motivation to learn [65].

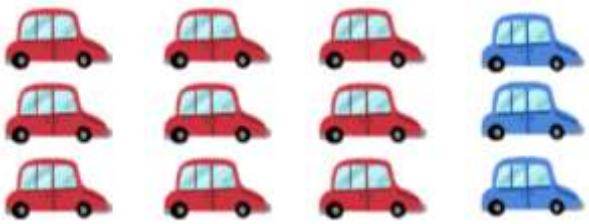
Previous research showed the PBL-based Mathematics e-module can help teachers in increasing the students' interest in mathematics lessons, provide new insights to them, and serve as the source of references for the sustainable study [66]. The electronic module (e-module) based on digital flipbook is in the very feasible category for students in elementary school [67]. The discovery of e-module flipbook products based on learning theory demonstrates that they are valid, practical and effective in boosting students' motivation and achieving learning outcomes [68].

2.4 Fraction Concepts

To mathematicians, fractions are rational numbers that can be written as 'a/b', where b = 0, rather than parts of wholes [69]. Moreover, fraction is interpreted in five terms consisted of part-whole, measure, operator, quotient and ratios [70,71]. Fractions are a foundational concept in elementary mathematics that aid in comprehending parts of a whole and enhancing proficiency in numerical calculations. Table 3 shows the graphical representation of five constructs of fractions.

Table 3
The five constructs of fractions

Fraction Constructs	Graphical Representation
Part-whole	 Hana gets "half" of the cake
Measure	 Kika jumped as far as 5/6 meters 
Quotient	3 : 4 = …… It can be represented by: 
Operator	

Ratio	 9 : 3 There are nine red cars and 3 blue cars

2.5 Heat Transfer

Heat refers to the transfer of thermal energy between two systems with differing temperatures [72]. In simple terms, heat transfer is the flow of energy caused by differences in temperature [73]. Thermal energy, also known as heat energy, is a characteristic of a body or system that is linked to its temperature [72]. Heat transfer between substances occurs in everyday life, either by absorbing or releasing heat to establish and maintain the necessary conditions for a continuous process [74]. Heat transfer is a crucial factor in the design of numerous devices, including automobile radiators, solar collectors, power generation components, and spacecraft [75].

Heat transfer is divided into three types consisting of conduction, convection and radiation. Radiation is the process of energy transfer through space via electromagnetic waves, similar to how light waves transmit light [76]. When a single piece of firewood burns in a fireplace, pyrolysis occurs, and the heat produced is lost to the environment through radiation, preventing further pyrolysis, but when a stack of firewood burns, the radiative heat lost by one piece is absorbed by the others, allowing pyrolysis to continue [76]. The calculation of radiation is based on the Stefan-Boltzmann formula [77], showed in Eq. 1 below.

$$q=\sigma.A.T^4 \quad (1)$$

In details, q represents the heat transfer rate (W), σ denotes the Stefan-Boltzmann constant (5.6703×10^{-8} W / m^2. K^4), A is the surface area of the radiating object (m^2), and T is the absolute temperature (K). Figure 3 showed the illustration of heat transfer in radiation process.

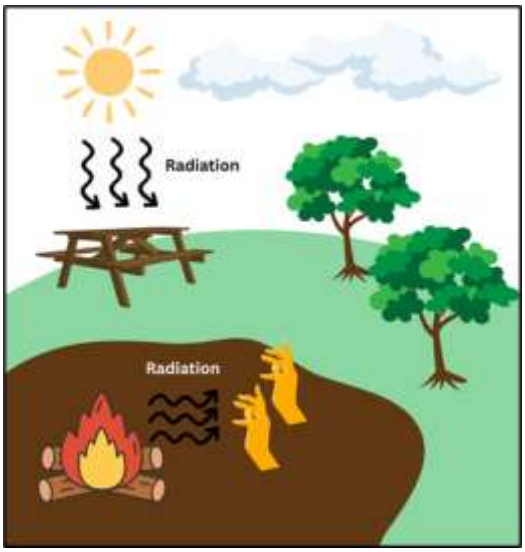


Fig. 3. The illustration process of heat transfer in radiation process

Convection is the process in which heat is transferred through the movement of molecules from one location to another [78]. Convective heat transfer is commonly categorized into forced convection and natural convection [79]. Natural convection heat transfer is commonly enhanced by adding rectangular fins to horizontal or vertical surfaces in various electronic applications, motors and transformers [80]. The significance of heat transfer through free natural convection is evident in various engineering applications, including energy transfer in buildings, solar collectors, nuclear reactors and electronic packaging [81].

Convection is the transfer of heat that occurs between a surface and a fluid flowing around it, using a conductive medium in the form of a fluid (liquid/gas) [82]. The primary factor influencing the heat transfer rate is the surface area; a larger surface area results in a higher heat transfer value [83]. The principle of convection is explained by Newton's Law of Cooling, which is stated in Eq. (2) as follows.

$$q = h.A.dT \tag{2}$$

Where, h is the convective heat transfer coefficient of the process (W/(m2.°C). Figure 4 showed the illustration of heat transfer in convection process.

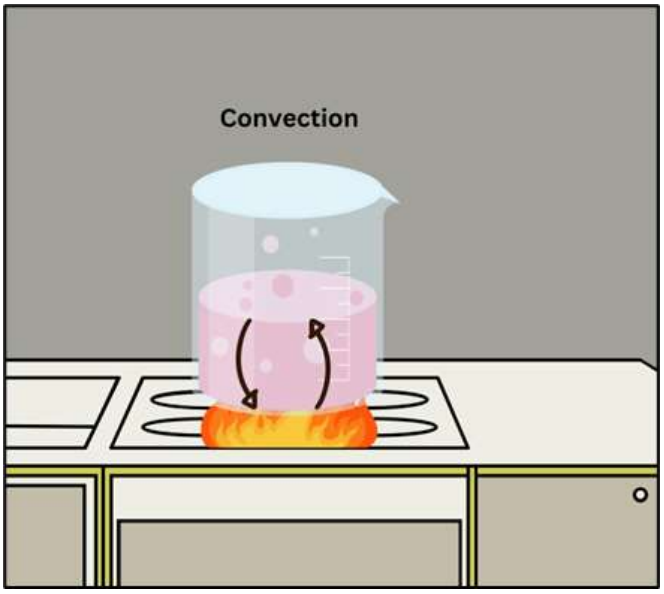


Fig. 4. The illustration process of heat transfer in convection process

Conduction heat transfer involves the transfer of energy from the more energetic particles of a substance to adjacent, less energetic particles through their interactions [84]. In conduction, energy gradually transfers from a region of higher temperature to a region of lower temperature through a conducting medium, without any movement of the particles within the medium [85]. Moreover, conduction is the process of transferring heat energy through collisions between adjacent atoms or molecules [86]. Conduction heat transfer can be divided into two types, namely steady state conduction and unsteady state conduction. Steady state conduction is a conduction process where the heat value (calories) is the same over time, while unsteady state conduction is a conduction process where the heat value changes over time [87].

Conduction is the dominant method of heat transfer within a solid or between solid objects in thermal contact [86]. This phenomenon is essential for understanding thermal regulation in both

engineering applications and natural systems. The concept of conduction is described in the Eq. (3) as follows [88].

$$q = -k.A\frac{dT}{dx} \tag{3}$$

In details, k is thermal conductivity (W/m. ^{o}C), and $d\frac{dT}{dx}$ is the temperature gradient. Figure 5 showed the illustration of heat transfer in conduction process.

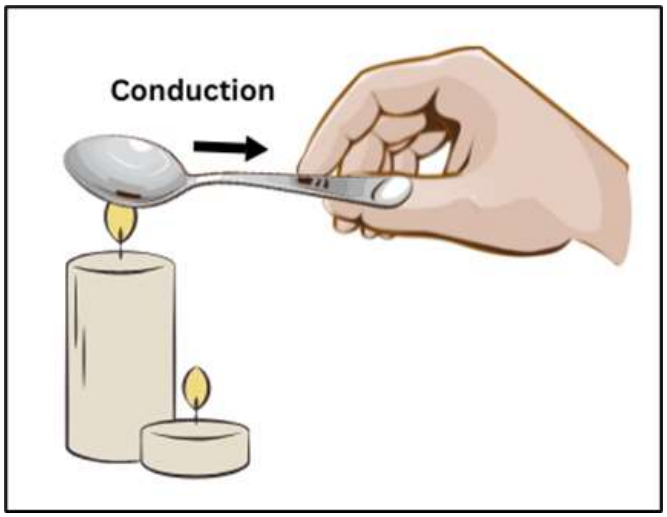


Fig. 5. The illustration process of heat transfer in conduction process

Table 4 shows numerous studies related to heat transfer.

Table 4
Research fractions on education

No.	Title	Reference
1.	Two-Phase Flow Boiling Heat Transfer Coefficient with R290 in Horizontal 3 mm Diameter Mini Channel	[89]
2.	Thermal Management System Based on Phase Change Material (PCM) and Heat Pipe in Lithium-Ion Electric Vehicle Batteries	[90]
3.	Evaluation of Indirect Evaporative Cooling Performance Integrated with Finned Heat Pipe and Luffa Cylindrica Fiber as Cooling /Wet Media	[91]
4.	Impacts of Nonlinear Thermal Radiation on A Stagnation Point of An Aligned MHD Casson Nanofluid Flow with Thompson and Troian Slip Boundary Condition	[92]
5.	Experimental and Numerical Study on the Effect of Teardrop Dimple/Protrusion Spacing on Flow Structure and Heat Transfer Characteristics	[93]
6.	Computational Investigation of Heat Transfer of Nanofluids in Domestic Water Heat Exchanger	[94]
7.	Utilization of Nanofluids in Minichannel for Heat Transfer and Fluid Flow Augmentation: A Concise Research Design	[95]
8.	Numerical Analysis of Heat Transfer in Microchannel Heat Transfer in Microchannel Heat Sink using Flow Disruption	[96]
9.	Heat Transfer Performance of Hybrid Nanofluid as Nanocoolant in Automobile Radiator System	[97]
10.	Heat Transfer Analysis in Microchannel Heatsink by using Different Nanoparticle Concentration of h-BN	[98]

2.6 Mathematics Literacy Related to Fraction and Heat transfer

Mathematics literacy is the ability to apply basic mathematics in everyday life [99]. Through mathematics literacy, an individual can reflect on his mathematical logic to be utilized in his life, community and society [23]. The Figure 6 shows a mathematical literacy framework compiled by The Organization for Economic Co-operation and Development (OECD).

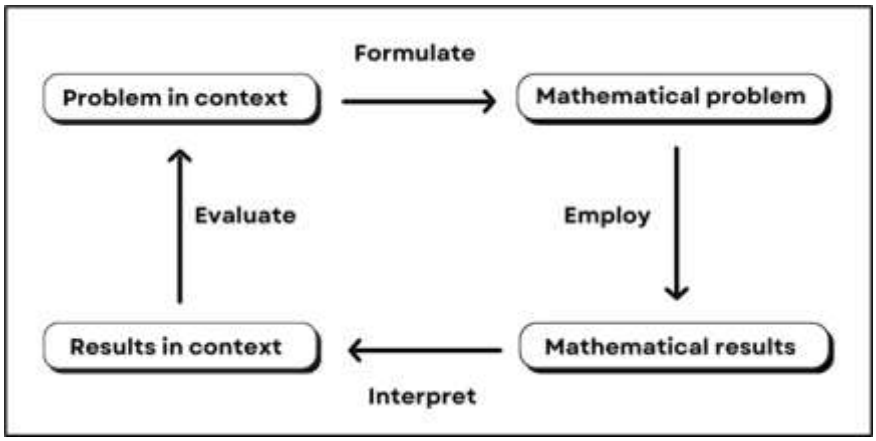


Fig. 6. Mathematical process cycle [100]

Mathematics literacy does not only include the ability to apply quantitative aspects of mathematics, but mathematics literacy also includes broader mathematical knowledge [101]. The indicators used to measure mathematics literacy are adapted from the 2018 PISA Framework [102], consisted of (1) formulating the situation mathematically, (2) using mathematical concepts, facts, procedures, and reasoning, and (3) interpreting, applying and evaluating mathematical results. The formulation process is the stage where a student can analyze a problem and recognize the use of mathematical concepts to solve the problem. The process of solving (employ) is a step in which students use mathematical concepts and facts to find a solution to a mathematical problem. Then, the interpretation process shows how effective students are in reflecting on mathematical solutions or conclusions and connecting them to everyday life situations. The evaluation process reflects the ability to assess performance by looking back at the solutions or results of problem solving that have been carried out on a given problem.

Students' achievement in mathematics has a positive relationship with their success in mathematics literacy tasks [103]. Mathematics literacy allows a person to overcome various problems from diverse contexts using mathematical principles [104]. This emphasizes the importance of internalizing the mathematical literacy framework in the mathematics learning process, especially in elementary schools, as a baseline for students' abilities. Figures 7 and 8 shows the mathematics literacy in fractions concept and heat transfer.

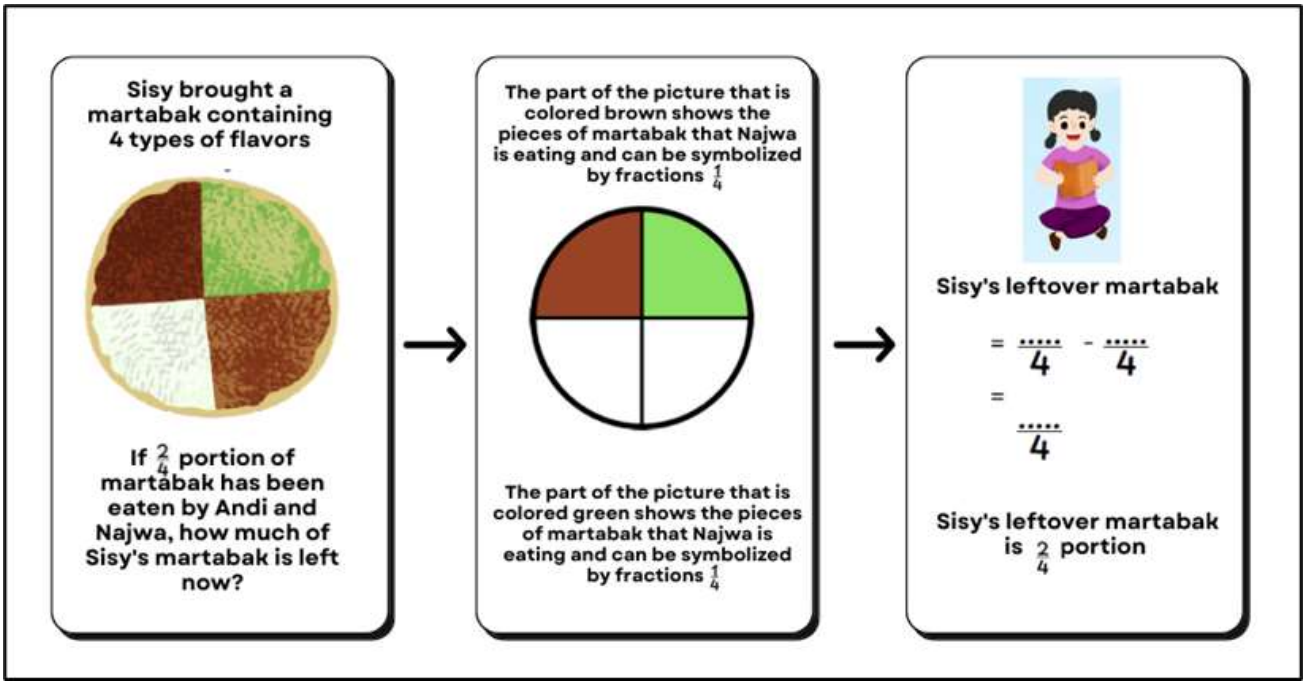


Fig. 7. Mathematics literacy in substraction operation of fractions

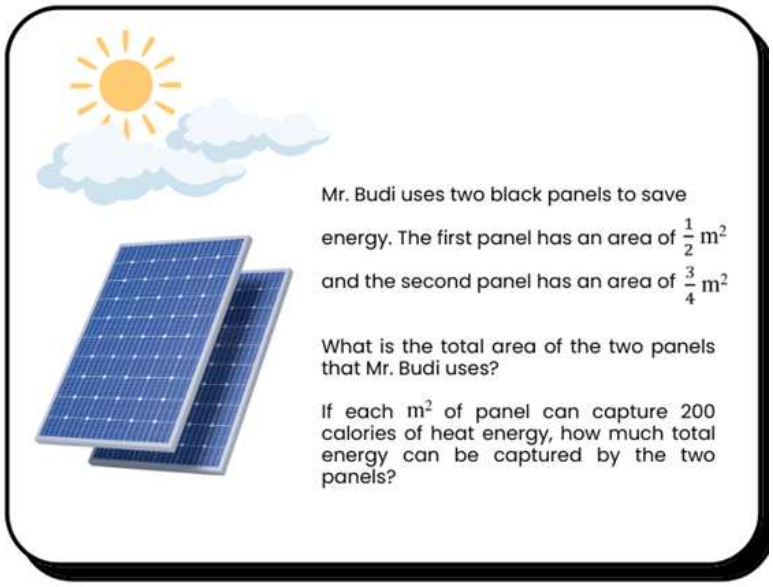


Fig. 8. Mathematics literacy in addition operation of fractions in heat transfer of radiation process

3. Methodology

3.1 Research Subjects and Locations

This research was conducted at one of elementary school in Bandung city, West Java Province, Indonesia. The subjects of this research consisted of students, teachers and experts. Fifth-grade students were taken as the participants of need analysis of design and implement the IDM. Teachers have roles as participants in need analysis and validating the IDM. In addition, the experts contribute in validating and giving judgements of IDM. Table 5 shows the demographics of sample.

Table 5
The demographics of sample

Variable	Categories	Frequency	Percent (%)
Gender	Male	23	48
	Female	25	52
Age	10 years old	14	29
	11 years old	34	71

For the generalization of the results, this study selected a sample based on its size and characteristics, taking into account variations in age and gender. Based on the sample selection, the findings of this research can be applied to similar populations in other countries. Additionally, the results are applicable to educational contexts with similar characteristics, such as elementary schools in comparable regions. If the research shows a positive relationship between students' self-regulated learning and mathematics literacy, these findings may also be observed in broader populations in other countries, given similar conditions.

3.2 Research Design

This research employed design-based research (DBR) to obtain an overview regarding to design and implement the IDM. Figure 9 shows the DBR procedure consisting of four steps including (1) identifying and analyzing of problem, (2) designing the IDM, (3) developing the IDM, and (4) reflecting the IDM.

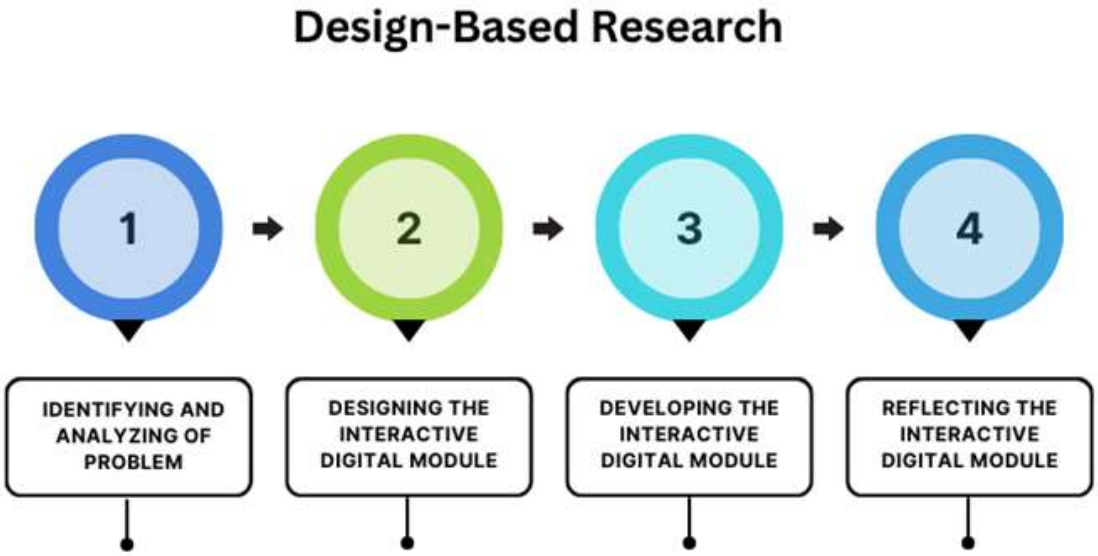


Fig. 9. Research flow

The procedure of design-based research was started by identifying and analyzing of problem through the need analysis of students to obtain an overview of profile of mathematics literacy of students, difficulties of mathematics literacy of students, and needs of students to improve their mathematics literacy. The identifying and analyzing were also conducted to the teachers regarding the needs of digital learning media to fostering mathematics literacy of students. The data obtained from this step can be a baseline to design the IDM. Next the second step contains designing the IDM. This step designed and developed the IDM using Flipbook design to overcome learning difficulties of students and fostering them in mathematics literacy as the final goal of this research. The last step is reflecting the IDM conducted through discussions with experts in the field of digital learning material for mathematics learning.

3.3 Data Collection

The research data collected through mathematics literacy test and expert judgements of IDM. The expert judgements were used to validating the digital module. The test instrument used is a mathematics literacy test which is carried out to measure students' mathematics literacy before and after using digital module in mathematics learning. The indicators of mathematics literacy questions can be seen in Table 6 below.

Table 6
Indicators of mathematics literacy test.

No.	Indicators	Sub-Indicators	Total of Questions
1	Formulate the situation mathematically	a. Identifying the mathematical components of a contextual-based problem and the significant variables contained	1
		b. Represent situations mathematically, using appropriate variables, symbols, diagrams, and models.	1
2	Uses mathematical concepts, facts, procedures, and reasoning	a. Develop and apply strategies to find mathematical solutions	1
		b. Manipulate numbers, data, graphic information, statistics, algebraic expressions and equations, and geometric representations	1
3	Interpret, apply and evaluate mathematical results	a. Interpret mathematical results against real-world contexts.	1
		b. Evaluate the reasonableness of mathematical solutions in real-world contexts.	1

3.4 Data Analysis

The data analysis aimed to evaluate, develop, and revise the design and development of IDM. Data processing was carried out using scores of mathematics literacy score and the percentage of expert judgements. The researchers examined the data to assess the students' mathematics literacy before and after using the digital module. The data from the expert judgements also were analyzed through steps of data collecting, data reduction, data presentation, and data conclusion.

4. Results and Discussion

4.1 Results of Identifying and Analyzing of Problem

Identifying and analyzing the problem were conducted through doing the need analysis to obtain an overview of profile of mathematics literacy of students, difficulties of mathematics literacy of students, and needs of students to improve their mathematics literacy. The profile of mathematics literacy of students was taken using mathematics literacy test. The test measures the three indicators of mathematics literacy consisted of (1) formulating the situation mathematically, (2) using mathematical concepts, facts, procedures and reasoning and (3) interpreting, applying and evaluating mathematical results. Table 7 shows the results of the mathematics literacy of students in 5th grade elementary school.

Table 7
Descriptive statistics of students' mathematics literacy in 5th grade elementary school

Students' Mathematics Literacy	N	Minimum	Maximum	Mean	Std. Deviation
	45	23	77	50,76	16,963

According to Table 7, the results showed that the mean of students' mathematics literacy was 50,76 which is categorized in low category of mathematics literacy. The minimum score was 23 and the maximum score was 77. Moreover, the standard deviation was 16,963 which means the data have variations. To obtain an overview result, Table 8 shows the results of mathematics literacy test of students based on three indicators of mathematics literacy.

Table 8
The results of mathematics literacy test of students based on the indicators

No.	Indicators	Sub-Indicators	Contents	Score
1.	Formulating the situation mathematically	Identify the mathematical components of a contextual problem and the significant variables contained therein.	Division of fractions	50%
		Represent situations mathematically, using appropriate variables, symbols, diagrams and models.	Multiplication of fractions	56%
2.	Using mathematical concepts, facts, procedures, and reasoning	Develop and apply strategies to find mathematical solutions.	Percentage	45%
		Manipulate numbers, data, graphical information, statistics, algebraic expressions and equations, and geometric representations.	Subtraction of fractions	51%
3.	Interpreting, applying and evaluating mathematical results	Interpreting mathematical results in real-world contexts.	Multiplication of decimal	51%
		Evaluate the reasonableness of mathematical solutions in real-world contexts.	Percentage	27%

According to Table 8, the results showed that students have the different achievement in each indicator of mathematics literacy. The highest percentage of indicators achievement is 56% which is students can formulate the situation mathematically, especially in sub-indicators of Represent situations mathematically, using appropriate variables, symbols, diagrams and models. In contracts, the lowest percentage of indicators achievement is interpreting, applying and evaluating mathematical results specifically in sub-indicators of Evaluate the reasonableness of mathematical solutions in real-world contexts, which is 27%.

In formulating the situation mathematically, students were given a mathematics literacy in Figure 10 as follows.

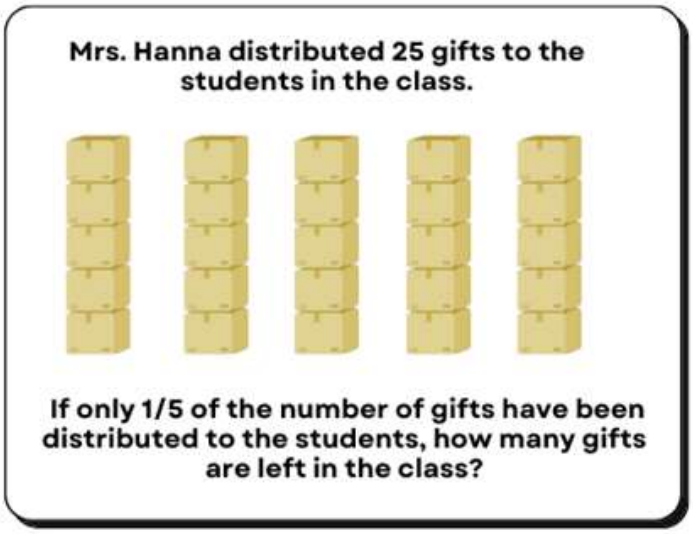


Fig. 10. Mathematics literacy test of the indicators of formulating the situation mathematically

To solve the problems, students try to represent situations mathematically such as changing the situation in the problems to symbol of fractions operation (1/5 x 25 = ...). They also try to use appropriate variables, symbols, diagrams and models through observing the total of gifts from Mrs. Hanna. Student's try to count how much 1/5 of 25 gifts. For students with high mathematics literacy, they directly doing the multiplication operation 1/5 x 25 = 5 gifts. However, students with low category of mathematics literacy find difficulties in representing the situation of problems to the mathematics symbols and also difficult to choose what operations that they need to do for finding the solutions. In representing the situation of problems, students difficult in analyzing what the important information for them to solve the problem. Some of them have a wrong representation so that they didn't get solve the problems. In addition, students also difficult in using the models in the question above to find how many gifts are left if only 1/5 of the number of gifts have been distributed to the students. In this case, only 56% the score achievement of this indicators. For the implication, students need the learning materials that can foster them in mathematics literacy.

In interpreting, applying and evaluating mathematical results, students were given a mathematics literacy in Figure 11 as follows.

To solve the problems, students try to count what is the current temperature of the pizza. For students with high mathematics literacy, they directly doing the multiplication operation (70% x 3^0C = ...), then he/she can find the current temperature of the pizza and decide whether the Hana's action is approriate or not to keep pizza from being contaminated by bacteria. However, most of students find difficulties to solve this problem. Students with low category of mathematics literacy find difficulties in interpreting, applying and evaluating mathematical results. and also difficult to choose what operations that they need to do for finding the solutions. Some of them only count the current temperature of the pizza, but they cannot interpret, apply and evaluate mathematical results. In this case, only 27% the score achievement of this indicators. For the implication, students need the learning materials that can foster them in mathematics literacy.

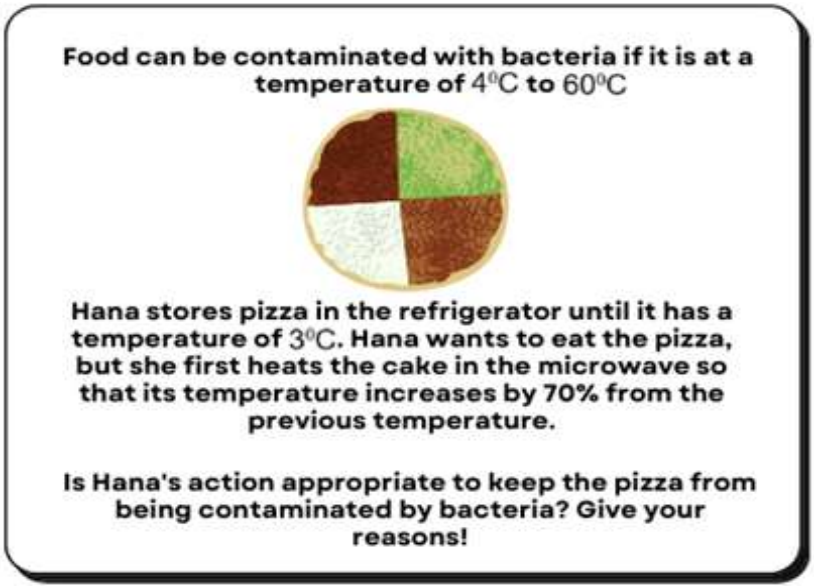


Fig. 11. Mathematics literacy test of the indicators of interpreting, applying and evaluating mathematical results

According to the interview results of students in elementary school, the difficulties found in elementary school students in solving mathematical literacy problems include 1) students have difficulty understanding the contents of the mathematical problems presented, 2) students have difficulty representing problems, 3) students have difficulty developing problem-solving strategies, 4) students have not been able to apply mathematical concepts correctly, 5) students have not been able to draw conclusions and evaluate the results found, and 6) students have not been able to organize themselves and lack enthusiasm in solving mathematical literacy problems. Moreover, according to the questionnaire, 100% students give response to agree and need the IDM.

The low achievement of students' mathematical literacy in elementary school is caused by various things, including students are not yet accustomed to story problems and problem solving, students give up easily when they find story problems and problems that are considered difficult, and students' struggle in solving problems is still low, and they tend to immediately ask for help from others [28]. In line with this, the previous research show that low mathematical literacy is caused by students not being trained in problem-solving activities in mathematical literacy questions and are still accustomed to solving routine and procedural questions [29]. In addition, there are difficulties for students in solving contextual problems contained in mathematical literacy questions [30]. The difficulties found in students in mastering mathematical literacy are also caused by a lack of mastery of reading, writing, and numeracy skills [105].

According to the interview of teachers about the need analysis of IDM, the teachers give some of reason why the IDM is important, consisted of 1) the lack of digital material learning in mathematics classroom especially to foster mathematics literacy, 2) students still difficult in mathematics literacy because the mathematics learning process have not facilitate students about it, 3) the limited understanding and perception of teachers about mathematics literacy, so that they need a reference of digital learning materials for it, and 4) most of resources of learning is available on printed-based resources, so that teachers need the digital-based resources. For the implication, teachers need the learning materials that can foster students in mathematics literacy.

4.2 Design of IDM

The design of IDM in this research is based on the results of identifying and analyzing of problem. The IDM is designed using Flipbook design. The Figure 12 shows the flow chart of design of IDM.

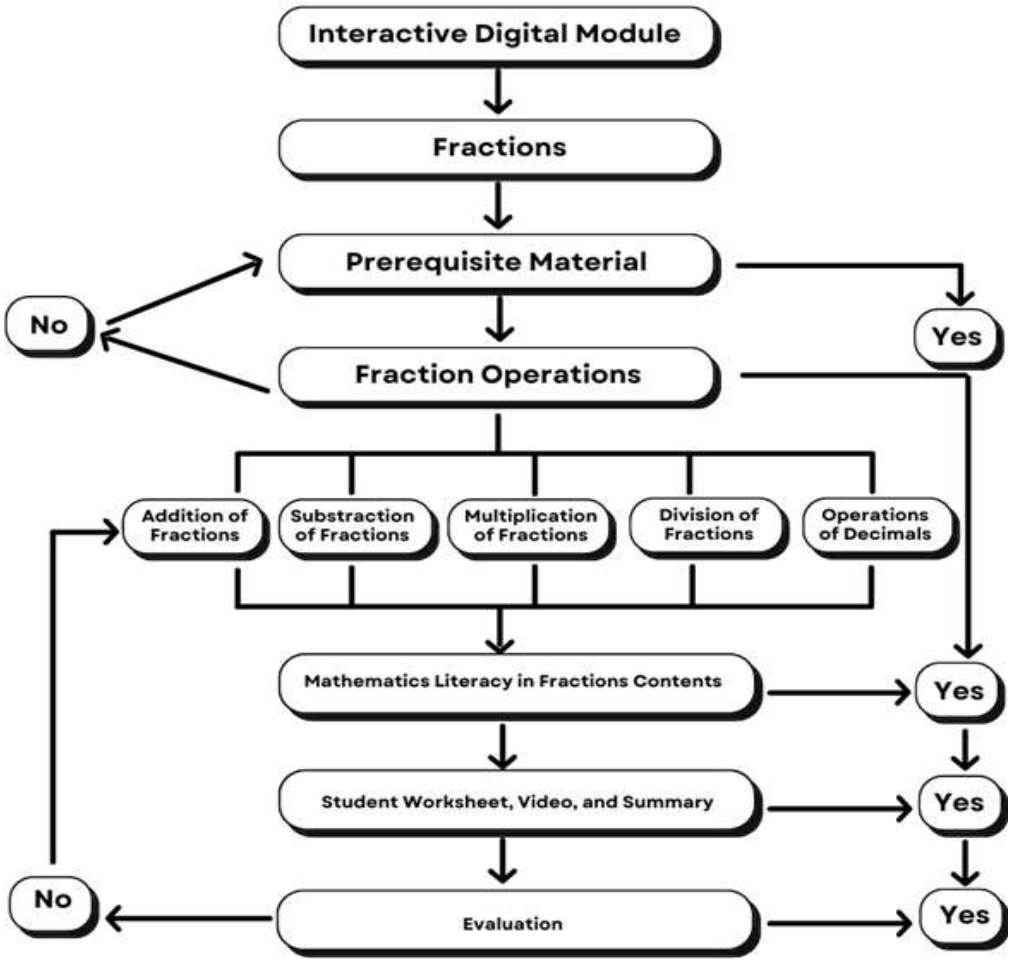


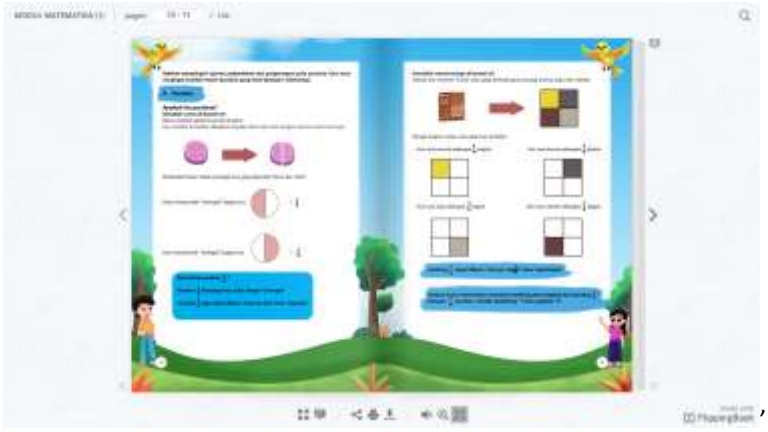
Fig. 12. Research flow chat

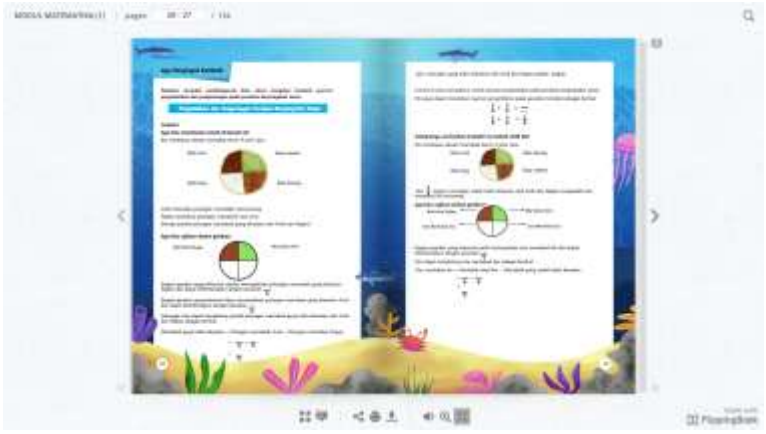
4.3 Development of IDM

The development of IDM in this research used the Flipbook design through Flipping book software. Flipbook is a form of digital book that combines text, photos, audio and video in one platform [62]. The design process should focus on accessibility to ensure that the app is user-friendly for elementary school students. Table 9 shows the development of IDM using Flipbook design.

The use of digital modules is needed to accommodate students' needs and facilitate students in learning in the digital era. Technology-based multimedia tutorials such as digital modules can provide assistance to students to overcome the shortcomings of conventional learning and can motivate students to be able to learn independently [13]. The results of the study showed that the learning outcomes of students who used digital modules could obtain understanding scores with a very good achievement category [17]. Therefore, the use of technology can be integrated into mathematics learning in Elementary Schools to improve mathematical literacy.

Table 9
Development of IDM

IDM	Description
	The cover display of IDM using Flipbook.
	The prerequisite material as a requirements should be mastered by students before they learn about fractions operation
	In each page, there is some of buttons in the below of IDM. The buttons were used to move from one page to another page and other activities such as share link, tur non the audio, and others.

	There are 5 chapters of learning materials. In each chapter, students are displayed a shor stories related to the matematics literacy on fractions concepts.
	The contents are displayed with colorfull pictures and representation of objects that can foster students with mathematics literacy.
	In the end of session of each chapter, students do the evaluation to measure the achievement of students.

4.4 Reflections of IDM Development

The reflection results from the development of the IDM found that mathematics literacy of students increased. In addition, according to the validation by experts, the IDM was quite effective in Flipbook design for students. Table 10 shows mathematics literacy of students before and after using IDM.

Table 10
Mathematics literacy of students before and after using IDM

No.	Achievement of Mathematics Literacy of Students	Sub-Indicators	Before	After
1.	Formulating the situation mathematically	Identify the mathematical components of a contextual problem and the significant variables contained therein.	40%	76%
		Represent situations mathematically, using appropriate variables, symbols, diagrams and models.	37%	80%
2.	Using mathematical concepts, facts, procedures, and reasoning	Develop and apply strategies to find mathematical solutions.	30%	75%
		Manipulate numbers, data, graphical information, statistics, algebraic expressions and equations, and geometric representations.	35%	78%
3.	Interpreting, applying and evaluating mathematical results	Interpreting mathematical results in real-world contexts.	27%	70%
		Evaluate the reasonableness of mathematical solutions in real-world contexts.	20%	71%

Mathematical literacy can develop with consistent use of technology to enhance students' exploration and relationship with mathematics. Several studies have shown that the use of technology has a vital role in mathematics learning and mathematical literacy practices. However, the instruments used in integrating technology in developing mathematical literacy must consider the pedagogical aspects and mathematical concepts themselves. Digital modules are a type of teaching material in the form of modules that are presented digitally and are easily accessible via digital devices, be it computers, laptops, or smartphones [35]. Along with the development of technology, modules are not only in print but have been developed in digital mode. This research has implications for using IDM as an innovation to improve student's mathematics literacy of fractions.

For the implementation, there are several potential challenges that may arise from the use of IDMs in mathematics learning. First, one of the main challenges in implementing educational technology is the disparity in students' access to technology. Not all students have equal access to devices such as computers, tablets, or stable internet connections. This can create inequities in technology-based learning. Second, Students from different backgrounds may have varying levels of digital skills. Students who are less familiar with technology or have limitations in using digital devices may struggle to utilize digital modules effectively.

In diverse classroom settings, each class has different dynamics and characteristics. The implementation of IDMs needs to be adjusted to the class context, including the number of students, available resources, students' technical ability levels and learning objectives. The implementation of IDMs in a classroom setting requires special attention to classroom management. Students can be divided into large groups or classes with varying levels of ability.

The results have some implications for educators and policymakers. Educators need to be more creative in using technology to support more engaging and effective learning. For example, they can use IDM as an innovation to improve student's mathematics literacy of fractions. For policymakers, policies should also encourage innovative use of technology, for example by providing incentives for schools that successfully integrate technology into mathematics teaching in effective ways.

Regarding generalization, these results are applicable to similar educational contexts, such as elementary schools in regions with comparable characteristics. These findings may also be observed in broader populations in other countries, given similar regional demographics and features of

elementary schools. However, there are limitations to the study, including the sample size and the need for more control variables to determine whether the positive relationship remains consistent across different conditions. For future research, the researchers can explore the effect of technology integration on mathematical literacy, the technology access gap and its impact on mathematical literacy, and the other topics related to IDM.

4. Conclusion

IDM is the innovation of technology-enable mathematics literacy for students in calculating heat transfer. This result revealed that the IDM was designed and developed using Flipbook design. The contents covered how to do fraction operations completed with materials of fractions, student worksheets, exercise of mathematics literacy tests, interactive videos and evaluations related to the need of students. The interactive and user-friendly design empower students to explore fractions and relation to the mathematics literacy. According to the validation by experts, the IDM was quite effective in Flipbook design for students. For the implementation, the IDM of fractions can enhance mathematics literacy of students. This research has implications for using IDM as an innovation to improve student's mathematics literacy of fractions.

Acknowledgement

We would like to acknowledge and thank the (1) Balai Pembiayaan Pendidikan Tinggi (Center of Higher Education Fund) – BPPT, The Ministry of Education, Culture, Research, and Technology, Republic of Indonesia, and; (2) Lembaga Pengelola Dana Pendidikan (Indonesia Endowment Fund for Education) – LPDP, Ministry of Finance Indonesia for granting a scholarship to the first author and the presenter to complete her study. BPI ID Number: 202101122344.

References

[1] Ahmad, Amar. "Perkembangan teknologi komunikasi dan informasi: akar revolusi dan berbagai standarnya." *Jurnal Dakwah Tabligh* 13, no. 1 (2012): 137-149.

[2] Raja, Rahat, and P. C. Nagasubramani. "Impact of modern technology in education." *Journal of Applied and Advanced Research* 3, no. 1 (2018): 33-35. https://doi.org/10.21839/jaar.2018.v3S1.165

[3] Haleem, Abid, Mohd Javaid, Mohd Asim Qadri, and Rajiv Suman. "Understanding the role of digital technologies in education: A review." *Sustainable operations and computers* 3 (2022): 275-285. https://doi.org/10.1016/j.susoc.2022.05.004

[4] McKnight, Katherine, Kimberly O'Malley, Roxanne Ruzic, Maria Kelly Horsley, John J. Franey, and Katherine Bassett. "Teaching in a digital age: How educators use technology to improve student learning." *Journal of research on technology in education* 48, no. 3 (2016): 194-211. https://doi.org/10.1080/15391523.2016.1175856

[5] Young III, Maurice H. "Using More Sophisticated Technology to Teach Mathematics." *Learning to Teach Language Arts, Mathematics, Science, and Social Studies Through Research and Practice* 6, no. 1 (2017): 47–53.

[6] Geiger, Vince, Merrilyn Goos, and Shelley Dole. "The role of digital technologies in numeracy teaching and learning." *International Journal of Science and Mathematics Education* 13, no.5 (2015): 1115-1137. https://doi.org/10.1007/s10763-014-9530-4

[7] Wakil, Karzan, Nsar Qaisar, and Chra Mohammed. "Enriching classrooms with technology in the basic schools." *European Journal of Open Education and E-learning Studies* 2, no. 1 (2017): 99–108. https://doi.org/10.5281/zenodo.841925

[8] Van den Heuvel-Panhuizen, Marja, and Paul Drijvers. "Realistic mathematics education." *Encyclopedia of mathematics education* (2020): 713-717. https://doi.org/10.1007/978-3-030-15789-0_170

[9] Novita, Rita, and T. Herman. "Digital technology in learning mathematical literacy, can it helpful?." *Journal of Physics: Conference Series* 1776, no. 1. (2021): 1–9. https://doi.org/10.1088/1742-6596/1776/1/012027

[10] Kuncahyono, K. "Pengembangan e-modul (modul digital) dalam pembelajaran tematik di sekolah dasar." *JMIE (Journal of Madrasah Ibtidaiyah Education)* 2, no.2 (2018): 219-231. https://doi.org/10.32934/jmie.v2i2.75

[11] Charlina, Charlina, Elvrin Septyanti, Tria Putri Mustika, and Annisa Rahmi. "Electronic module as learning needs to write exposition texts for junior high school students." *Journal of Education and Learning (EduLearn)* 16, no. 2 (2022): 219-225. https://doi.org/10.11591/edulearn.v16i2.20402
[12] Trilestari, Kuntum, and Nurul Fitriyah Almunawaroh. "E-Module as a solution for young learners to study at home." *4th Sriwijaya University Learning and Education International Conference (SULE-IC 2020)*. Atlantis Press, (2021): 364–369. https://doi.org/10.2991/assehr.k.201230.132
[13] Dalal, Medha. "Impact of Multi-media Tutorials in a Computer Science Laboratory Course An Empirical Study." *Electronic Journal of e-Learning* 12, no. 4 (2014): 367-375.
[14] Chaeruman, Uwes Anis. "Petunjuk Teknis Bimbingan Praktek Kerja Individu/Kelompok Pelatihan Penulisan Modul Online." *Jakarta: Pusat Teknologi Informasi dan Komunikasi the representational fluency and conceptual Pendidikan Kementrian Pendidikan dan Kebudayaan* (2014).
[15] Delıta, Fitra, Nurmala Berutu, and Nofrion Nofrıon. "Online learning: The effects of using e-modules on self-efficacy, motivation and learning outcomes." *Turkish Online Journal of Distance Education* 23, no. 4 (2022): 93-107. https://doi.org/10.17718/tojde.1182760
[16] Tarigan, Wenny Pinta Litna, Herbert Sipahutar, and Fauziyah Harahap. "The effect of interactive digital learning module on student's learning activity and autonomy." *BIOEDUKASI: JPB* 14, no.2 (2021): 196-208. https://doi.org/10.20961/bioedukasi-uns.v14i2.49366
[17] Usmaedi, Usmaedi, Putri Yuniar Fatmawati, Indhira Asih Vivi Yandari, and Aan Subhan Pamungkas. "Using the digital module rainbow book as a supporting media for learning mathematics in improving the understanding of primary students." *JPSD (Jurnal Pendidikan Sekolah Dasar)* 6, no. 2 (2020): 227-237.
[18] Darpiyah, and Sulastri. "The Effectiveness of Using an Interactive e-Module to Improve Learning Outcomes." *Journal of Accounting and Business Education*, 8, no. 2 (2023): 1–10. https://doi.org/10.17977/jabe.v8i2.47605
[19] McCrone, Sharon Soucy, and John A. Dossey. "Mathematical Literacy--It's Become Fundamental." *Principal Leadership* 7, no. 5 (2007): 32-37.
[20] De Lange, Jan. "Mathematics for literacy." *Quantitative literacy: Why numeracy matters for schools and colleges* 80 (2003): 75-89.
[21] Rizki, L. M., and N. Priatna. "Mathematical literacy as the 21st century skill." *Journal of Physics: Conference Series* 1157, no. 4. (2019): 1–5. https://doi.org/10.1088/1742-6596/1157/4/042088
[22] Kilpatrick, Jeremy. "Understanding mathematical literacy: The contribution of research." *Educational studies in mathematics* 47, no. 1 (2001): 101-116. https://doi.org/10.1023/A:1017973827514
[23] Masjaya, Masjaya, and Wardono Wardono. "Pentingnya Kemampuan Literasi Matematika untuk Menumbuhkan Kemampuan Koneksi Matematika dalam Meningkatkan SDM." *PRISMA, Prosiding Seminar Nasional Matematika* 1. (2018): 568–574.
[24] Department of Education. "National curriculum statement grades 10–12 (General): Mathematics." *Mathematical Literacy Government Printer.* (2003).
[25] Dores, Olenggius Jiran, and Beni Setiawan. "Literasi Matematis Siswa Sekolah Dasar Se-Kota Sintang." *Prosiding Silogisme* 1, no. 1 (2019).
[26] Harahap, Dharma Gyta Sari, et al. "Analisis kemampuan literasi siswa sekolah dasar." *Jurnal Basicedu* 6, no. 2 (2022): 2089-2098. https://doi.org/10.31004/basicedu.v6i2.2400
[27] Putra, Muhammad Jaya Adi, Tri Agmadya, and Syahrilfuddin Syahrilfuddin. "Mathematical literacy skills of fifth grade elementary school students: A case study in Pekanbaru." *Journal of Teaching and Learning in Elementary Education* 4, no. 1 (2021): 39-50. https://doi.org/10.33578/jtlee.v4i1.7842
[28] Rakhmawati, Yeni, and Ali Mustadi. "The circumstances of literacy numeracy skill: Between notion and fact from elementary school students." *Jurnal Prima Edukasia* 10, no. 1 (2022): 9-18. https://doi.org/10.21831/jpe.v10i1.36427
[29] Diputra, Komang Komang Sujendra, et al. "Investigating the mathematical literacy of primary school students in curriculum 2013." *5th International Conference on Education and Technology (ICET 2019)*. Atlantis Press. (2019): 65–67. https://doi.org/10.2991/icet-19.2019.16
[30] Manfreda Kolar, Vida, and Tatjana Hodnik. "Mathematical Literacy from the Perspective of Solving Contextual Problems." *European Journal of Educational Research* 10, no. 1 (2021): 467-483. https://doi.org/10.12973/EU-JER.10.1.467
[31] Al Husaeni, Dwi Fitria, and Asep Bayu Dani Nandiyanto. "Bibliometric using Vosviewer with Publish or Perish (using google scholar data): From step-by-step processing for users to the practical examples in the analysis of digital learning articles in pre and post Covid-19 pandemic." *ASEAN Journal of Science and Engineering* 2, no. 1 (2022): 19-46. https://doi.org/10.17509/ajse.v2i1.37368

[32] Farokhah, L., T. Herman, W. Wahyudin, Z. Abidin, A. Alman, and M. Zulfadhli. "Research Trends on Self-Regulated Learning and Mathematics Literacy: A Bibliometric Analysis." *Journal of Engineering Science and Technology* 18, no. 3 (2023): 81-89.
[33] Farokhah, Laely, Tatang Herman, W. Wahyudin, and Zaenal Abidin. "Global research trends of mathematics literacy in elementary school: A bibliometric analysis." *Indonesian Journal of Educational Research and Technology* 4, no. 3 (2024): 279-290.
[34] Feriyanti, Nindy, Sholeh Hidayat, and Luluk Asmawati. "Pengembangan e-modul matematika untuk siswa SD." *(Jurnal Teknologi Pendidikan dan Pembelajaran): Edutech and Intructional Research Journal* 6, no. 1 (2019): 1–12.
[35] Novita, Rita, and Tatang Herman. "Digital technology in learning mathematical literacy, can it helpful?." In *Journal of Physics: Conference Series*, vol. 1776, no. 1, p. 012027. IOP Publishing, 2021. https://doi.org/10.1088/1742-6596/1776/1/012027
[36] Letwinsky, Karim Medico. "Examining the Relationship between Secondary Mathematics Teachers' Self-Efficacy, Attitudes, and Use of Technology to Support Communication and Mathematics Literacy." *International Journal of Research in Education and Science* 3, no. 1 (2017): 56-66. https://doi.org/10.21890/ijres.267371
[37] Rodriguez, Manuel. "A Systematic Review of Technological Impact on Math Literacy in the Postsecondary Classrooms." *Higher Education Studies* 10, no. 4 (2020): 54-61. https://doi.org/10.5539/hes.v10n4p54
[38] Yaniawati, Poppy, et al. "Development of Mobile-Based Digital Learning Materials in Blended Learning Oriented to Students' Mathematical Literacy." *International Journal of Information and Education Technology* 13, no. 9 (2023): 1338-1347. https://doi.org/10.18178/ijiet.2023.13.9.1936
[39] Nuri, Bulan, Lissa Zikriana, and Iqbal Iqbal. "Effectiveness of Desmos Application Integrated with PjBL in Multimedia Mathematics Learning in Terms of Mathematical Literacy Skills." *Jurnal Penelitian Pendidikan IPA* 9, no. 11 (2023): 10457-10465. https://doi.org/10.29303/jppipa.v9i11.5497
[40] Mulyasari, Dini Wahyu, Gunarhadi, and Roemintoyo. "E-LKPD based on Problem Based Learning (PBL) Approach to Measure Mathematics Literacy Ability of Elementary Students." *International Journal of Elementary Education* 6, no. 3 (2022): 393-402.
[41] Supianti, In In, Poppy Yaniawati, Siti Zuraidah Md Osman, Jasem Al-Tamar, and Niki Lestari. "Development of teaching materials for e-learning-based statistics materials oriented towards the mathematical literacy ability of vocational high school students." *Infinity Journal* 11, no. 2 (2022): 237-254. https://doi.org/10.22460/infinity.v11i2.p237-254
[42] Firdaus, Dhiya Fathiyyah, Suripah Suripah, and Lilis Marina Angraini. "Development of Animated Video-based Mathematics Learning on The Three-dimensional Material of Class XII SMA to Improve Mathematical Literacy." *Kreano (Jurnal Matematika Kreatif-Inovatif)* 14, no. 2 (2023): 267-279.
[43] Purbaningrum, Mayang, and Ali Mahmudi. "The Effect of GeoGebra-Assisted Problem-Based Learning on Students' Mathematical Literacy Skills and Learning Motivation." *Al-Ishlah: Jurnal Pendidikan* 16, no. 2 (2024): 1337-1350. https://doi.org/10.35445/alishlah.v16i2.4620
[44] Putri, Dian Permana, Ferry Ferdianto, and Sandi Hermana Fauji. "Designing a Digital Teaching Module Based on Mathematical Communication in Relation and Function." *Journal on Mathematics Education* 11, no. 2 (2020): 223-236. https://doi.org/10.22342/jme.11.2.7320.223-236
[45] Wijaya, Eril, Latri Latri, and Siti Raihan. "(Development of a Numerical Pop-Up Book Oriented to Mathematical Literacy for Elementary School Students." *Pinisi Journal of Education* 4, no. 4 (2024): 13-23. http://creativecommons.org/licenses/by/4.0/
[46] Delgado, Adolph J., Liane Wardlow, Katherine McKnight, and Kimberly O'Malley. "Educational technology: A review of the integration, resources, and effectiveness of technology in K-12 classrooms." *Journal of Information Technology Education: Research* 14 (2015). https://doi.org/10.28945/2298
[47] Escueta, Maya, Andre Joshua Nickow, Philip Oreopoulos, and Vincent Quan. "Upgrading education with technology: Insights from experimental research." *Journal of Economic Literature* 58, no. 4 (2020): 897-996. https://doi.org/10.1257/JEL.20191507
[48] Nasution, Nur Hakima Akhirani, Silfa Hafizah Pulungan, and Yusniar Harahap. "Learners' Perceptions and Participation in Digital-Based Learning: A Review of the Effectiveness of Teaching Materials and Worksheets." *Jurnal Penelitian Pendidikan IPA* 9, no. 10 (2023): 8791-8797. https://doi.org/10.29303/jppipa.v9i10.5287
[49] Alshehri, Sami. "What is the impact of e-books on students' mathematics performance? A qualitative systematic review." *Online Learning and Educational Technology* 1, no. 1 (2023): 2591.
[50] Rochsun, R., and Ririn Dwi Agustin. "The development of e-module mathematics based on contextual problems." *European Journal of Education Studies* 7, no. 10 (2020).
[51] Gusteti, Meria Ultra, Suci Wulandari, Widdya Rahmalina, Melani Putri, and Elva Kurnia Putri. "Development of electronic handouts using numerical literacy-based mathemagics methods for learning in the digital era." *Jurnal Eksakta Pendidikan (JEP)* 7, no. 1 (2023): 115-125. https://doi.org/10.24036/jep/vol7-iss1/709

[52] Amalia, Rizki, Fadilah Fadilah, Mamay Komarudin, and Jaka Wijaya Kusuma. "Development of Mathematics E-Books in Improving Mathematical Literacy and Entrepreneurial Spirit." *Al-Ishlah: Jurnal Pendidikan* 13, no. 3 (2021): 2425-2434. https://doi.org/10.35445/alishlah.v13i3.987
[53] Sagita, Meira, and Petra Kristi Mulyani. "Numeracy E-Module with Edugame As A Support For Mathematics Learning for Sixth-Grade Elementary School Students." *Journal of Education Technology* 7, no. 3 (2023). https://doi.org/10.23887/jet.v7i3.65920
[54] Hernawan, Asep Herry, Hj Permasih, and Laksmi Dewi. "Pengembangan bahan ajar." *Direktorat UPI, Bandung* 4, no. 11 (2012): 1-13.
[55] Rakasiwi, Singgih, Tri Murwaningsih, and Feri Setyowibowo. "the Effectiveness of Internet of Things-Based Module in Improving Students' Digital Literacy." *International Journal of Education and Social Science Research* 6, no. 03 (2023): 212-220. https://doi.org/10.37500/ijessr.2023.6318
[56] Irwansyah, Ferli Septi, I. Lubab, Ida Farida, and Muhammad Ali Ramdhani. "Designing interactive electronic module in chemistry lessons." In *Journal of Physics: Conference Series*, vol. 895, no. 1, p. 012009. IOP Publishing, 2017. https://doi.org/10.1088/1742-6596/895/1/012009
[57] Pratiwi, Ni Kadek Anggi, and IN Laba Jayanta. "Elementary School Science Skills Practical Digital Teaching Module." *Jurnal Edutech Undiksha* 11, no. 2 (2023): 240–250. https://doi.org/10.23887/jeu.v11i2.61524
[58] Utama, Noveridha. "Meta-Analisis praktikalitas penggunaan e-modul oleh guru dan peserta didik dalam pembelajaran." *Jurnal Biologi dan Pembelajarannya (JB&P)* 9, no. 1 (2022): 27-33. https://doi.org/10.29407/jbp.v9i1.17671
[59] Rahdiyanta, Dwi. "Teknik penyusunan modul." *Artikel.(Online) http://staff. uny. ac. id/sites/default/files/penelitian/dr-dwi-rahdiyanta-mpd/20-teknik-penyusunan-modul. pdf. diakses* 10 (2016): 1-14.
[60] Sariyatun, Hermanu Joebagıo, and Muhammad Akhyar. "Teachers' perception on digital teaching material development in social science education." *Journal of Turkish Science Education* 15, no. 1 (2018): 13-21.
[61] Sari, Nola, and Christina Khaidir. "Needs Analysis and Design of FlipBook-Based E-Module Development with RME Model to Improve Students' Concept Understanding Ability." *JDIME: Journal of Development and Innovation in Mathematics Education* 1, no. 2 (2023): 12-24. https://doi.org/10.32939/jdime.v1i2.2979
[62] Mulyowati, Dwi, Triyanto Triyanto, and Ario Wiraya. "Digital Flipbook-Based Mathematics Teaching Materials using RME Approach to Improve Mathematical Problem-Solving Ability." *Jurnal Pendidikan Progresif* 13, no. 3 (2023): 1460-1468. https://doi.org/10.23960/jpp.v13.i3.202342
[63] Perdana, Meylani Astino, Dodiet Enggar Wibowo, and Mochamad Kamil Budiarto. "Digitalization of learning media through digital book development using the flipbook application." *Jurnal Pendidikan Dan Pengajaran* 54, no. 2 (2021): 263. https://doi.org/10.23887/jpp.v54i2
[64] Roemintoyo, Roemintoyo, and Mochamad Kamil Budiarto. "Flipbook as innovation of digital learning media: Preparing education for facing and facilitating 21st Century learning." *Journal of Education Technology* 5, no. 1 (2021): 8-13. https://doi.org/10.23887/jet.v5i1.32362
[65] Bunari, Bunari, Johan Setiawan, Muhammad Anas Ma'arif, Reski Purnamasari, Hadisaputra Hadisaputra, and Sudirman Sudirman. "The Influence of Flipbook Learning Media, Learning Interest, and Learning Motivation on Learning Outcomes." *Journal of Education and Learning (EduLearn)* 18, no. 2 (2024): 313-321. https://doi.org/10.11591/edulearn.v18i2.21059
[66] Triwahyuningtyas, Dyah, Ayu Setyo Ningtyas, and Sri Rahayu. "The problem-based learning e-module of planes using Kvisoft Flipbook Maker for elementary school students." *Jurnal Prima Edukasia* 8, no. 2 (2020): 199-208. https://doi.org/10.21831/jpe.v8i2.34446
[67] Ramadhani, Dini, Ary Kiswanto Kenedi, Muhammad Febri Rafli, and Ciptro Handrianto. "Advancement of STEM-based digital module to enhance HOTS of prospective elementary school teachers." *Jurnal Pendidikan Progresif* 12, no. 2 (2022): 981-993. https://doi.org/10.23960/jpp.v12.i2.202245
[68] Fitriyah, Isnanik Juni, and Salma Nur Salsabila Sahda. "Development of E-Module Flipbook Based on Discovery Learning to Increase Learning Motivation." *JIPVA (Jurnal Pendidikan IPA Veteran)* 7, no. 2 (2023): 66-88.
[69] Tsai, Tsung-Lung, and Hui-Chuan Li. "Towards a framework for developing students' fraction proficiency." *International Journal of Mathematical Education in Science and Technology* 48, no. 2 (2017): 244-255. https://doi.org/10.1080/0020739X.2016.1238520
[70] Reeder, Stacy, and Juliana Utley. "What is a fraction? Developing fraction understanding in prospective elementary teachers." *School science and mathematics* 117, no. 7-8 (2017): 307-316. https://doi.org/10.1111/ssm.12248
[71] Ciosek, Marianna, and Maria Samborska. "A false belief about fractions–What is its source?." *The Journal of Mathematical Behavior* 42 (2016): 20-32. https://doi.org/10.1016/j.jmathb.2016.02.001

[72] Schnittka, Christine, and Randy Bell. "Engineering design and conceptual change in science: Addressing thermal energy and heat transfer in eighth grade." *International Journal of Science Education* 33, no. 13 (2011): 1861-1887. https://doi.org/10.1080/09500693.2010.529177
[73] Nandiyanto, Asep Bayu Dani, et al. "Experimental demonstration for enhancing vocational students' comprehension on heat transfer through conduction and radiation of light bulb." *Journal of Technical Education and Training* 12, no. 3 (2020): 189-195.
[74] Mahmuddin, Mahmuddin. "Karakteristik Perpindahan Panas Pada Pipa Penukar Kalor Selongsong Aliran Searah Vertikal." *Journal Of Chemical Process Engineering* 1, no. 2 (2016): 30-35. https://doi.org/10.33536/jcpe.v1i2.68
[75] Puspawan, Angky, Mirza Aditya Pangestu, Agus Suandi, and A. Sofwan Furqon Alqaf. "The heat transfer flow analysis of standard plate stell of JIS G3106 Grade SM20B on pre-heating joint web plate I-Girder process case study in PT. Bukaka Teknik Utama, Bogor Regency, West Java Province." *Rekayasa Mekanika* 4, no. 1 (2020): 1-8.
[76] Ciftcioglu, Gokcen A., Fulya Kunter, Gulsah Yilan-Ciftci, and MA Neset Kadirgan. "The Importance of Daily Life Phenomena in Chemical Engineering Education." *International Journal of Information and Education Technology* 7, no. 11 (2017). https://doi.org/10.18178/ijiet.2017.7.11.982
[77] Giddings, Steven B. "Hawking radiation, the Stefan–Boltzmann law, and unitarization." *Physics Letters B* 754 (2016): 39-42. https://doi.org/10.1016/j.physletb.2015.12.076
[78] Alaria, Saly Windy Irene, Aswin Hermanus Mandolang, and Patricia Mardiana Silangen. "Penerapan guided discovery learning untuk meningkatkan hasil belajar siswa materi perpindahan kalor." *Charm Sains: Jurnal Pendidikan Fisika* 4, no. 2 (2023): 63-69. https://doi.org/10.53682/charmsains.v4i2.246
[79] Wan, Junchi. "The heat transfer coefficient predictions in engineering applications." *Journal of Physics: Conference Series* 2108, no. 1 (2021). https://doi.org/10.1088/1742-6596/2108/1/012022
[80] Hegana, Mr Vishal, and Mr PR Kulkarni. "Review of Natural Convection Heat Transfer From Different Configuration of Horizontal Rectangular Fin Arrays." *International Journal of Innovations in Engineering Research and Technology*: 1-4.
[81] Andrew, Ogie Nosa, and Joel Oluwayomi Oyejide. "Comparative Analysis of Free Natural Convection Heat Transfer on Rectangular and Triangular Fins with and without Perforation." *European Journal of Engineering and Technology Research* 3, no. 5 (2018): 60-64. https://doi.org/10.24018/ejeng.2018.3.5.740
[82] Riupassa, Helen, Suyatno Suyatno, and Abraham Bayani. "Analisis perpindahan panas pada heat exchanger tipe T147D menggunakan sirip duri bentuk kerucut." *Jurnal Teknik Mesin* 6, no. 2 (2017): 63-75.
[83] Michaleris, Panagiotis. "Modeling metal deposition in heat transfer analyses of additive manufacturing processes." *Finite Elements in Analysis and Design* 86 (2014): 51-60. https://doi.org/10.1016/j.finel.2014.04.003
[84] Jaivignesh, J., Sachin Menon, Shyam Gadhwala, Vishnu Prakash, Basil Punnus, Akhil Kandunoori, Pratap Babu, Reshma Sreekumar, Ankit Gokul Govind, and Praveen Kumar. "Study of one dimensional conduction heat transfer for constant thermal conductivity through composite plane slab and in cylinder at steady state condition." *Technology* 8, no. 11 (2017): 456-465.
[85] Wijaya, Rizza, and Budi Hariono. "Analysis Of Heat Transfer Evaporationprocess For Making Ants Sugar Made Fromfresh Raw Neera." *Proceeding of the 1st International Conference on Food and Agriculture* 2 (2019).
[86] Thanda, Aye. "Theoretical and Numerical Analysis of Conduction Heat Transfer by Steady State Condition." *International Journal For Innovative Research In Multidisciplinary Field* 5, no. 8 (2019): 297-300.
[87] Budiana, Eko Prasetya, and Zainal Arifin. "Simulasi Perpindahan Panas Konduksi Pada Pengelasan Logam Tak Sejenis Antara Baja Tahan Karat Aisi 304 Dan Baja Karbon Rendah SS 400 Dengan Metode Beda Hingga." *Mekanika* 9, no. 1 (2010).
[88] Hrma, Pavel, Richard Pokorny, SeungMin Lee, and Albert A. Kruger. "Heat transfer from glass melt to cold cap: melting rate correlation equation." *International Journal of Applied Glass Science* 10, no. 2 (2019): 143-150. https://doi.org/10.1111/ijag.12666
[89] Akbar, Ronald, A. S. Pamitran, and J. T. Oh. "Two-phase flow boiling heat transfer coefficient with r290 in horizontal 3 mm diameter mini channel." *Journal of Advanced Research in Experimental Fluid Mechanics and Heat Transfer* 3, no. 1 (2021): 1-8.
[90] WafirulHadi, Mohamad, Titin Trisnadewi, and Nandy Putra. "Thermal management system based on phase change material (PCM) and heat pipe in Lithium-ion electric vehicle batteries." *Journal of Advanced Research in Experimental Fluid Mechanics and Heat Transfer* 3, no. 1 (2021): 26-35.
[91] Sofia, Evi, Nandy Putra, and B. Ali Gunawan. "Evaluation of indirect evaporative cooling performance integrated with finned heat pipe and luffa cylindrica fiber as cooling/wet media." *Journal of Advanced Research in Experimental Fluid Mechanics and Heat Transfer* 3, no. 1 (2021): 16-25.
[92] Akaje, Wasiu, and B. I. Olajuwon. "Impacts of Nonlinear thermal radiation on a stagnation point of an aligned MHD Casson nanofluid flow with Thompson and Troian slip boundary condition." *Journal of Advanced Research in Experimental Fluid Mechanics and Heat Transfer* 6, no. 1 (2021): 1-15.

[93] Oo, Ye Min, Makatar Wae-hayee, and Chayut Nuntadusit. "Experimental and numerical study on the effect of teardrop dimple/protrusion spacing on flow structure and heat transfer characteristics." *Journal of Advanced Research in Experimental Fluid Mechanics and Heat Transfer* 2, no. 1 (2020): 17-32.
[94] Keen, Lee Yoke. "Computational Investigation of Heat Transfer of Nanofluids in Domestic Water Heat Exchanger." *Journal of Advanced Research Design* 84, no. 1 (2021): 1-11.
[95] Muhammad, Nura Mu'az, and Nor Azwadi Che Sidik. "Utilisation of nanofluids in minichannel for heat transfer and fluid flow augmentation." *Journal of Advanced Research Design* 50, no. 1 (2018): 18-45.
[96] Rohaizan, Muhammad Hazeer Khiralsaleh Mohamad, Nor Azwadi Che Sidik, and Kamyar Shameli. "Numerical Analysis of Heat Transfer in Microchannel Heat Transfer in Microchannel Heat Sink using Flow Disruption." *Journal of Advanced Research Design* 106, no. 1 (2023): 1-14. https://doi.org/10.37934/ard.106.1.114
[97] Hong Wei Xian, Nor Azwadi Bin Che Sidik, and M'hamed Beriache. 2023. "Heat Transfer Performance of Hybrid Nanofluid As Nanocoolant in Automobile Radiator System". *Journal of Advanced Research Design* 51 (1):14-25.
[98] Abd Halim, Muhammad Ashraf, Nor Azwadi Che Sidik, and Kamyar Shameli. "Heat Transfer Analysis in Microchannel Heatsink by Using Different Nanoparticle Concentration of h-BN." *Journal of Advanced Research Design* 82, no. 1 (2021): 1-14.
[99] Ojose, Bobby. "Mathematics literacy: Are we able to put the mathematics we learn into everyday use?." *Journal of mathematics education* 4, no. 1 (2023).
[100] OECD. "Mathematical Literacy." *OECD Publishing*. (2013).
[101] De Lange, Jan. "Mathematical literacy for living from OECD-PISA perspective." *Tsukuba Journal of Educational Study in Mathematics* 25 (2006): 13-35.
[102] OECD. "*PISA 2018 Assessment and Analitycal Framework*." *OECD Publishing*. (2018).
[103] Heyd-Metzuyanim, Einat, Aviv J. Sharon, and Ayelet Baram-Tsabari. "Mathematical media literacy in the COVID-19 pandemic and its relation to school mathematics education." *Educational Studies in Mathematics* 108, no. 1 (2021): 201-225. https://doi.org/10.1007/s10649-021-10075-8
[104] Hayati, Tri Rahmah, and Kamid Kamid. "Analysis of mathematical literacy processes in high school students." *International Journal of Trends in Mathematics Education Research* 2, no. 3 (2019): 116-119. https://doi.org/10.33122/ijtmer.v2i3.70
[105] Yesika, Simarmata, Wedyawati Nelly, and Sri Rejeki Hutagaol Anita. "Analisis literasi matematika pada penyelesaian soal cerita siswa kelas V sekolah dasar." *J-PiMat* 2, no. 1 (2020): 100-105. https://doi.org/10.31932/j-pimat.v2i1.654