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How to Teach Fraction for Empowering Student Mathematics Literacy: Definition, Bibliometric, and Application Using Digital Module

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ABSTRACT

This research explored how to teach fractions and investigate mathematics literacy in fractions of students through realistic mathematics education assisted by digital modules based on the level of self-regulated learning in elementary school. This research employed a quantitative study using a factorial design. The students who participated were 48 fifth-grade students in one of an elementary school in Bandung, Indonesia. Mathematics literacy tests and self-regulated questionnaires were taken in collecting the research data. The data were analyzed using a two-way ANOVA test. The results revealed that the teaching stage of fraction consists of two methods. There is a difference in mathematics literacy between students who learn using realistic mathematics education assisted by digital modules and students who learn using a scientific approach based on the level of self-regulated learning. These results have implications for future learning to empower mathematics literacy on fractions through integrating technology into learning activities.

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1. INTRODUCTION

Fraction as a part of numbers is one of the mathematical topics that should be mastered by students in elementary school. Fractions are a fundamental element of elementary mathematics that helps students understand parts of a whole and improve their skills in numerical calculations. Fractions are characterized as a ratio or division of two whole numbers, involving a numerator and a denominator, which makes them more complex than a single whole number [1]. Through understanding the fraction, students can solve the problem related to the fraction contents. Moreover, fractions are not only used in mathematics subjects, but also it was found in other subjects such as language, economy, and others.

Technology in education can help students in mastering mathematical concepts, such as fractions. The digital module is one of the technology products designed systematically and attractively to encompass materials, methodologies, constraints, and evaluation methods electronically. The digital module comprises educational resources encompassing learning objectives or competencies within each learning activity, material, summary, and structured assessment [2]. The advantage of digital 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 [3].

A comprehensive overview of prior research on technology in mathematics education is presented in **Table 1**.

Table 1. Research on technology in mathematics education.

No	Title	Reference
1.	Learning to think mathematically: Problem-solving, metacognition, and sense-making in mathematics (Reprint)	[4]
2.	Online learning: A panacea in the time of COVID-19 crisis	[5]
3.	Gamification in education: A systematic mapping study	[6]
4.	A conceptual framework for integrated STEM education	[7]
5.	Defining computational thinking for mathematics and Science Classrooms	[8]
6.	Teaching and learning with technology: Effectiveness of ICT integration in schools	[9]
7.	Adapting to online teaching during COVID-19 school closure: teacher education and teacher competence effects among early career teachers in Germany	[10]
8.	Blended learning: the new normal and emerging technologies	[11]
9.	Education in the era of generative artificial intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning	[12]
10.	COVID-19 and teacher education: a literature review of online teaching and learning practices	[13]

Mathematics literacy is the ability to formulate, use, and interpret mathematical concepts in various contexts. For example, mathematics literacy on fractions, and understanding the units or whole numbers associated with fractions in the context of multiplying and dividing fractions is key to understanding the concept well [14]. Mathematics literacy is closely connected to various other factors and skills. Numerous past studies have explored the mathematics literacy of students in different affective aspects [15, 16]. Self-regulated learning is the capacity of an individual to control their emotions, behavior, and focus in socially appropriate ways to achieve positive outcomes, such as fostering healthy relationships, enhancing learning, and ensuring overall well-being [17]. Students who can manage their

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learning effectively gain the most benefit from their education, as their actions are driven by a desire for learning rather than by external rewards [18].

This research aims to explore how to teach fractions and investigate the mathematics literacy of students through realistic mathematics education assisted by digital modules based on the level of self-regulated learning in elementary school. The collected research data focuses on the mathematics literacy of students, particularly within the context of fraction and self-regulated learning of students. Several previous studies have been conducted regarding increasing mathematics literacy through various learning approaches, including research on the implementation of realistic mathematics education for mathematics literacy of students [19-21]. However, these previous studies still focused on increasing mathematics literacy through the implementation of learning approaches. These previous studies have not integrated the use of technology such as digital modules in the learning activity to increase the mathematics literacy of students.

Figure 1 illustrates the network visualization of research related to mathematics literacy in elementary schools. The data was sourced from our earlier study [22].

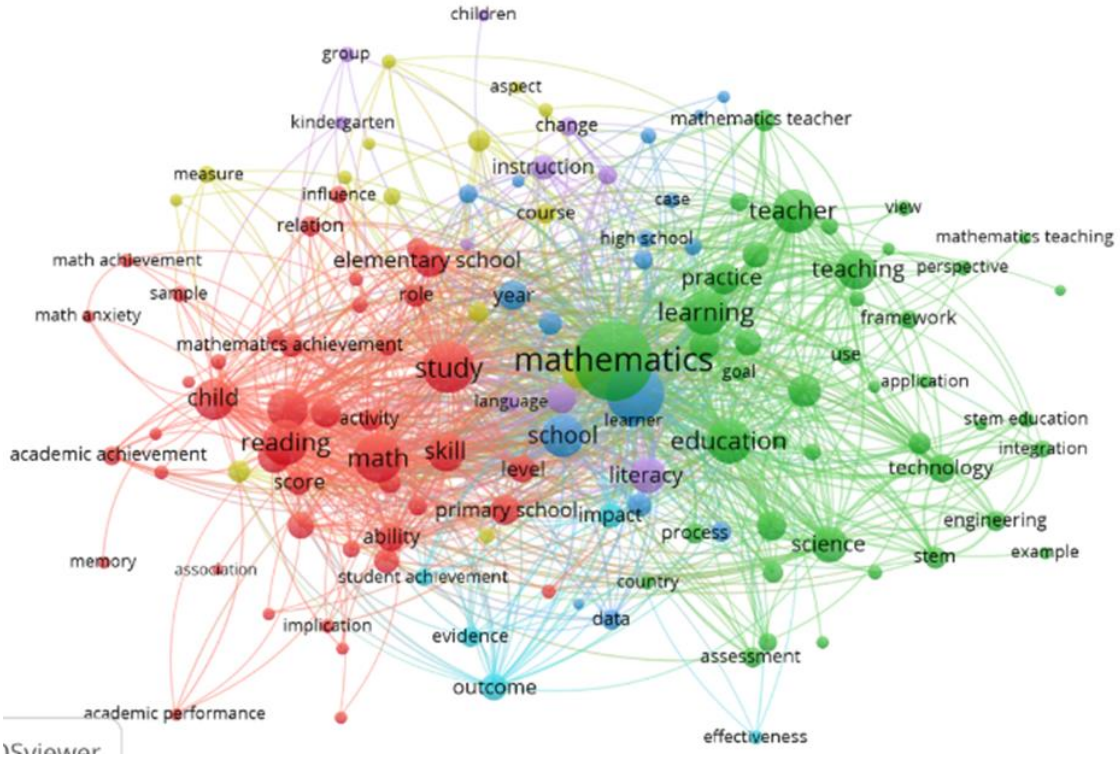

Figure 1. Network visualization based on co-occurrence of terms [23].

The novelties in this research are (i) this study explores how to teach fractions using two methods, (ii) this study examines the mathematics literacy of students using realistic mathematics education assisted by digital modules based on the level of self-regulated learning in elementary school, and (iii) this study finds the next future research.

2. LITERATURE REVIEW

2.1. Fraction

Fractions in mathematics have some interpretations including part-whole, measure, operator, quotient, and ratios [24]. While fractions reflect numerical relationships and quantities, the decimal equivalent of quantities loses the relational structure inherent in fractions, and more directly expresses one-dimensional value [25]. Many reports regarding

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fractions have been published [26]. **Figure 2** shows the representation of fractions as a part-whole.

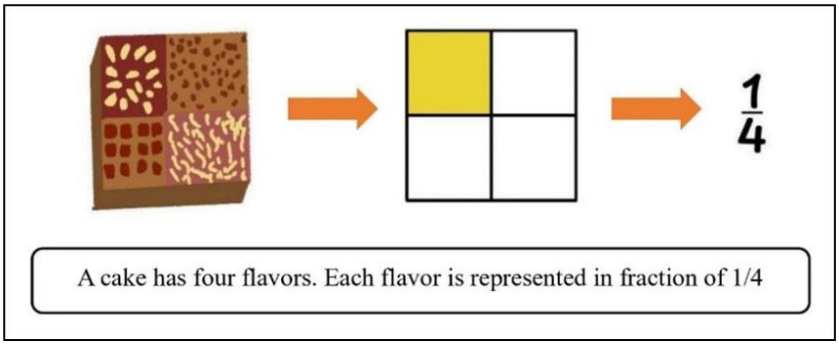

Figure 2. Representation of fractions as a part-whole.

In addition, fractions also can be represented as a measure [24]. **Figure 3** shows the representation of fractions as a measure.

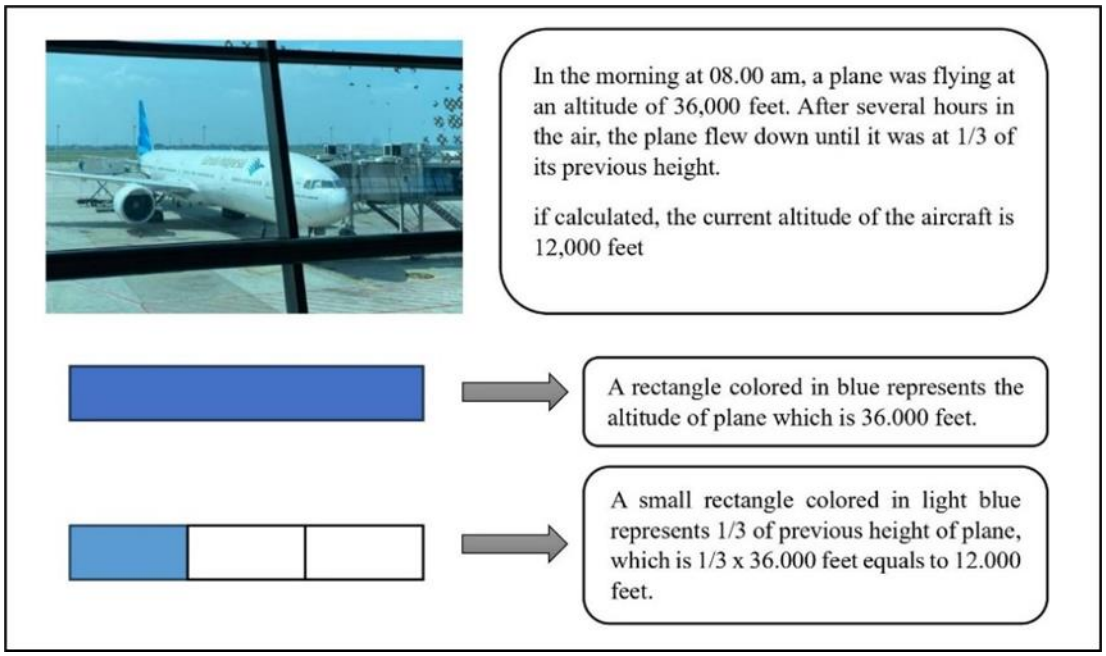

Figure 3. Representation of fractions as a measure.

Fractions are a fundamental principle in basic mathematics, which helps in understanding the parts of a whole and promotes numerical calculation skills. Fractions provide students with the first opportunity to gain an understanding of the concept of expressing relationships between quantities [25]. Having a strong understanding of fractions at the elementary school level is associated with improved math achievement at the higher grade levels [27].

Providing a detailed and structured definition of fractions is crucial in supporting the learning process. Introducing fractions early in elementary education can lay the foundation for understanding more complex math concepts at later grade levels. Understanding the concept of fraction relationships can help students gain an implicit understanding of general regularities such as the associative property [25]. For example, in the addition of 2/4 + 1/2, a student might argue that 2/4 is the same as 1/4 + 1/4. Exploration of the concept of part and whole in fractions can be represented through food, for example, half, quarter [28].

Table 2 shows numerous studies related to learning to enhance students' understanding of fractions.

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Table 2. Research fractions on education.

No	Title	Reference
1.	Effects of COVID-19 on college student's mental health in the United States: Interview survey study	[29]
2.	When should you adjust standard errors for clustering?	[30]
3.	ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?	[31]
4.	Introduction to radiomics	[32]
5.	Benefits, limits, and risks of GPT-4 as an AI chatbot for medicine	[33]
6.	How financial literacy and impatience shape retirement wealth and investment behaviors	[34]
7.	The effect of educational games on learning outcomes, student motivation, engagement and satisfaction	[35]
8..	Teacher mentoring in service of preservice teachers' learning to teach: Conceptual bases, characteristics, and challenges for teacher education reform.	[36]
9.	Do school spending cuts matter? Evidence from the Great Recession	[37]
10.	Investigating special education teachers' knowledge and skills: Preparing general teacher preparation for professional development	[38]

2.2. Mathematics Literacy on Fraction

Mathematics literacy is the ability to understand, analyze, interpret, assess, and integrate information from a given problem, then translate it into a mathematical model, and find the solution through the effective application of mathematical concepts [39]. Mathematics literacy provides individuals with awareness and understanding of the contribution of mathematics to everyday life [40]. A person with mathematics literacy is capable of making estimates, interpreting data, addressing everyday problems, reasoning in numerical, graphical, and geometric contexts, and using mathematics to communicate [41].

The indicators for assessing mathematics literacy, based on the PISA (Programme for International Student Assessment) framework include (1) formulating the situation into a mathematical form, (2) applying mathematical concepts, facts, procedures, and reasoning, and (3) interpreting, applying, and evaluating mathematical outcomes. Cultivating mathematics literacy allows students to approach problems mathematically, applying mathematical concepts and methods across various contexts and situations [39]. **Figure 4** shows the mathematics literacy in fractions concept.

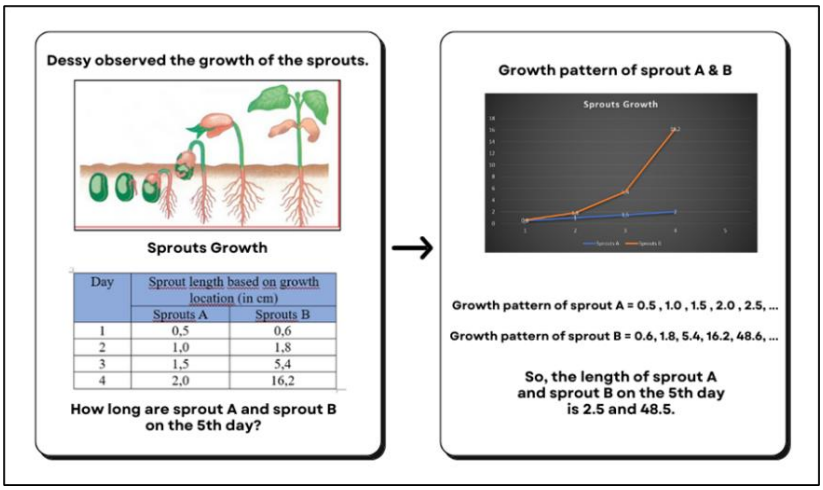

Figure 4. Mathematics literacy in the operation of decimals.

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Table 3 shows numerous studies related to the mathematics literacy of fractions. Previous studies have been conducted regarding mathematics literacy on fractions. However, most studies focus on mathematics literacy and learning activity in general. It is limited to exploring in detail related to mathematics literacy on fractions, especially for elementary students.

Table 3. Research of mathematics literacy on fractions.

No	Title	Reference
1.	Financial education and student financial literacy: A cross-country analysis using PISA 2012 data	[42]
2.	Evaluating the effectiveness and insights of preservice elementary teachers' abilities to construct word problems for fraction multiplication	[43]
3.	The effectiveness of using problem-based learning (PBL) in mathematics problem-solving ability for junior high school students	[44]
4.	Development of Instrument numeracy skills test of minimum competency assessment (MCA) in Indonesia	[45]
5.	Food for thought?: Experimental evidence on the learning impacts of a large-scale school feeding program	[46]
6.	Just do it! Study time increases mathematical achievement scores for grade 4-10 students in a large longitudinal cross-country study.	[47]
7.	An analysis of the interaction between mathematical literacy and financial literacy in PISA	[48]
8.	Relations among phonological processing skills and mathematics in children: A meta-analysis	[49]
9.	An ePub learning module and students' mathematical reasoning ability: A development study	[50]
10.	Personalised and adaptive learning: Emerging learning platforms in the era of digital and smart learning	[51]

2.3. Correlation of Mathematics Literacy on Fraction and Self-Regulated Learning

Self-regulated learning is characterized by an individual's proactive engagement in overseeing their learning process. This ability involves systematically directing and monitoring their cognition, motivation, and behavior to achieve their learning objectives [52, 53, 54]. The characteristics of self-regulated learning include being active and constructive, having goals to be achieved, using metacognition, motivation, and systematic behavior, having learning strategies, reflecting on learning outcomes, and having a self-oriented feedback cycle [53, 55, 56]. **Figure 5** shows the self-regulated learning phase.

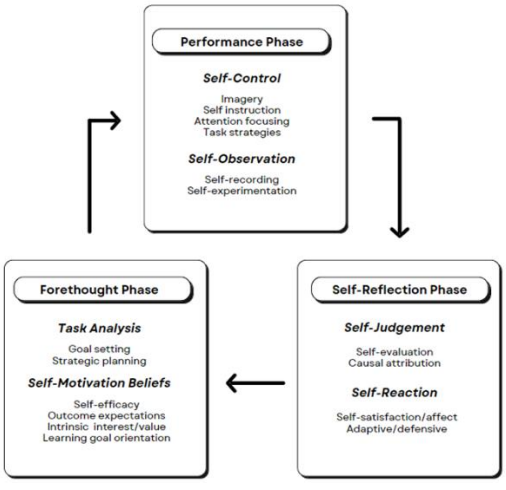

Figure 5. Self-regulated learning phase [54].

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Table 4 shows numerous studies related to self-regulated learning and mathematics literacy on fractions. Most studies still focus on self-regulated in general. It is limited to exploring in detail related to the correlation between self-regulated learning and mathematics literacy on fractions.

Table 4. Research of self-regulated learning and mathematics literacy on fractions.

No	Title	Reference
1.	Student engagement in online learning in Latin American higher education during the COVID-19 pandemic: A systematic review	[57]
2.	Self–efficacy and Student Satisfaction in the Context of blended learning courses	[58]
3.	Academia's responses to crisis: A bibliometric analysis of literature on online learning in higher education during COVID-19	[59]
4.	The application of AI technologies in STEM education: a systematic review from 2011 to 2021	[60]
5.	Transitioning to online teaching during the COVID-19 pandemic: An exploration of STEM teachers' views, successes, and challenges	[61]
6.	Achievement emotions and academic achievement: Reciprocal relations and the moderating influence of academic buoyancy.	[62]
7.	Cognitive appraisals, achievement emotions, and students' math achievement: A longitudinal analysis.	[63]
8.	The university students' self-regulated effort, flexibility, and satisfaction with distance education	[64]
9.	“This weird time we're in”: How a sudden change to remote education impacted college students' self-regulated learning.	[65]
10.	Self-efficacy and language learning–what it is and what it isn't	[66]

2.4. Using Digital Module in Realistic Mathematics Education Approach for Mathematics Literacy on Fraction

Digital modules can help students through realistic mathematics education. The advantage of digital modules 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 [3]. Based on the characteristics of the module, 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 on fractions.

Different from the previous modules, in this research the digital module consisted of the guidelines for using the module, materials of fraction concepts, exercise for mathematics literacy, worksheet of student activity, assessment, and summary. **Figure 6** shows the digital module for fractions.

Besides using digital modules, there is a need to use appropriate learning approaches that can support mathematics literacy achievements. Realistic mathematics education is a learning approach that encourages students to understand mathematical concepts through their relationship to real or contextual situations [67]. The term realistic in realistic mathematics education also has a broader connotation, where realistic can also be interpreted as a problem situation that students can imagine [68]. Realistic situations are also used as a learning resource for mathematical concepts. Realistic situations act as a source for developing mathematical concepts, tools, and procedures, and function as a framework for students to apply mathematical knowledge which gradually develops to become more formal

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and universal [68]. Moreover, the principles of realistic mathematics education can be described in **Figure 7** [68].

Figure 6. The digital module for fractions.

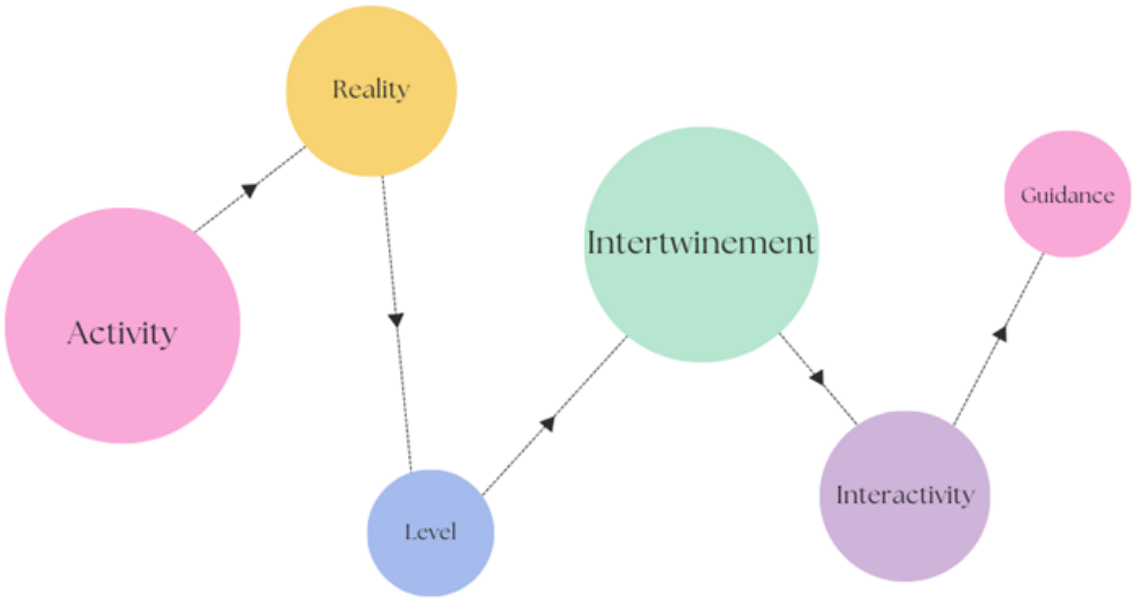

Figure 7. Principles of Realistic Mathematics Education (RME).

There are five distinctive characteristics specifically associated with realistic mathematics education, consisting of (1) utilizing meaningful context, (2) building models to ease the transition from real contexts to more formal mathematical concepts, (3) engaging in rediscovery of mathematical concepts, (4) there is interaction between students and teachers, and (5) viewing mathematics as connected subjects [69]. **Table 5** shows numerous studies related to learning using digital modules as learning materials.

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Table 5. Research on digital modules in education.

No	Title	Reference
1.	Application of gamification tools for identification of neurocognitive and social function in distance learning education	[70]
2.	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	[22]
3.	Determination of the needs of students by psychological and pedagogical teaching tools using remote technologies	[71]
4.	A systematic review on trends in using Moodle for teaching and learning	[72]
5.	Pros and cons of computer technologies in education	[73]
6.	Empowering teachers: Integrating technology into livelihood education for a digital future	[74]
7.	Artificial intelligence in education: AIEd for personalised learning pathways	[75]
8.	Flipped classrooms in higher education during the COVID-19 pandemic: findings and future research recommendations	[76]
9.	Using digital technology to promote higher education learning: The importance of different learning activities and their relations to learning outcomes	[77]
10.	Effectiveness of virtual reality and interactive simulators on dental education outcomes: systematic review	[78]

2.5. Research Trends of Digital Module and Mathematics Literacy on Fractions

The research trends of the digital module and mathematics literacy in elementary school were obtained from the publication data of Google Scholar. The results were found that 994 data articles obtained from Google Scholar related to the research criteria. Based on the results, the number of article citations is 30.278. The number of citations per year is 3027.80, the number of citations per article is 30.28, the average author in the articles used is 2.82, all articles have an average h-index is 78, and the g-index is 137. **Figure 8** describes the research trends of digital modules and mathematics literacy through article publications from 2014 to 2024. According to data, research trends on digital modules and mathematics literacy are volatile and it has decreased from 2022 until now.

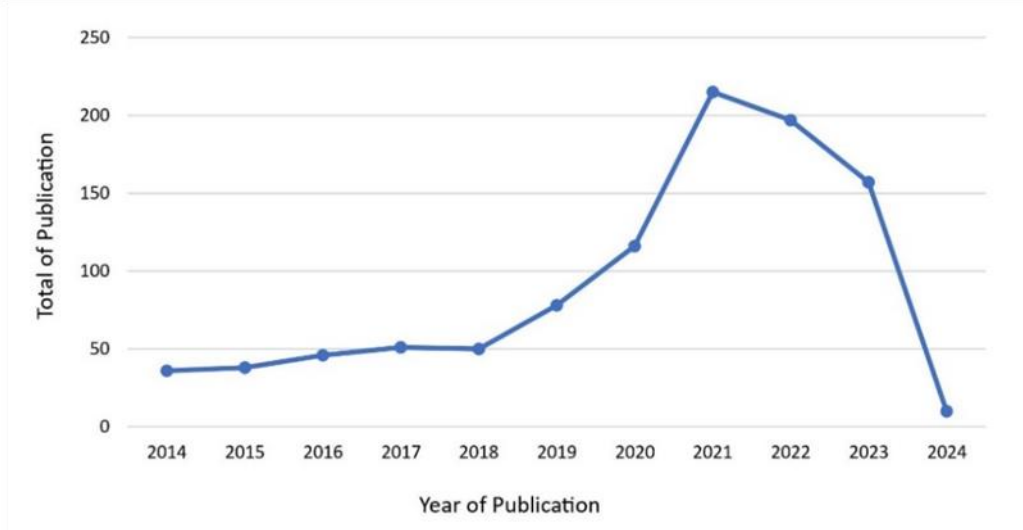

Figure 8. Digital module and mathematics literacy research trends.

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Figure 9 shows that the terms module, digital module, and e-module have a connection. They are also connected to mathematics, education, learning, and scientific approaches. It means that from 2014 to 2024 research about digital modules has been conducted although there is no direct connection to the term of mathematics literacy. This means that the research published on the relationship between mathematics literacy and digital modules is still limited to be researched.

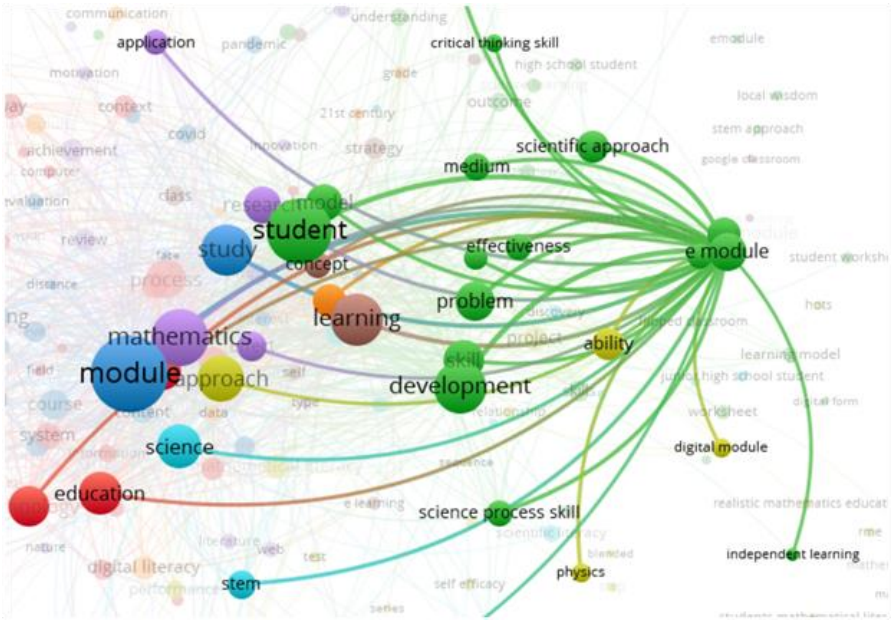

Figure 9. Digital module research trends by VOSviewer.

3. METHODS

This research employed a quantitative study using a 3 x 2 factorial design to explore how to teach fractions and to investigate the mathematics literacy of students using realistic mathematics education assisted by digital modules based on the level of self-regulated learning in elementary school. Moreover, the research procedure can be described in **Figure 10**.

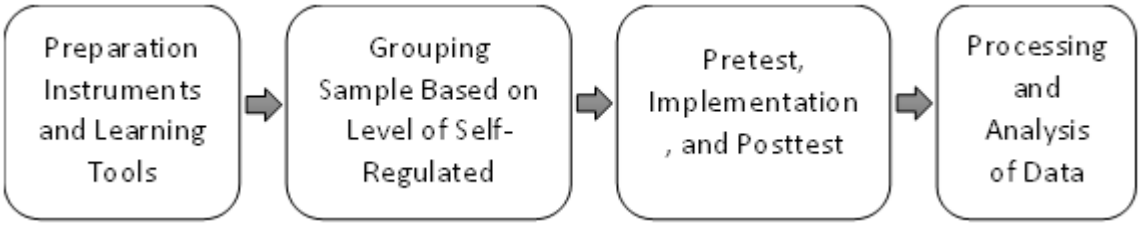

Figure 10. Research procedure.

The research process began with the planning and preparation stages. What the researcher did at this stage was to prepare and plan before the researcher collected research data which consists of designing research instruments and designing learning tools. The next stage was selecting samples and grouping them based on the level of self-regulated learning. The research implementation was done by collecting data by giving a mathematics literacy pretest to determine the initial mathematics literacy abilities of students. In experimental class, I received learning using realistic mathematics education assisted by digital modules. Experimental class II received learning using a scientific approach. Next, the researchers

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conducted a mathematics literacy post-test to obtain the final mathematics literacy abilities of students. Then, the research data were analyzed through quantitative data analysis.

The research participants consisted of 48 fifth-grade students in one elementary school in Bandung, Indonesia. The data collection used mathematics literacy tests and self-regulated learning questionnaires. The test instrument used is the mathematics literacy test which is carried out at the beginning (pretest) and the end after receiving the learning activity (post-test). The indicators of the mathematics literacy test consist of formulating the situation mathematically, using mathematical concepts, facts, procedures, and reasoning, and interpreting, applying, and evaluating mathematical results. The self-regulated learning questionnaires are employed to assess students' levels of self-regulated learning. The indicators of self-regulated learning questionnaires consist of cognitive, motivational, and behavioral aspects.

Data processing was carried out using post-test scores and two-way ANOVA results. The researchers examined the data to assess the effect of realistic mathematics education assisted by digital module interventions on the mathematics literacy of students, compared to the scientific approach. The two-way ANOVA was used to evaluate the statistical significance of the differences in post-test results between the two groups.

4. RESULTS AND DISCUSSION

4.1. Teaching Fractions Using Conventional Method

Teaching fractions through conventional methods can be done by using directly formal mathematics. The teacher gives an example of a fraction problem for a student, for example, "The teacher brought a cake in front of the class. The teacher gave $\frac{1}{2}$ of the cake to a girl student and $\frac{1}{3}$ of the cake to a boy student. How many parts of the cake did the teacher give to the girl student and boy student?". To solve the problem, the teacher allows students to use directly formal mathematics. The step of teaching addition operations of fractions using conventional methods for students is as follows.

(i) Making mathematical symbols of the problem situation, to find how many parts of the cake the teacher gave to the girl student and boy student, students are fostered to write the addition operation, such as $\frac{1}{2} + \frac{1}{3} = \ldots$

(ii) Encouraging students to equate the denominators of the two fractions above by finding the Least Common Multiple, for example, the Least Common Multiple of 2 and 3 as follows.
2: 2, 4, 6, 8, ….
3: 3, 6, 9, 12, ….
the Least Common Multiple of 2 and 3 is 6.

(iii) Students are fostered to write the addition operation of the fractions, as follows:
$\frac{1}{2} + \frac{1}{3} = \frac{\ldots\ldots}{6} + \frac{\ldots\ldots}{6}$

(iv) Completing the addition of fractions, we can do the following.
$\frac{1}{2} + \frac{1}{3} = \frac{\ldots\ldots}{6} + \frac{\ldots\ldots}{6} = \frac{1\ x\ 3}{6} + \frac{1\ x\ 2}{6} = \frac{3}{6} + \frac{2}{6} = \frac{5}{6}$

(v) Concluding the answer, the teacher gives $\frac{5}{6}$ of cake to girl student and boy student.

4.2. Teaching Fractions using Realistic Mathematics Education (RME)

4.2.1. Preparation stage

In the preparation stage, two steps were taken as follows.

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(i) Choose the real context of mathematics situations in daily life related to fractions, teaching mathematics concepts such as fractions should be started from the real context of mathematics situations. The real context has an essential role as a bridge for students to understand formal mathematics in school. To teach the concept of fractions, the teacher can use the real context as follows.
   (a) Contextual situation for teaching the basic concept of fractions, for example, "A father bought a cake at the market. The cake was divided into two equal portions for the daughter and son. How big was each piece of cake that the daughter and son got?". The student response is expected the daughter got "half" of the cake and the son got "half" of the cake".
   (b) Contextual situation for teaching the addition of fractions, for example, "A son brought a cake containing 4 types of flavors, namely Oreo flavor, cheese flavor, peanut flavor, and chocolate flavor. He gives some parts of the cake to his mother and father. The mother ate the peanut-flavored cake. The father ate the Oreo-flavored cake. How many parts of cake did the mother and father eat?". The student's response is expected they can predict how many parts of cake the mother ate and how many parts of cake the father ate. Then, they can do the addition of fractions.
   (c) Contextual situation for teaching the subtraction of fractions, for example, "A girl has a yellow ribbon that is 5/6 meters long. She uses a 1/6 meter long yellow ribbon to cover the photo frame. How much yellow ribbon does the girl have left?". The student response is expected that they can do the subtraction of the girl's yellow ribbon that is 5/6 meters long and 1/6 meter long yellow ribbon used to cover the photo frame.
   (d) Contextual situation for teaching the multiplication of fractions, for example, "A boy keeps a cake in the refrigerator. On Monday, he eats 1/6 of the cake. The next day, Tuesday, he eats another 1/6 of the cake. Finally, on Wednesday, he also eats 1/6 of the cake. How many pieces of cake did the boy eat from Monday to Wednesday?". The student responds that they can do the multiplication between 1/6 of the cake and 3 days that he ate the cake.
   (e) Contextual situation for teaching the division of fractions, for example, "A girl has 2 meters of ribbon. She will use it to decorate a gift. 1 gift requires 1/4 m of ribbon. How many gifts can she decorate?". The student response is expected that they can divide 2 meters of ribbon and 1/4 meter of ribbon for 1 gift.
   (f) Contextual situation for teaching decimals, for example, "A garden is divided into several plots with black lines until it contains 10 plots. Can we show which is 1/10 of the garden? Let's color 1/10 of the garden". The student response is expected they color 1/10 of the garden and connect to the decimal of 0,1.

(ii) Find the right media to teach fractions, the teacher can use the learning media as follows.
   (a) Learning media for teaching the basic concept of fractions, for example using a cake can represent the concept of 1/2, 1/3, 1/4, etc in **Figure 11**.

Figure 11. Learning media for teaching the basic concept of fractions.

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(b) Learning media for teaching the addition and subtraction of fractions, for example using a cake with some flavors can represent the addition and subtraction of fractions in **Figure 12**.

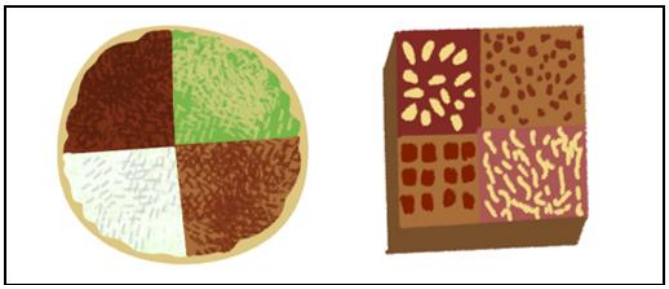

Figure 12. Learning media for teaching the addition and subtraction of fractions.

(c) Learning media for teaching the multiplication and division of fractions, for example using a set of cars in the parking area and a set of pencils, etc in **Figure 13**.

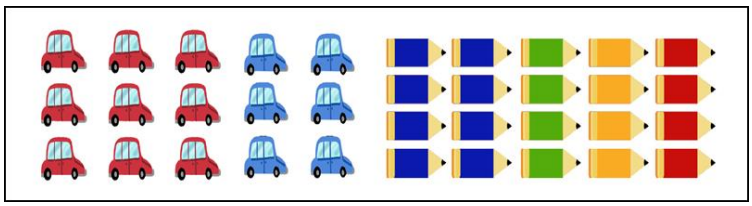

Figure 13. Learning media for teaching the multiplication and division of fractions.

4.2.2. Teaching fraction stage of addition of fractions

In teaching the fraction stage of addition of fractions, several steps were taken as follows.

(i) Providing the contextual situation, the teacher provides the contextual situation to foster students related to the understanding of addition of fractions. An example of a contextual situation on addition fractions is as follows: "The teacher brought a cake in front of the class. The teacher gave $\frac{1}{2}$ of the cake to a female student and $\frac{1}{3}$ of the cake to a boy student. How many parts of the cake did the teacher give to the girl and boy students?". Some students may respond that they need to add up. $\frac{1}{2}$ of the cake to the female student and $\frac{1}{3}$ of the cake to the boy student. Another student may formulate the problem in formal mathematics such as $\frac{1}{2} + \frac{1}{3} = \ldots$

(ii) Demonstrating the fraction concept using mathematical modeling, a cake can be used to demonstrate the parts of the cake of the girl and boy students. Students with the guiding from the teacher divide the cake into some parts in **Figure 14**.

Figure 14. Mathematical modeling for teaching addition of fractions.

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(iii) Constructing the knowledge, students make a representation from the mathematical modeling to the addition of fractions. Students try to represent that cake by drawing it and coloring which parts of the cake of the girl and boy student, described in **Figure 15**. Parts of the cake the teacher gave to the girl and boy students represent $\frac{1}{2} + —$. The dark brown parts show the parts of the girl's cake which can be represented as $\frac{2}{6} = \frac{1}{3}$. The light brown parts show the parts of the boy's cake which can be represented as $\frac{3}{6} = \frac{1}{2}$. The white parts show the remaining cake owned by the teacher which can be represented to $\frac{1}{6}$. If we count the number of dark brown and light brown parts, there are $\frac{5}{6}$ parts.

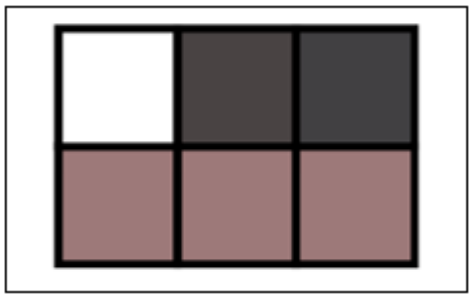

Figure 15. Constructing the knowledge of addition of fractions.

(iv) Building formal mathematical knowledge, the teacher encourages the student to calculate the number of pieces of cake that the teacher gave to the girl and boy student by adding up the pieces of cake given to the girl student and the pieces of cake given to the boy student. The addition of fractions can be formulated to $\frac{2}{6} + \frac{3}{6} = \frac{\ldots\ldots}{6}$. In conclusion, the number of cakes that the teacher gave to the girl and boy students was $\frac{5}{6}$ Parts.

4.3. Teaching Complex Calculation of Fractions

4.3.1. Teaching mix numbers using conventional method

Teaching mixed numbers using conventional methods can be done by teaching using directly formal mathematics. The teacher gives an example of a problem for a student. For example, A girl has $1\frac{1}{2}$ pieces of cake. A boy has $1\frac{2}{3}$ Pieces of cake. If combined, how many cakes will the girl and boy have? The teacher allows students to learn directly about formal mathematics. The step of teaching the addition of mixed numbers using the conventional method for students is as follows.

(i) Making mathematical symbols of the problem situation, to find how many cakes will the girl and boy have, students are fostered to write the addition operation, such as $1\frac{1}{2} + 1\frac{2}{3} = \frac{\ldots\ldots}{\ldots\ldots}$

(ii) Changing the mixed numbers above into fraction form $\frac{a}{b}$.

$1\frac{1}{2} = \frac{3}{2}$

$1\frac{2}{3} = \frac{5}{3}$

(iii) Formulating the addition of mix number: $\frac{3}{2} + \frac{5}{3} = \frac{\ldots\ldots}{\ldots\ldots}$

(iv) Encouraging students to equate the denominators of the two fractions above by finding the Least Common Multiple. Determine the Least Common Multiple of 2 and 3!

2: 2, 4, 6, 8, ….

3 : 3, 6, 9, 12, ….

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the Least Common Multiple of 2 and 3 is 6.

(v) Students are fostered to write the addition operation of the fractions, as follows.
$\frac{3}{2} + \frac{5}{3} = \frac{.....}{6} + \frac{.....}{6}$

(vi) To complete the addition of fractions above, we can do the following.
$\frac{3}{2} + \frac{5}{3} = \frac{.....}{6} + \frac{.....}{6} = \frac{3\ x\ 3}{6} + \frac{2\ x\ 5}{6} = \frac{9}{6} + \frac{10}{6} = \frac{19}{6}$

(vii) Concluding, the total of the girl and boy cakes is $\frac{19}{6}$.

4.3.2. Teaching mix numbers using realistic mathematics education

There are several aspects:

(i) Providing contextual situation, the teacher provides the contextual situation to foster students related to the understanding of the addition of mixed numbers. The example of a contextual situation on addition fraction is as follows: "A girl has $1\frac{1}{2}$ pieces of cake. A boy has $1\frac{2}{3}$ pieces of cake. If combined, how many cakes will the girl and boy have?". Another student may formulate the problem in formal mathematics such as $1\frac{1}{2} + 1\frac{1}{3} = ...$ The students' responses can be the basis for understanding the addition of mixed numbers.

(ii) Demonstrating the mixed number concept using mathematical modeling, a cake can be used to demonstrate the parts of a girl's cake and a boy's cake. Students with the guiding from the teacher divide the cake into some parts described in **Figure 16**.

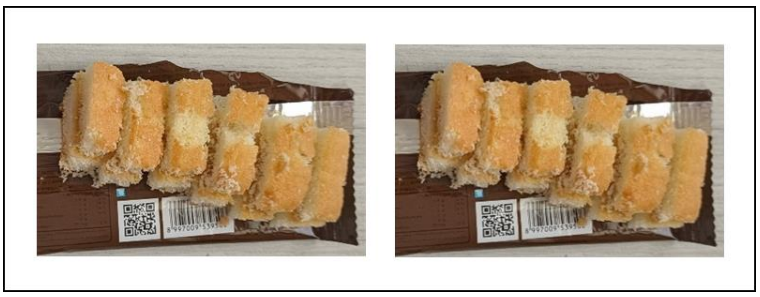

Figure 16. Learning media for teaching addition of fractions.

(iii) Constructing the knowledge, students make a representation from the mathematical modeling to the addition of mixed numbers. Next, students try to represent that cake by drawing that cake and coloring which parts of the girl's and boy's cake. Parts of the cake did the girl and boy have represented $1\frac{1}{2} + 1\frac{1}{3} = ...$ To complete the addition operation, the teacher can do the following in **Figure 17**. The dark brown parts show the parts of the girls's cake which can be represented by $1\frac{1}{2} = \frac{3}{2}$. The light brown parts show the parts of the boy's cake which can be represented by $1\frac{2}{3} = \frac{5}{3}$.

(iv) Building formal mathematical knowledge, we can calculate the number of pieces of cake for the girl and boy. The addition of the mixed number can be formulated as $1\frac{1}{2} + 1\frac{1}{3} = \frac{3}{2} + \frac{5}{3} = \frac{3\ x\ 3}{6} + \frac{2\ x\ 5}{6} = \frac{9}{6} + \frac{10}{6} = \frac{19}{6}$.

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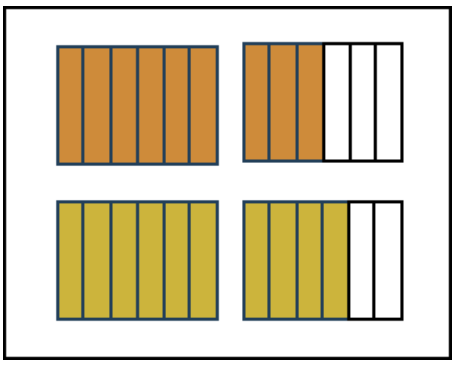

Figure 17. Learning media for teaching addition of mixed numbers.

4.4. Experimental Results

4.4.1. Overview of mathematics literacy on fraction

This research aims to investigate the mathematics literacy of students through realistic mathematics education assisted by digital modules and scientific approaches in elementary school reviewed by the level of self-regulated learning. At this stage, experimental class I received learning using realistic mathematics education assisted by a digital module, and experimental class II received learning using a scientific approach. **Table 6** shows the overview of mathematics literacy on fractions.

Table 6. Overview of mathematics literacy on fractions.

Class	Self-regulated learning	Mean	Std. Deviation	N
Realistic Mathematics	High	88.60	9.737	5
Education Assisted by	Medium	79.33	11.782	15
Digital Module	Low	64.25	12.606	4
	High	80.00	5.933	6
Scientific Approach	Medium	64.31	13.750	13
	Low	59.80	14.550	5

Based on **Table 6**, the descriptive statistics revealed that the average score of mathematics literacy of students who receive realistic mathematics education assisted by digital modules is higher than the average mathematics literacy of students who receive scientific approach. In realistic mathematics education assisted by digital module classes, students with high self-regulated have a higher average of mathematics literacy than students with medium and low self-regulated learning. In line with the class scientific approach, students with high self-regulated have a higher average of mathematics literacy than students with medium and low self-regulated learning.

These results are supported by previous studies. The digital module used in an experimental class has supported the learning process through realistic mathematics education (RME). Previous research showed that achievement and improvement of students' reasoning abilities in mathematics learning using realistic mathematics education (RME) approach is better than conventional learning [79]. The previous study implied that integrating technology in learning through realistic mathematics education (RME) has a significant effect on the mathematics literacy of students.

4.4.2. the differences in mathematics literacy based on learning activity

The two-way ANOVA test was taken to determine whether there is a difference between the score of pretest and post-test in experimental class I and experimental class II or not

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reviewed by the level of self-regulated learning. **Table 7** outlines the two-way ANOVA results of mathematics literacy scores of two groups of students which are the experimental class I and the experimental class II, before the implementation of any interventions or treatments.

Table 7. The differences in mathematics literacy.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4272.127	5	854.425	5.892	0.000
Intercept	198228.158	1	198228.158	1366.899	0.000
Class	820.866	1	820.866	5.660	0.022
SRL	2501.339	2	1250.669	8.624	0.001
Class * SRL	219.873	2	109.937	0.758	0.475

On the two-way ANOVA test, there is hypothesis (H_0) and hypothesis (H_1). Hypothesis (H_0) means there is no difference between the mathematics literacy of students who receive realistic mathematics education assisted by digital modules and the mathematics literacy of students who receive a scientific approach based on the level of self-regulated learning. The hypothesis (H_1) means that there is a difference between the mathematics literacy of students who receive realistic mathematics education assisted by digital modules and the mathematics literacy of students who receive a scientific approach based on the level of self-regulated learning.

Based on decision-making criteria, if (sig.) < 0.05, so H_0 is rejected. The two-way ANOVA test results have been obtained with a significance value of less than 0.05 that is 0.001 which means that there is a difference between the mathematics literacy of students who receive realistic mathematics education assisted by digital modules and mathematics literacy of students who receive scientific approach based on the level of self-regulated learning.

The digital module used in this research has a variety of contents. The digital module consisted of the guidelines for using the module, materials for fraction concepts, exercises for mathematics literacy, student activity worksheets, assessments, and summaries.

The use of digital modules is needed to accommodate student needs and facilitate students learning in the digital era. Technology-based multimedia tutorials such as digital modules can assist students in overcoming the shortcomings of conventional learning and can motivate students to be able to learn independently [80]. The research results show that the learning outcomes of students who use digital modules can obtain comprehension scores in the very good achievement category [81]. Therefore, the use of technology can be integrated into mathematics learning in elementary schools to increase mathematics literacy. **Figure 18** shows the materials of fraction and mathematics literacy in the digital module.

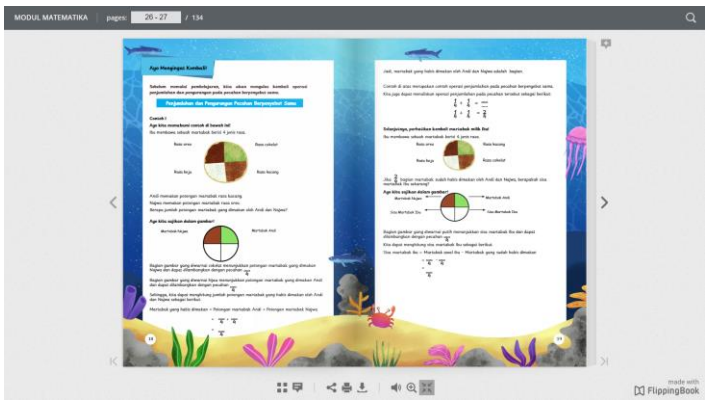

Figure 18. Digital module for mathematics literacy in fraction concepts.

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4.4.3. Overview of self-regulated learning and learning activity

According to the results of the two-way ANOVA test, we can see the correlation between the learning activity of realistic mathematics education assisted by digital modules and scientific approach and self-regulated learning. **Figure 19** shows the correlation between learning activity and self-regulated learning.

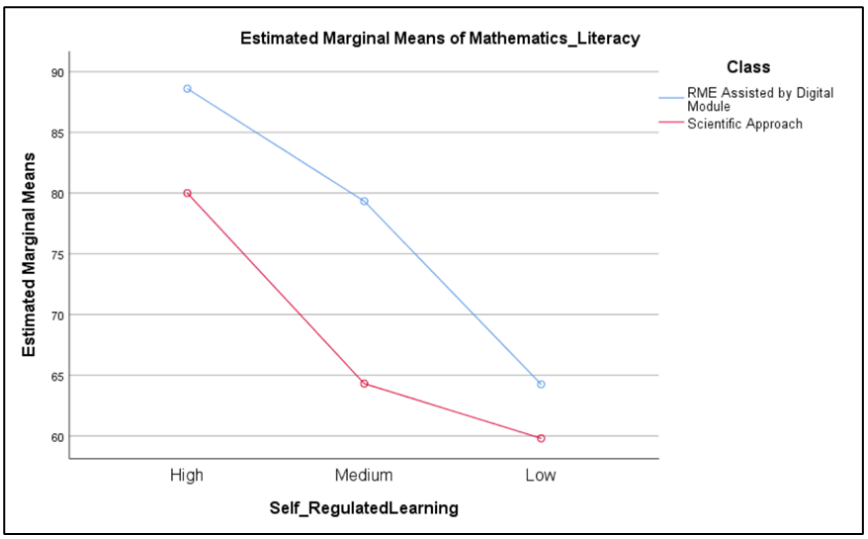

Figure 19. Connection between learning activity and self-regulated learning.

Based on **Figure 19**, there is no correlation between learning activity and self-regulated learning. The two-way ANOVA output in the Class Self-Regulated Learning row has a significance of 0.475 and a score larger than = 0.05. It also means that there is no interaction effect between self-regulated learning and learning activity on the mathematics literacy of students. **Figure 19** reveals how realistic mathematics education assisted by digital modules and a scientific approach is extremely beneficial for students with high levels of self-regulated learning.

In the class of realistic mathematics education assisted by digital module, students with high self-regulated learning outscored students with moderate and low self-regulated learning. Students with moderate levels of self-regulated learning outperformed those with low levels. In the class of scientific approach, students with high self-regulated learning fared better than moderate and low self-regulated learning students. Students with moderate levels of self-regulated learning outperformed those with low levels.

Self-regulated learning plays a pivotal role in academic success [82]. Previous research showed that self-regulated learning significantly impacts academic achievement [83]. Self-regulated learners possess the knowledge, skills, and attitudes needed to achieve the academic goals they set for themselves [84]. The findings reveal that self-regulation was the most significant factor influencing academic success [82]. Students with advanced self-regulated learning (SRL) skills use metacognition, motivation, and self-efficacy to adjust their behavior in order to achieve their learning goals, outcomes, or processes [18]. Students who demonstrated strong self-regulated learning (SRL) skills showed the most positive results, both in their classroom involvement and in their mathematics performance [85].

Technology has been implemented in various context of mathematics learning [83]. This results give a new information for empowering student skills through integrating learning with technology, not only in mathematics learning but also in other fields, as previous research conducted such as:

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(i) Technology in science learning [86, 87, 88]
(ii) Technology in chemistry learning [89, 90, 91]
(iii) Technology in biology learning [92, 93]
(iv) Technology in physics learning [94]
(v) Technology in other field of learning subjects [95, 96, 2, 97, 98, 99, 81]

The results have implications for empowering mathematics literacy through integrating digital module with learning approaches such as RME and scientific approach. Moreover, this research also have some of limitations, consisted of (1) the limitations of the number of sample, (2) limitations of study of other aspects that can affect the mathematics literacy. For future research, This research can be considered for conducting further research related to the application of digital module using other learning approaches and can be viewed from various aspects of different learning styles, levels of motivation, and others.

5. CONCLUSION

Mathematics literacy is an ability of students to formulate, use, and interpret mathematical concepts in various contexts. The results revealed that teaching stage of fraction consists of two methods. In addition, there is difference between mathematics literacy of students who receive realistic mathematics education assisted by digital module and mathematics literacy of students who receive scientific approach based on the level of self-regulated learning. The results have implications for future learning to empower mathematics literacy of students through integrating digital module in learning activity.

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7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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