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Research Article

Development of Interactive E-Module with Realistic Mathematics Education (RME) Approach to Increase Numeracy Skills and Mathematical Growth Mindset

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Abstract: This research aims to: (1) produce mathematics learning media in the form of interactive e-modules with a learning approach.realistic mathematics education (RME) which is oriented towards numerical ability and mathematical growth mindset students and describe their characteristics; (2) describe the quality of the learning e-module which meets the criteria of being valid, practical and effective so that it is suitable for use by junior high school students using the approach realistic mathematics education (RME). The development model used in this development research is the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). The research subjects consisted of one teacher and 32 seventh grade students of SMP Negeri 3 Pajangan in Bantul Regency, Yogyakarta, who participated in this research.The results of the study show that the developed e-module has the following main characteristics: (1) using the RME approach in learning strategies; (2) facilitating the improvement of numeracy through learning videos, LKPD, and quizzes; (3) fostering growth mindset through motivational videos, inspirational sentences, discussion spaces, as well as feedback and self-evaluation features; and (4) using test- and questionnaire-based evaluation instruments. Validity tests showed very good results with an average score of 96% from media experts and 98% from material experts. The practicality of the e-module was assessed as very good by teachers (96.19%) and good by students (80.47%), and the implementation of learning reached 96.8%. Effectiveness was proven through MANOVA and t-tests which showed a significant increase in numeracy and mathematical growth mindset after using the e-module. Thus, the RME-based interactive e-module is suitable for use as an innovative mathematics learning medium at the junior high school level.

Keywords: Interactive E-Module; Junior High School; Mathematical Growth Mindset; Numeracy Skills; Realistic Mathematics Education

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1. Introduction

The world has entered a new phase of industrial development since 2011, known as the Industrial Revolution 4.0. This revolution is capable of increasing efficiency and productivity in various sectors, as well as creating new opportunities and challenges in the economic, social, and educational fields. Education entering the Industrial Revolution 4.0 phase is synonymous with 21st-century learning, a combination of literacy skills and mastery of technology (Sari et al., 2020). According to Zenita et al. (2020), 21st-century learning requires continuous innovation in its process by utilizing technology effectively and efficiently. Sidiq and Najuah (2020) also explain that educators in 21st-century learning must be able to facilitate students by developing innovations or teaching creativity that utilize technology such as electronic whiteboards or electronic modules. According to Cotet, Caruta, and Chiscop (2020), educators also need to change their learning styles as an adaptation to 21st-century learning by using virtual learning media effectively, because in this era, educational goals have changed from conventional delivery of materials to interactive learning, where educators become facilitators, whose job is to accompany students' work both individually and in groups, and provide contextual problems.

The aim of all these changes is to equip students with the knowledge and skills needed to face the increasingly complex challenges of the world in the 21st century, therefore, students need 21st century skills which are commonly known as the 4Cs, namely *critical thinking and problem solving* (critical thinking and problem solving), *collaboration* (collaboration), *communication* (communication), as well as *creativity and innovation* (creativity and innovation). The increasing expectations of students' skills require educators to find innovations to increase the effectiveness and efficiency of learning. 21st century learning focuses on: *self directed learning* (learning that gives students the freedom to determine learning goals), *multi source learning* (learning that utilizes various learning sources and media), *lifelong learning* (learning that is not limited by age), learning that utilizes information technology, learning that motivates, *adaptive learning* (learning that adapts to change), learning that encourages *growth mindset* (Wibawa, 2018).

In 21st-century learning, skills or abilities are needed to interpret and understand various problems in real life and the workplace. Therefore, school graduates are expected to have better abilities than before. According to Goos et al. (2014), numeracy is a primary tool for students to understand and interact with the world and fosters students' awareness of the relevance of mathematics in various aspects of life in shaping the modern world. As Dave Tout (2020) stated, "*Numeracy is a critical awareness which builds bridges between mathematics and the real world"* with numeracy skills, individuals can formulate, apply, and interpret mathematical concepts in various contextual situations, and possess the ability to reason mathematically using concepts, methods, and data to describe, explain, or predict events (Basri et al., 2021). Students with creativity enriched with appropriate numeracy skills will be able to survive amidst the increasing complexity of problems in the modern era.

However, the reality on the ground is that the numeracy skills of students in Indonesia are still low. Based on the results of the study, *Program for International Students Assessment* (PISA) 2018, the numeracy ability of students in Indonesia is still at a low level, ranking 72 out of 79 countries that are test participants (OECD, 2019). The study results *Program for International Students Assessment* (PISA) 2022 was announced on December 5, 2023, Indonesia ranked 68th with scores of 371 in reading, 379 in mathematics, and 398 in science. The results of PISA 2022 show that compared to PISA 2018, Indonesia's literacy learning outcomes ranking rose by 5 to 6 points. However, the overall PISA 2022 results show relatively low performance, comparable to the results obtained in 2003 for reading and mathematics, and in 2006 for science. This means that there has not been a significant increase in quality as represented by the scores obtained throughout Indonesia's participation in PISA (OECD, 2023). The measurement results *Trends in International Mathematics and Science Study* (TIMSS) in 2015 where Indonesia still occupies the 6th lowest position out of 49 countries with an average score of 397 on mathematics assessment which includes measurement for numeracy ability (Ina et al., 2016). As for Winata et al. (2021) conducted research and obtained the results that the numeracy ability of class XI students is still low, this can be seen from the results of the measurement of numeracy ability which shows that there are 61.90% of students who get a score of less than 50. Another research that measures numeracy ability was also conducted by Purwanto (2021) who found that there are still many students who do not understand numeracy. This is seen from the quantity of less than 50% of class XI students who can solve the given numeracy test questions. The research by Sa'dijah et al. (2023) who have measured numeracy ability, found that SMP students both in boarding and regular schools in solving numeracy ability questions still get low marks, this is proven by their work results that only 8% of students are in the high category, while there are 62% of students in the low or poor category.

There are several factors that cause students' numeracy skills to be classified as low, because many students are still unable to interpret and understand contextual problems, even though for the application of mathematics in everyday life, students must be able to understand how to formulate real situations into mathematical forms. Another factor that causes students' numeracy skills to be still low, including the fact that mathematics learning activities are still started by teachers by directly conveying definitions and formulas, followed by discussions of several example problems and their solutions, and the learning process ends with providing practice problems that have a similar pattern to the examples. So, it can be concluded that students are not accustomed to solving mathematical problems that require high-level thinking or have characteristics such as PISA and TIMSS questions. Hadi and Novaliyosi (2019) stated that in learning activities at school, educators still have not fully attempted to habituate students to provide test questions that require students to think at a high level in their solutions.

Students' low numeracy skills are not only due to the factors mentioned above, but also to other influencing factors, such as their lack of confidence in thinking numerically. Many students still believe that mathematical proficiency is only for those who are talented and intelligent in mathematics. Most students believe that ability is something that is fixed (not something that develops), which may be the main reason for students' low achievement and makes them uninterested in mathematics (Sun, in Kismiantini, 2021). This contrasts with the opinion of Alpar & Van Hoeve (2019) who stated that all students can explore mathematics because mathematics is something that can be learned. If students believe that ability or talent can be developed through effort, and think that they will be able to solve mathematical problems with effort, their minds will respond by activating supporting data such as courage, focus, and energy. Dweck (2006) stated that *a growth mindset* is the simple belief that human talent and intelligence can be developed through effort. So, *mathematical growth mindset* is an individual's belief that each individual's mathematical abilities can be developed (Boaler, 2013). Research by Good et al. (in Yeager et al., 2019) proves that in the United States, *a growth mindset* can improve the grades of low-achieving students and increase their interest in learning mathematics, by taking advanced mathematics courses in secondary education. In line with Horn's research (in Boaler et al., 2018), which states that a fixed mindset can contribute to students' poor work, half-hearted participation, and disinterest in mathematics. Thus, a mindset or *mindset* can contribute to students' academic performance, including interest and participation in mathematics.

In the era of the industrial revolution 4.0, one of the learning focuses in the education system is the application of *growth mindset* not on *fixed mindset* (Wibawa, 2018). In the 2018 PISA test, important variables were added to the student questionnaire, namely *growth mindset*. *Growth mindset* is the belief that a person's abilities and intelligence can develop over time (Caniels et al., 2018), whereas someone who believes that a person's intelligence cannot change is someone who has a mindset which remains (*fixed mindset*) (King, in Brett McNabb, 2021). Students who have *a growth mindset* believing that understanding or abilities can be acquired through effort, students, when faced with challenges, will try harder and take more risks (Dweck, in Kismiantini, 2021). However, the results of the 2018 PISA test showed that at least 60% of students in Indonesia still believe that their intelligence or abilities cannot be changed (*fix mindset*) (Avvisati et al., in Kismiantini, 2021). Therefore, the results of the 2018 PISA show that students in Indonesia are still relatively low in mathematics because they are influenced by the low level of *growth mindset* students (Kismiantini et al., 2021). On the other hand, the research results of Wijaya et al. (2023) show that the level of *growth mindset* students are in the medium category, and it was also found that in schools with a medium level of strata *growth mindset* tends to be low.

Why do many students still have a fixed mindset (*fixed mindset*) and level *growth mindset* they still tend to be low, this is likely due to several influencing factors such as the learning environment, social media, economic factors, and others. Mindset growth can be influenced by economic factors, where students who live in families with low incomes (poor) will tend to show a fixed mindset (*fix mindset*) (Claro et al., 2016). In line with the research of Avvisati et al. (in Kismiantini, 2021) which stated that the results of the 2018 PISA showed that the majority of students in OECD countries (developed countries) had *growth mindset*, which is proven by the responses of those who disagree or strongly disagree with the statement that intelligence cannot change, in contrast to developing countries such as Indonesia, the Philippines, Panama, Kosovo, and the Dominican Republic which are countries with low achievements in PISA 2018, where students believe that intelligence is something that is fixed or cannot be changed (*fix mindset*).

Other factors influencing changes in mindset include academic experience, the learning environment, peers, and formal learning (Limeri et al., 2020). The learning environment during the pandemic changed, with educational conditions stagnating. Schools, as one of the educational institutions, were also impacted by the pandemic, resulting in learning activities not running as normally as before the pandemic. Learning took place at home, with parents playing a crucial role in supporting their children as they studied at home. Therefore, changing *mindset* one factor affecting students during the pandemic is parents. According to King (in Brett McNabb, 2021), students' mindsets can be influenced by other people in their lives, such as parents, teachers, and friends. When parents provide math assistance to their children, this assistance can be counterproductive to student achievement due to the parents' anxiety in doing the work (DiStefano et al., in Brett McNabb, 2021). When these parents project their beliefs about math ability, they lead their children to believe that they are not math people, or that they were not born with a math brain (Miller, 2020).

The learning environment in formal learning is another factor that affects the development of numeracy skills as well as *mathematical growth mindset.* In learning, problems often occur, including the use of teaching materials in the form of teacher and student textbooks, where students only learn from explanations and notes from the teacher. Student textbooks usually contain brief descriptions of the material and practice questions, the descriptions of the material contain detailed material that is broadly without any description that directs students to understand the concept in depth, and the practice questions used are only routine questions that have not been fully able to improve students' numeracy skills. The same problem related to learning in schools encountered in the field by Agustyarini and Jailani (2015), namely the mathematics teaching materials used during learning are only in the form of quick formulas and memorization, and teachers who only use published teacher textbooks. Based on this, it is hoped that teachers or educational practitioners in the future can design good learning by providing teaching materials as learning media that can help improve students' numeracy skills, so that students are accustomed to working on contextual or numeracy problems, which focus on the ability to process important information contained in practice questions, it is also hoped that they can discuss more deeply regarding numeracy skills from the aspects of content, context, and cognitive level and see their relationship with the level of *growth mindset* students (Wijaya, Fanggidae, & Setyaningrum, 2023).

Problems that occur in schools from previous research that only use teaching materials in the form of textbooks provided by schools. Therefore, there is a need for learning innovation, one of the innovation alternatives that can be used by teachers or educators to improve numeracy skills and *mathematical growth mindset* is through the use of appropriate teaching materials. Teaching materials according to Prastowo (2013) are various materials in the form of texts, devices/tools, and information arranged in an organized manner to describe the skills that must be mastered by students, including modules. Nurmeidina et al. (2020) explain that modules are teaching materials commonly used in the learning process because they have characteristics as a source of independent learning for students. According to Pepin et al. (2017) teaching modules also have a contribution in helping educators design the learning process. Educators can design learning activities in a module based on the development of 21st-century skills in electronic form that will have more potential when applied in the learning process, where education in the era of the industrial revolution 4.0 is also known for the rapid development of new technologies (Ghufron, 2018).

Electronic modules or what can be termed e-modules, are the same as the opinion of Gunadharma (in Hilaliyah, Sudiana, & Pamungkas, 2019) who said that e-modules are an electronic form of a printed module that is developed using...*software*certain on electronic devices. Adawiyah et al. (2020) stated that e-modules are electronic versions of printed modules designed using *software* and the results are read through digital devices, such as computers, laptops, tablets, smartphones, and others. El-Sabagh (2023) also states that e-modules are a combination of multimedia and interactive elements, such as animations and quizzes, used in blended or online learning environments to make learning easily accessible to students. E-modules are characterized by the principle of independent learning, namely a learning process that involves the active participation of students to develop themselves without relying on the presence of educators or on the learning process in the classroom alone (Wulandari et al., 2019). In addition, e-modules can also be used as an alternative to support teaching, namely by supporting student learning independence and improving the quality of learning (Tobing et al., 2022). So, e-modules are electronic forms of a printed module developed by combining multimedia and interactive elements, the results of which can be read through digital devices, this electronic teaching material has the characteristic of the principle of independent learning, namely a learning process that emphasizes individual initiative to develop abilities or self-potential independently without relying on the presence of teachers, and in the learning process in the classroom the teacher only acts as a facilitator. E-Modules are expected to attract students' interest in learning and illustrate abstract material, and can be easily accessed by students using various types of electronic devices, such as gadgets, laptops, tablets, and computers anytime and anywhere, thus enabling students to get immediate feedback and fully understand the material (Saraswati et al., 2019). E-Modules are used as a learning medium to convey material so that it is not monotonous so that learning is more interesting and enjoyable for students, the use of e-modules gets a positive response by developing mathematical knowledge by students (Setyani et al., 2020).

The use of e-modules as learning resources used to support learning, then developed by being equipped with several components of the program *software* or *platform*which is used so that the e-module becomes interactive by showing the interactivity of students with other students through*link*discussion, students with teachers through*link*complaint or *feedback*, and students with e-modules through*quiz game* or LKPD. According to Abdullah et al. (2013), interactive e-modules are the result of developing learning modules equipped with the integration of various electronic media in the form of software such as *macromedia flash*, *power point*, and others, to support interactivity in the learning process. One example of an interactive e-module is a computer-based module that uses an application. *Heyzine Flipbook* is software (*software*) or *platform* which is used to convert PDF files into interactive digital books with visual and audio effects on each page turn. Each page of the resulting PDF can be edited *flip* (back and forth) interactively like the pages of a real book. With*Heyzine Flipbook*, pdf files can be accompanied by multimedia elements such as background images, audio, video, images, audio, and links or *link* go to page *flipbook* the other equipped with interactive buttons. Examples of links include games that are already on the internet or that are provided by interactive websites such as *Quizizz, Quizalize, Kahoot*, etc. Therefore, *Heyzine Flipbook* is able to facilitate a more effective learning process, thanks to its interesting and interactive features, and is also able to make students more enthusiastic and motivated to learn. E-Modules that use *platform heyzine flipbook* can be accessed by students through *link* and can be opened on electronic devices such as computers, laptops, and*smartphone*Murod, Utomo, and Utaminingsih (2021) stated that interactive e-module teaching materials are effective in improving students' understanding of mathematical concepts. Erawati, Purwanti, and Saraswati (2022) in their research used *heyzine flipbook* to develop products in the form of e-modules, based on the research results, e-modules meet the valid, practical and effective categories, this shows that the use of e-modules that utilize *heyzine flipbook* can support the learning process well. Muafiyah, Kartono, and Halidjah (2024) also developed e-module products with the assistance of *heyzine flipbook* to teach in grade V of elementary school, the e-module produced meets the valid and practical categories, so it can be concluded that the e-module uses *heyzine flipbook* more interesting and suitable for use as teaching materials that can support the learning process.

In relation to the interactive e-module in learning, to ensure the achievement of learning objectives, it is necessary to apply a teaching approach that is adapted to the obstacles or challenges faced by the students. So, to solve challenges related to numeracy skills and *mathematical growth mindset*Students can use an approach that is oriented towards daily activities and integrate mathematics into student activities. Referring to this, the approach *realistic mathematics education* (RME) is considered capable of helping improve numeracy skills because apart from presenting realistic problems, it also considers mathematics as an activity *Realistic Mathematics Education* (RME) in Indonesia is interpreted as Indonesian Realistic Mathematics Education (PMRI) which is an approach to learning mathematics developed by a group of mathematicians from the Freudenthal Institute, Utrecht University in the Netherlands since 1971, where this approach is based on the opinion of Hans Freudenthal (1905-1990) who stated that mathematics is a human activity or activity (Makonye, 2014).

According to Suharta (in Widodo, 2014), *realistic mathematics education* (RME) is an approach to learning mathematics that is not only fun but also connected to the context of everyday life. *Realistic Mathematics Education* (RME) is a learning and teaching process that views mathematics as something related to mathematical activities related to reality (Treffers, in Makonye, 2014). Polya (1973) said that in solving problems, students still experience difficulties in modeling situations because they do not have adequate conceptual understanding, in addition Schoenfeld (1985) also stated that students tend not to know where to start because they do not have a structured strategy. However, according to Wijaya (in Mufidah & Wijaya, 2017) *realistic mathematics education* (RME) functions as a bridge from non-formal mathematics to formal mathematics (mathematization). So, to apply mathematics in everyday life, students will be guided to learn how to model situations they encounter in real life into mathematical forms. Therefore, e-learning modules with a mathematical approach *realistic mathematics education* (RME) which uses realistic problems, are expected to motivate students to think critically, creatively, innovatively, and be able to encourage students to interact and collaborate. As educators in order to improve numeracy and*mathematical growth mindset*need to develop interactive e-modules using an interactive approach *realistic mathematics education* (RME).

For research related to the development of e-modules in mathematics learning using the approach *realistic mathematics education* (RME) was previously carried out by Hilaliyah, Sudiana, and Pamungkas (2019) who conducted research on the development of teaching materials in the form of modules *Realistic Mathematics Education* (RME) with Banten cultural values, with the aim of improving students' mathematical literacy skills. The resulting module met the criteria of validity, practicality, and effectiveness. One proof of its effectiveness is that students' mathematical literacy skills reached 93%, which is considered effective. Therefore, it can be concluded that the module is capable of improving students' mathematical literacy skills. Furthermore, Gistituati and Atikah (2022) also developed e-module teaching materials entitled "*E-Module Based on RME Approach in Improving the Mathematical Communication Skills of Elementary School*", the purpose of this study is to test the effectiveness of the e-module which is a follow-up to the validity test and practicality test. The effectiveness test was obtained by analyzing pretest and posttest data using a descriptive test, the data obtained were analyzed using the t-test and N-test-*Gain score*. The conclusion from the research results shows that the e-module developed with the approach *realistic mathematics education* (RME) is effective in improving students' mathematical communication skills in elementary schools. Nesri and Kristanto (2020) also conducted research on the development of technology-assisted teaching modules to develop students' 21st-century skills. This study found that the electronic modules, or e-modules, developed in this study were valid based on expert assessments, practical based on teacher and student assessments, and effective based on student work results.

Even though there has been a lot of research that has developed e-modules, this does not mean that e-module development is no longer necessary, but rather remains important because this development research is different from existing e-module development, such as using a methodological approach.*realistic mathematics education*(RME) and is linked to two different abilities simultaneously, namely numeracy and mathematical abilities *mathematical growth mindset* students, applied to different subject matter, and viewed from different subjects.

Based on the description above, the researcher plans to develop an e-module that is packaged interactively using an interactive approach *realistic mathematics education* (RME) to improve numeracy skills and *mathematical growth mindset*. Therefore, the researcher proposed the title "Development of Interactive E-Modules with a Learning Approach"*Realistic Mathematics Education* (RME) to Improve Numeracy Ability and *Mathematical Growth Mindset*".

2. Material and Method

This research is a research and development which aims to produce interactive e-module based on the Realistic Mathematics Education (RME) approach in order to improve numeracy skills and mathematical growth mindsetJunior High School (SMP) students.

The development model used ismodel ADDIE (Analysis, Design, Development, Implementation, Evaluation) because it is considered systematic, flexible, and appropriate for producing valid, practical, and effective learning products.

Research Stages

The research stages use the ADDIE model, which includes the following five main steps.

a. Level of analysis

This stage aims to identify the needs for e-module development. The analysis is conducted through three main aspects: needs analysis, student analysis, and curriculum and materials analysis. The needs analysis was conducted through questionnaires and interviews with teachers and students to obtain information on learning constraints and the need for appropriate media. The student analysis included learning characteristics, readiness, and initial abilities. The curriculum and materials analysis was conducted by examining learning outcomes and the characteristics of the Two-Variable Linear Equation System (SPLDV) material in the Independent Curriculum.

b. Design stage
At this stage, the e-module framework is designed based on the analysis results. The design process includes structuring the module content (introduction, learning activities, worksheets, reflection, and evaluation), as well as determining the RME-based learning syntax, which includes understanding contextual problems, exploring concepts, discussing, and reflecting. The visual design of the e-module was created using the Heyzine Flipbook application, which allows the integration of various media such as videos, images, and interactive links. Furthermore, research instruments were developed, including validation sheets, practicality questionnaires, observation sheets, and numeracy ability tests.

c. Development stage
This stage focuses on the creation of e-module products and validation by experts. The products are developed by adding learning video features, interactive quizzes, and online discussion spaces to encourage active student participation. Validation was conducted by two experts: a material expert and a media expert. The material expert assessed content, presentation, and language aspects, while the media expert assessed instructional design, software engineering, and visual communication. Validation results served as the basis for product revisions before the implementation phase.

d. Implementation stage
A field trial was conducted at SMP Negeri 3 Pajangan, Bantul, Yogyakarta, involving one mathematics teacher and 32 seventh-grade students. The e-module was implemented in five learning sessions using the RME approach. Data was collected through teacher and student response questionnaires, learning implementation observation sheets, and tests.*pretest–posttest*numeracy and questionnaire skills*mathematical growth mindset*The aim of this stage is to assess the practicality and effectiveness of the e-module that has been developed.

e. Evaluation stage
Evaluation is conducted formatively at each stage and summatively at the final stage. Formative evaluation is used to improve the product during the development process, while summative evaluation aims to assess the final quality of the e-module based on three main criteria: validity, practicality, and effectiveness.

Trial Design and Instruments

This study uses a one group pretest–posttest design to determine the improvement in learning outcomes before and after using e-modules. The research instruments include material and media expert validation sheets, teacher and student practicality questionnaires, numeracy ability tests, questionnaires, *mathematical growth mindset*, as well as observation sheets for learning implementation.

Data Analysis Techniques

Data analysis was carried out quantitatively and qualitatively. Product validity analysis was conducted using expert assessment results using the average validation score formula. Practicality was calculated based on the percentage of the obtained score compared to the maximum score, with the criteria being very practical if ≥85%. Product effectiveness was analyzed using MANOVA and paired sample t-tests to test for significant differences between the pretest and posttest results of numeracy skills.*growth mindset*. The increase in learning outcomes is calculated using the N-Gain formula, with high ($g>0.7$), medium ($0.3\leq g\leq 0.7$), and low ($g<0.3$) categories.

Product Eligibility Criteria

E-modules are declared eligible for use when meeting the following three criteria:

a. Validity: validation results from material and media experts ≥85%;
b. Practicality: teacher and student response ≥80%;

c. Effectiveness: there is a significant increase (p<0,05) in numeracy results and *growth mindset*.

The validation results show that the e-module obtained a validity score of 96% from media experts and 98% from material experts, included in the category*Very good*The product's practicality was also high, with 96.19% approval from teachers and 80.47% approval from students. Effectiveness testing showed a significant increase in results.*pretest–posttest* numeracy ability and *mathematical growth mindset* (p<0,05).

3. Research and Development Result

Initial Product Development Result

Level of analysis (analysis)

The analysis stage is carried out as a basis for designing interactive e-modules based on*Realistic Mathematics Education* (RME) to improve numeracy skills and *mathematical growth mindset*The analysis includes the needs of teachers and students, student characteristics, and the curriculum used.

The analysis shows that mathematics learning remains teacher-centered and utilizes digital media minimally. Teachers have not yet used interactive e-modules, while students tend to be passive and rely solely on textbooks. This situation raises the need for innovative learning media that are contextual, engaging, and encourage independent learning.

Basically theoretical, e-modules are needed to help students understand mathematical concepts through real-life contexts and support teachers in creating interactive learning. Development focuses on the material *System of Linear Equations in Two Variables* (SPLDV) according to*Independent Curriculum*, by utilizing the platform *Canva*, *Heyzine Flipbook*, *Paddled*, *Live Worksheet*, And *Quizizz* to make learning more interactive and collaborative.

The analysis of students shows that they are accustomed to using technology, but their numeracy skills are still low and their learning motivation is suboptimal. The RME-based e-module is expected to increase student engagement, conceptual understanding, and confidence that mathematical abilities can develop through effort and practice. The curriculum used is *Independent Curriculum* with phase D learning outcomes. The SPLDV material was chosen because it is relevant in training mathematical modeling skills. The RME approach is implemented by emphasizing contextual, collaborative, and reflective learning so that students are active in discovering and understanding mathematical concepts independently.

Desain stage

The design phase aimed to create an interactive e-module structure that adheres to RME principles. The e-module is structured with a contextual learning flow that includes real-world problem recognition, concept exploration, practice, reflection, and evaluation. Each section includes videos, digital worksheets, and interactive quizzes.

Visual design is created with*Canva*and converted through*Heyzine Flipbook*to appear dynamic. Additional features such as discussion rooms (*Paddled*) and learning motivation are included to strengthen *growth mindset;* the product design is then validated by subject matter and media experts to ensure its suitability for content, appearance, and effectiveness before the development and implementation stages are carried out.

Development stage

Is a continuation of the design process, where the results of the interactive e-module design based on *Realistic Mathematics Education* (RME) was realized into an initial product. Development was carried out using *Canva* for display design and *Heyzine Flipbook* as an interactive publishing platform in HTML format. This e-module is designed to be accessible online via a link or scan.*QR code*, and includes various features such as learning videos, digital worksheets, interactive quizzes, and self-reflection. Content development also involves supporting applications such as *Paddled* for discussion, *Live Worksheet* for worksheets, *Quizizz* for evaluation, as well as *Google Form* for feedback and practicality surveys.

This e-module product was developed with the main purpose of improving numeracy skills and *mathematical growth mindset* students through contextual and reflective learning. The e-module structure includes an introduction, concept map, learning outcomes, learning activities, and a conclusion consisting of a summary, glossary, and final test. Each learning activity is structured according to the RME steps—starting with contextual problems, working with mathematical models, collaborative discussions, and reflection. The e-module also features a *psychology corner* and *vent corner* which contains motivational narratives to foster students' self-confidence and fighting spirit in learning mathematics.

Development orientation is also directed at the formation of *growth mindset*, through graded practice questions, giving *feedback* positive feedback and opportunities for self-reflection. E-modules provide space for students to actively learn, collaborate, and experiment to find solutions, while internalizing the belief that mathematical abilities can be developed through effort and perseverance. After development is complete, the product is consulted with the supervising lecturer and then validated by media and content experts to assess the appropriateness of the content, design, and integration of RME principles into the learning process.

Implementation stage

The e-module, which had been declared valid, was then implemented with 32 students in class VII A of SMP Negeri 3 Pajangan, Bantul. The implementation took place in five meetings using the RME approach, with the mathematics teacher acting as an observer. The implementation process began with the provision of *pre-test* numeracy and questionnaire skills *mathematical growth mindset*, followed by learning activities using interactive e-modules.

Each meeting is focused onsub-materialTwo-Variable Linear Equation Systems (SLEs) using various methods—from substitution, elimination, graphing, to mixed equations. Students are invited to watch motivational and apperception videos, work on context-based worksheets, and discuss them through the space.*Paddled.* Learning activities take place in a collaborative atmosphere,WhereStudents formulate, work on, and interpret real problems according to RME principles.

During implementation, students showed increased participation and interest in learning, despite challenges such as network disruptions and limited devices. Researchers also implemented an activity points system to encourage motivation. At the end of each meeting, students were asked to complete a self-reflection and *feedback* learning. The implementation stage ends with*post-test*and filling out a practicality questionnaire, which forms the basis for measuring product effectiveness.

Evaluation stage

The evaluation phase was conducted to assess the overall quality of the e-module based on its validity, practicality, and effectiveness. Evaluation was conducted before and after implementation through expert assessments, teacher and student responses, and numeracy test and questionnaire results.*growth mindset.* Validation by material experts and media experts shows that the e-module is very valid both in terms of content and appearance, while the results of the practicality test show that the e-module is easy to use and attractive to users.

From the results of the effectiveness test, a significant increase was obtained between the values*pre-test* And *post-test* numeracy ability ($p < 0.05$), as well as score improvement *growth mindset* students. This demonstrates that the RME-based interactive e-module is not only valid and practical, but also effective in improving students' understanding of mathematical concepts, numeracy skills, and developmental mindset. Therefore, this e-module is suitable for use as an innovative learning medium to support the implementation of the Independent Curriculum.

Product Trial Result

Numeracy test instruments are also evaluated empirically to find out reliability by using methods *criterion referenced test* (CRT). This method can measure student learning outcomes empirically (Sanjaya, 2015). The criteria for assessing the reliability of the questionnaire refer to *Cronbach Alpha* in Table 1.

Table 1. Results of Values *Cronbach Alpha* Questionnaire *Mathematical Growth Mindset.*

Cronbach Alpha	**N of Items**
0,874	20

The questionnaire scores *mathematical growth mindset* is 0.874 in the good category. The questionnaire can be said to be reliable if the value *Cronbach Alpha* approaches the number 1. Based on the results of validity and reliability, the questionnaire *mathematical growth mindset* can be stated to be valid and reliable.

Practical Data Analysis

Practicality was also assessed by observers in the classroom during the learning process using e-modules. Observations were used to assess the practicality of using e-modules implemented in the classroom at each meeting. The learning implementation observation sheet serves as a guideline.observationto observe the implementation of learning at each meeting. The observer in this study was a mathematics teacher. The following is a summary of the results of the learning implementation observations, presented in Table 2.

Table 2. Learning Implementation Percentage.

Pertemuan	Presentase Keterlaksanaan Pembelajaran	
	Kegiatan Guru	Kegiatan Peserta Didik
Pertemuan ke-1	96,4%	96,4%
Pertemuan ke-2	96,4%	89,3%
Pertemuan ke-3	100%	89,3%
Pertemuan ke-4	100%	100%
Pertemuan ke-5	100%	100%
Rata-rata Presentase	98,6%	95%
Rata-rata Keterlaksanaan Pembelajaran	96,8%	

Based on Table 2, the average percentage of teacher activity implementation was 98.6% and student activity was 95%, with an average of 96.8% for both, which falls into the practical category. The complete results of the observation sheet can be seen in Appendix 19.

The e-module productslearning e-module developed in this study used the Canva and Heyzine Flipbook applications. The e-module was designed with features that can help improve numeracy skills and a mathematical growth mindset in learning SPLDV material. However, this e-module learning product has the disadvantage of only being accessible online. Furthermore, the use of electronic devices can also cause eye fatigue for students, as they have to stare at smartphone or laptop screens for extended periods of time.

Product Revisions

Activity trials were conducted to determine whether the e-learning module was successful. The trial was conducted with a practical test. At the timetrialsIn class VII A, an issue was discovered that led to revisions to the e-module. This finding included errors in the instructions in the worksheet (LKPD) from meeting 5. This caused students to be confused about solving problems and had difficulty concluding the material taught in that meeting. Some students provided criticism and suggestions for improvement.at the endmeeting. In addition, there were positive responses and comments from students that the e-module was very good and interesting, so they were enthusiastic about learning in class. Students also tried harder to understand the material by accessing the video material provided by the researcher in the e-module at the end of the lesson and could ask questions about things they did not understand from the material during the learning process in class or by pressing the activity button on the e-module to ask the teacher. These findings became material for improvements to the e-module. After completing the product trial, the researcher revised it by improving the LKPD at meeting 5 with the sub-material on solving SPLDV using a mixed method.

Final Product Review

The quality of a product can be determined by examining its validity, practicality, and effectiveness (Nieveen & Folmer, 2013). The next step is the evaluation phase, which evaluates the developed product based on data obtained from both the validator and the results of the trials. The following explains each aspect of product quality.

Validity of E-Modules

Based on the data obtained, it can be concluded that the developed e-learning module is valid and suitable for use in terms of both material and media, according to the indicators of each validity aspect. This is in accordance with the opinion of Nieveen & Folmer (2013), who stated that a product is declared valid if the product is developed based on strong theoretical rationale and there is internal consistency between the product components.

The interactive e-module with a realistic mathematics education (RME) approach has met the validity requirements, thus the learning e-module oriented towards numeracy skills and mathematical growth mindset on the material of two-variable linear equation systems (SPLDV) is declared suitable for use.

Practicality of E-Modules

Based on the results of the practicality of the e-modules completed by teachers and students, as well as the implementation of learning, it can be concluded that learning using interactive e-modules can help the learning process become practical and efficient and make the learning process student-centered. This was also stated by Sutisna et al. (2021) that the use of electronic learning media can increase student motivation, understanding, and involvement in carrying out activities in the learning process. Istikomah et al. (2020) also stated that electronic media based on E-learning can increase student interactivity, namely, it occurs in the constructive process by observing interaction, negotiation, intervention, cooperation, and evaluation between students.fellowstudents, between students and teachers, and between teachers and the learning environment. Therefore, it can be said that the development of interactive e-modules with a learning approach *realistic mathematics education* (RME) to improve numeracy skills and *mathematical growth mindset* in the material of two-variable linear systems (SPLDV) fulfills the practical aspects.

Effectiveness of E-Modules

The results obtained showed that the implementation of e-learning modules provided a significant difference in the average scores of numeracy abilities and mathematical growth mindset of students before and after using interactive e-modules with a realistic mathematics education (RME) approach. The results of the study are in line with the research of Moreno-Guerrero et al. (2020) who stated that the use of electronic learning media can improve students' mathematics learning outcomes. Sumarwati et al. (2020) also stated that the use of learning media using technology is one of the media that can assist teachers in the learning process and can improve students' higher-order thinking skills. Itikomah et al. (2020) e-moduleselectronicRealistic-based learning is effective in classroom learning because students are more interested, happy, and understand easily because the realistic approach is characterized by student activity and is in the student's environment so it is easy to imagine, especially for medium and low groups.

The final product of the interactive e-module using the Realistic Mathematics Education (RME) approach with the help of Heyzine Flipbook on SPLDV material can improve students' numeracy skills and mathematical growth mindset. The advantages of the developed e-module are:activity organized learning based on situations that are close to students' daily lives or phenomena frequently encountered in everyday life. Furthermore, the learning e-modules can be accessed anytime and anywhere, without having to carry them around physically. These e-modules are also engaging to read because they use an engaging design and are characterized by activities that can make students happy and enthusiastic about learning because the problems are situated in their environment and therefore easy to visualize.

4. Conclusion

Based on the results of research and development, it was concluded that the interactive e-module with the approach*Realistic Mathematics Education* (RME) on the material of Two Variable Linear Equation Systems (SPLDV) was successfully developed using the ADDIE model and has characteristics that support the improvement of numeracy skills and *mathematical growth mindset* students. This e-module is designed with a real-world context-based learning flow through stages *opening*, *individual work*, *discussion*, and *closing*. This product was developed using *Heyzine Flipbook* which is integrated with various interactive platforms such as*Live Worksheet*, *Quizizz*, *Paddled*, And *Google Form*, and is equipped with self-reflection features and *feedback* to strengthen interactions between students, teachers, and learning media. Numeracy skills are facilitated through contextual problem-based exercises that require mathematical reasoning, while*mathematical growth mindset*grown through non-routine exercises, motivational videos, and the "*Psychology Corner*" And "*Confession Corner*". The validation results show that this e-module meets the criteria of valid, practical, and effective with a media validity level of 96% and material of 98% (very good category), a practicality level of 96.19% from teachers and 80.48% from students, and a learning implementation level of 96.8%. In terms of effectiveness, there was a significant increase in the average pretest and posttest scores of numeracy skills (from 36.91 to 77.53) and *growth mindset* (from 57.66 to 82.84), with the results of the multivariate test and t-test showing significant differences before and after using the e-module.

Further development is recommended to add more interactive and animated learning videos to increase student interest and motivation. The e-module also needs to be equipped with a "*Help Hints*" as a step-by-step guide in solving training questions to reduce student frustration. Teachers are advised to get used to the use of contextual questions that demand high-level reasoning, strengthen understanding of the RME approach, numeracy skills, and *growth mindset*, and ensure device readiness and internet connection during the learning process. Furthermore, material development should be expanded to other mathematics topics, and further research should involve larger samples with experimental designs that include control and experimental classes to strengthen evidence of the effectiveness of e-modules in improving students' cognitive and affective competencies, including reasoning skills, problem-solving, learning interest, and perseverance.

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