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VALIDITY AND PRACTICALITY OF STEAM-BASED MATHEMATICS MODULE

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Abstract

Developments in the world of education and technology have brought various challenges and real problems that need to be overcome. In facing these challenges, innovation is needed in learning methods that can improve students' skills in understanding and solving problems in everyday life. STEAM-based learning encourages students to develop their potential through exploration and problem solving. This study aims to develop a STEAM-based integer mathematics module. The development model used is ADDIE (analysis, design, development, implementation, evaluation). This section focuses on the validity and practicality of the module. Module validation was carried out by 3 experts which included material validation and media validation. The validation results obtained from the Content Validity Index (CV) were 1 in the aspects of content feasibility, language, presentation, and media. The module practicality test was carried out by implementing the module in two learning sessions attended by 16 grade 7 students. After learning, students were given a practicality questionnaire. Based on the results of the practicality questionnaire, a score of 4 was obtained. Therefore, it can be said that the developed module is very feasible and very practical to use in learning. Thus, it can be concluded that the STEAM-based integer mathematics module is valid and practical for use in learning to improve students' problem-solving abilities.

Keywords: math module, STEAM, integers, validity, practicality

Abstrak

Perkembangan dalam dunia pendidikan dan teknologi telah membawa berbagai tantangan serta permasalahan nyata yang perlu diatasi. Dalam menghadapi tantangan tersebut, diperlukan inovasi dalam metode pembelajaran yang dapat meningkatkan keterampilan siswa dalam memahami dan menyelesaikan permasalahan dalam kehidupan sehari-hari. Pembelajaran berbasis STEAM mendorong siswa untuk mengembangkan potensi mereka melalui eksplorasi dan pemecahan masalah. Penelitian ini bertujuan mengembangkan modul matematika bilangan bulat berbasis STEAM. Model pengembangan yang digunakan adalah ADDIE (analysis, design, development, implementation, evaluation). Bagian ini memfokuskan pada validitas dan kepraktisan modul. Validasi modul dilakukan oleh 3 orang ahli yang meliputi validasi materi dan validasi media. Hasil validasi yang diperoleh dari Content Validity Index (CV) yaitu sebesar 1 pada aspek kelayakan isi, kebahasaan, penyajian, dan media. Uji kepraktisan modul dilakukan dengan mengimplementasikan modul dalam dua kali pembelajaran yang diikuti oleh 16 siswa kelas 7. Setelah pembelajaran, siswa diberikan angket kepraktisan. Berdasarkan hasil angket kepraktisan diperoleh skor 4. Oleh karena itu, dapat dikatakan bahwa modul yang dikembangkan sangat layak dan sangat praktis untuk digunakan dalam pembelajaran. Dengan demikian dapat disimpulkan bahwa modul matematika bilangan bulat berbasis STEAM valid dan praktis untuk digunakan dalam pembelajaran meningkatkan kemampuan pemecahan masalah siswa.

Kata kunci: modul matematika, STEAM, bilangan bulat, validitas, kepraktisan

INTRODUCTION

Mathematics can be used to help understand and solve difficulties in everyday life. Concepts are one of the things in mathematics learning. Jamal (2019) argues that obstacles in understanding concepts are the biggest obstacles for students in learning mathematics. There

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are 3 things that cause students to have difficulty when solving problems, namely 1) perception or mathematical calculations, 2) interventions or procedures that students must go through to get the right results, 3) extrapolation or procedures for predicting the results to be obtained.

Integers are one of the materials studied at the junior high school level that studies integer operations, namely addition operations, subtraction operations, multiplication operations, and division operations (Yanala et al., 2021). According to Dewi (2020), there are several difficulties students experience when studying integers, namely difficulty determining what is known and asked, difficulty writing sentences in questions into mathematical form, and difficulty solving operation problems in integers. Mandasari & Rosalina (2021) revealed that students' difficulties in solving integer problems are their low ability to understand basic concepts in solving integer operation problems. Meanwhile, according to Benge (2021), the difficulty experienced by students in solving integer operation problems is when positive and negative signs are side by side.

Benge, et al (2021) in their research results showed that students had difficulty in adding positive and negative numbers. Students have difficulty if a small number is subtracted from a larger number. Students only understand addition on positive numbers and have difficulty in solving problems if the signs are different. This difficulty is because students do not understand the concept of negative signs in adding integers. To overcome difficulties in learning integers, learning tools are needed that can train students' abilities such as LKPD or Modules.

A study conducted by Sutriana (2024) showed that LKPD using the STEAM approach can increase the effectiveness of learning on integer material. STEAM-based electronic modules that are packaged attractively by adding animations and projects to each material as well as explanations of each STEAM component including science, technology, engineering, art, and mathematics can improve students' high-level thinking skills and can be used as a tool in the independent learning process (Sari, 2022). Electronic modules can be one of the teaching materials that can be applied to learning integers. Teaching materials using electronic modules can be accessed anywhere so that students can be effective in learning integer material independently.

STEM (Science, Technology, Engineering and Mathematics) education has been at the forefront of curriculum reform efforts and guidelines for various purposes, ranging from knowledge and skills development (Nipyrakis et al., 2024). The benefits of STEM in practice are very helpful in developing critical thinking skills, problem-solving skills, and creativity (Siregar et al., 2024). Several researchers in the study (AlMuraie et al., 2021) have identified the positive impact of teaching in accordance with STEM education in forming positive attitudes towards STEM, improving academic achievement and developing 21st century skills. STEM also increases positive impacts on skills, habits of mind, habits of mind, thinking skills, decision-making skills, decision-making, creative thinking and motivation. STEM education began to be widely recognized in the late 20th and early 21st centuries when educators and policy makers realized the importance of equipping students with the skills to work in these fields.

STEM education turns into STEAM when education begins to include creative disciplines such as art (Mukarramah & Hajrah, 2023). STEAM education means that art is combined with STEM (science, technology, engineering and mathematics) disciplines and is a new paradigm in education in many countries around the world (Areljung & Günther-Hanssen, 2022). STEAM is a type of learning that combines elements of art, mathematics, technology, and science to encourage students to develop their own strategies during the learning process (Jannah et al., 2022). The goal of STEAM education is to improve students' proficiency, confidence, and interest in science and facilitate an integrated understanding of science, technology, engineering, art, and mathematics (Kim & Chae, 2016). STEAM education helps students learn science by combining analytical thinking and creativity, allowing for broader and deeper exploration of scientific concepts.

In the midst of increasingly complex and dynamic world developments, the education system is required to be able to equip students with skills that are relevant to the needs of the 21st century. One innovative approach that has received widespread attention is STEAM (Science, Technology, Engineering, Arts, and Mathematics). This approach combines various interrelated disciplines with the aim of improving students' ability to think critically, creatively, and solve problems in everyday life (Afifah, 2021; Becker & Park, 2011)

Various studies have shown significant benefits from the implementation of the STEAM method. Tabin (2020) noted that the implementation of STEAM in early childhood education

not only helps children in critical thinking and problem solving but also contributes to their social development. Meanwhile, Nurhikmayati (2019) highlighted that the implementation of STEAM in mathematics learning can improve students' cognitive, affective, and psychomotor aspects.

Furthermore, STEAM has great potential in motivating students, making learning more interesting, and encouraging them to think critically and creatively in dealing with pressing issues, including the development of renewable energy resources in society (Conradty & Bogner, 2020; Ellianawati et al., 2025). In addition, Wachidi and Sudarwan (2021) added that the STEAM approach can increase students' interest, creativity, and communication skills through interesting and enjoyable learning.

Overall, the STEAM approach not only focuses on academic learning outcomes, but also contributes to the development of student competencies to compete in the era of globalization. With the implementation of STEAM, students not only become more skilled in utilizing technology, but are also able to solve complex problems creatively and innovatively.

The STEAM approach can help students develop their mathematical problem-solving skills (Mabsutsah & Yushardi, 2022). This approach integrates various disciplines. In developing students' knowledge skills while increasing students' creativity, the application of the STEAM approach in mathematics learning is very much needed (Nurhikmayati, 2019).

Based on the problems described above, it is necessary to have teaching materials that can develop students' skills in understanding and applying mathematical concepts more effectively. The teaching materials that will be developed are in the form of a mathematics module using the STEAM approach. This module is designed by presenting contextual problems that are relevant in everyday life so that students can more easily understand and apply the concepts learned. In this module, the STEAM approach is applied to help students understand mathematical concepts and improve mathematical literacy.

METHODS

This research design uses the research and development (R&D) method. According to Rumetna et al. (2020), the R&D method is a very important tool used in research aimed at improving the system. This study developed a product in the form of a STEAM (Science, Technology, Engineering, Mathematics)-based mathematics module on integer material for

7th grade junior high school/Islamic junior high school students in semester 1. The ADDIE development model developed by Dick and Carry, namely the ADDIE model, was chosen to answer the needs of this research regarding the validity, practicality, and effectiveness of the developed module. The ADDIE development model consists of five stages, namely analysis, design, development, implementation, and evaluation (Papavlasopoulou & Giannakos, 2020).

At the analysis stage, researchers carried out activities including: 1) Identifying student problems related to problem-solving abilities, characteristics of the STEAM approach in students, and student responses related to the application of technology in learning, and 2) Analyzing class VII semester 1 material in the independent curriculum that can be integrated with the STEAM-AR approach in learning. Then at the design stage, researchers carried out activities including: 1) Designing module learning activities that integrate STEAM, 2) Designing contextual problems that can develop students' computational thinking skills. At the development stage, researchers carried out activities including: 1) validating the module with three experts, 2) validating the one-to-one module with teachers and students, 3) Revising the module, 4) Testing the practicality of the module. This paper will focus on the explanation related to the validation results and the practicality of the developed module.

The module was validated by three validators, namely a STEAM and media expert with a doctoral degree, a media expert with a master's degree, and a material expert with a master's degree. The validation questionnaire consists of two parts, namely material validation and media validation. Material validation consists of validation related to the appropriateness of content, language, and presentation. Furthermore, media validation includes the appearance of the module design, ease of use, graphics, and consistency. To see the appropriateness of each part, the researcher used the Content Validity Index (CVI) calculation for three validators (Yusof, 2019).

Table 1. The number of experts and its implication on the acceptable cut-off score of CVI

Number of experts	Acceptable CVI values
Two experts	At least 0.80
Three to five experts	Should be 1
At least six experts	At least 0.83
Six to eight experts	At least 0.83
At least nine experts	At least 0.78

The module practicality test was conducted by testing the module on students in a limited class. In this study, the trial was conducted in 2 meetings, each with 2 lesson hours

(80 minutes). There were 16 grade VII students who participated in the module trial. After the learning process, the researcher gave a practicality questionnaire consisting of 15 question items with an assessment using a Likert scale with a score of 5: Very Good, 4: Good, 3: Enough, 2: Less, 1: Very Less.

RESULTS AND DISCUSSION

Steam-Based Mathematics Module

Researchers have developed a STEAM-based mathematics module on integer material. The content of the developed module contains a structure that helps students develop mathematical problem-solving skills as presented in figure 1-8.

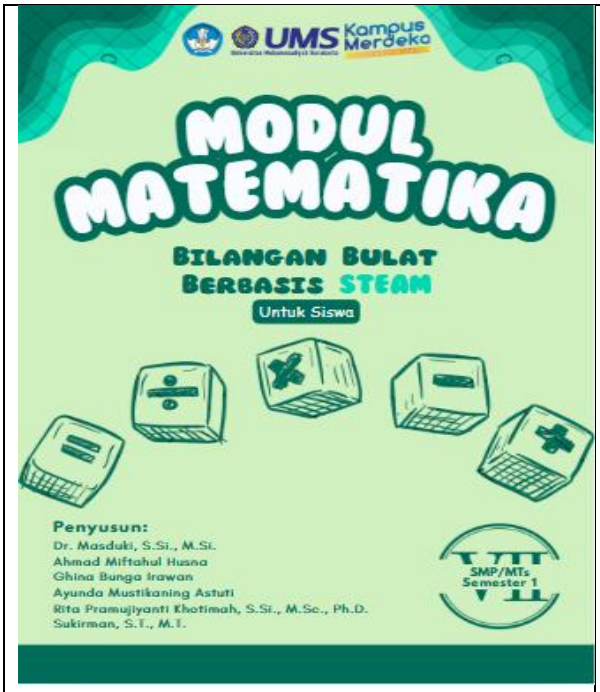


Figure 1. Module cover

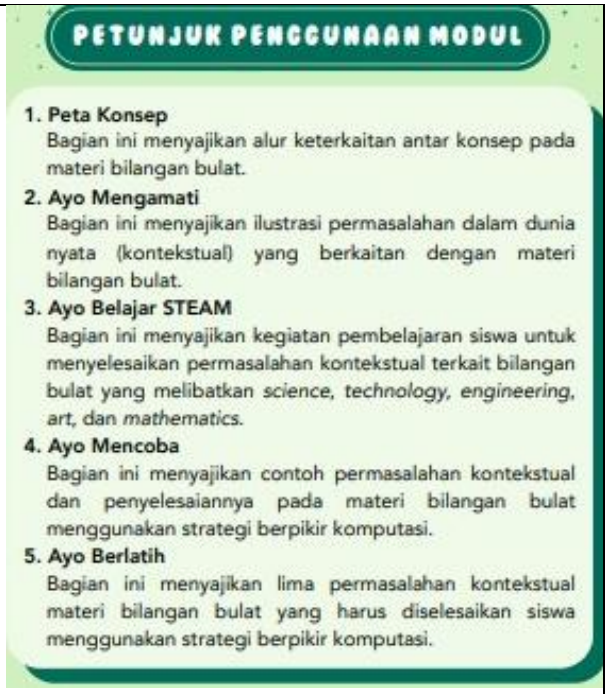


Figure 2. Instructions for using the module

Figure 1 shows the cover of the module used for learning integers with the STEAM approach. The module cover contains the module title, author's name, and school identity as a sign that this module is used in a particular educational environment. Figure 2 explains how to use the module with a systematic learning flow. This module consists of several main parts, such as Concept Map, Let's Observe, Let's Learn STEAM, Let's Try, Let's Practice.

Figure 3. STEAM-based learning principles

Figure 4. Concept maps

Figure 3. explains the main principles in STEAM learning, such as Interdisciplinary, Creativity and Innovation, Inquiry-Based Learning, Collaboration and Communication, Relevant to the Real World. Figure 4. illustrates the structure of the material in the module, which covers various aspects of integers with a STEAM approach. Some of the main sections in this concept map cover Positive and Negative Integers, Addition and Subtraction, Multiplication and Division.

Figure 5. Come Observe

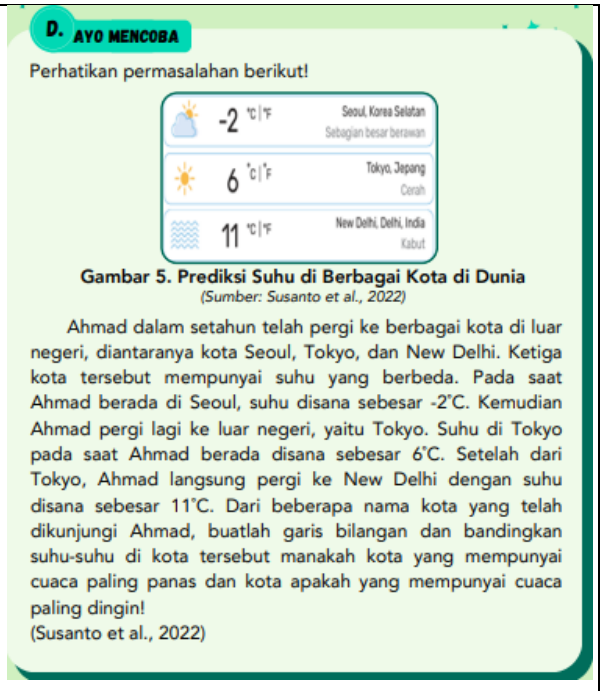


Figure 6. Let's Try

In Figure 5. there is one part of the learning module structure that aims to encourage students to conduct observation activities. In this section, there are illustrations in the form of pictures of mountains and seas, which provide a visual depiction of the learning theme. The purpose of this section is to help students understand the material through a visual approach while stimulating their curiosity about the topic being discussed. In Figure 6. focuses on independent activities carried out by students. In the picture, there is data showing temperature predictions in various cities in the world. This information is designed to motivate students to conduct analysis based on the data provided. With this approach, students are trained to apply critical thinking and problem-solving skills directly.

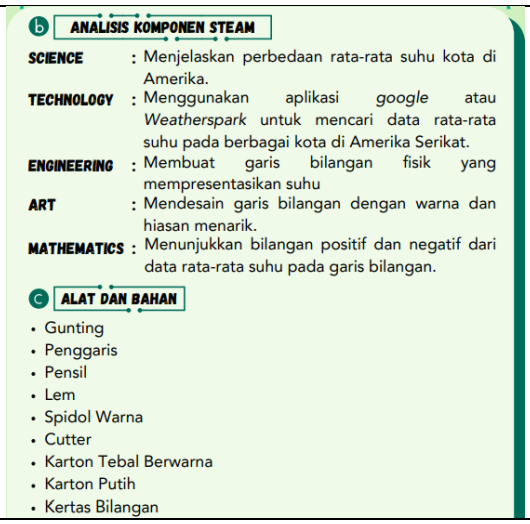

C. AYO BELAJAR STEAM

a PERMASALAHAN

Amerika Serikat (*United States of America, USA*) adalah sebuah negara besar yang terletak di benua Amerika Utara, terdiri dari berbagai kota bagian. Misalnya, Kota New York, Los Angeles, Miami, Phoenix, dan Minneapolis. Dengan luas wilayah sekitar 9,8 juta kilometer persegi dan populasi lebih dari 330 juta orang.

Gambar 3. Snowman
(Sumber: www.assetstore.unitiy.com)

Figure 7. Figure Naming Example


b ANALISIS KOMPONEN STEAM

SCIENCE : Menjelaskan perbedaan rata-rata suhu kota di Amerika.

TECHNOLOGY : Menggunakan aplikasi *google* atau *Weatherspark* untuk mencari data rata-rata suhu pada berbagai kota di Amerika Serikat.

ENGINEERING : Membuat garis bilangan fisik yang mempresentasikan suhu

ART : Mendesain garis bilangan dengan warna dan hiasan menarik.

MATHEMATICS : Menunjukkan bilangan positif dan negatif dari data rata-rata suhu pada garis bilangan.

c ALAT DAN BAHAN

- Gunting
- Penggaris
- Pensil
- Lem
- Spidol Warna
- Cutter
- Karton Tebal Berwarna
- Karton Putih
- Kertas Bilangan

Figure 8. Figure Naming Example

Figure 7 presents a contextual problem based on STEAM using temperature data in the United States. Figure 8 explains how each aspect of STEAM is integrated into integer learning consisting of Science, Technology, Engineering, Art, Mathematics.

Module Validation

The feasibility results of each module with CVI calculations are presented in Table 2-6.

Table 2. Validation of Integer Module Material Aspect of Content Feasibility

No	Item	Expert 1	Expert 2	Expert 2	Expert Agreement	I-CVI	UA (Universal Agreement)
1	The material in the module corresponds to the learning phase in the curriculum.	1	1	1	3	1	1
2	Learning objectives are in accordance with the learning phase in the curriculum	1	1	1	3	1	1

3	The **let's observe** activity provides examples of real situations that are relevant to learning objectives.	1	1	1	3	1	1
4	**Let's learn STEAM** activities can help students understand the mathematical concepts they are learning.	1	1	1	3	1	1
5	**Let's learn STEAM** activities can help students understand the relationship between mathematics material and other materials outside of mathematics.	1	1	1	3	1	1
6	**Let's learn STEAM** activities can help develop students' creativity.	1	1	1	3	1	1
7	**Let's learn STEAM** activities help develop student collaboration and communication.	1	1	1	3	1	1
8	**Let's learn STEAM** activities help students understand the relevance of math concepts to the real world.	1	1	1	3	1	1
9	**Let's try** activities can help students break down complex problems into simpler ones to solve.	1	1	1	3	1	1
10	**Let's try** activities can help students identify important information from the problems to be solved.	1	1	1	3	1	1
11	**Let's try** activities can help students identify solution patterns.	1	1	1	3	1	1
12	**Let's try** activities can help students solve complex problems systematically.	1	1	1	3	1	1
13	The problems in **let's practice** are challenging questions for students.	1	1	1	3	1	1
14	Problems in **let's practice** can develop students' computational thinking skills.	1	1	1	3	1	1
	Total	14	14	14	42	14	14

Based on Table 2. obtained S-CVI/Ave = Number of Expert Agreemnt/(Number of Items x number of experts) = 42/42 = 1. Then based on Table 2. also obtained S-CVI/UA = Number of UA/Number of Items = 16/16=1. Based on the S-CVI/Ave and S-CVI/UA scores, it can be concluded that the Integer Module is valid in terms of content feasibility.

Table 3. Validation of Integer Module Material Linguistic Aspects

No	Item	Expert 1	Expert 2	Expert 2	Expert Agreement	I-CVI	UA
1	The explanations in the module are easy to understand according to the student's ability level.	1	1	1	3	1	1
2	The mathematical terms used are clear and in accordance with standards.	1	1	1	3	1	1
3	The sentence structure used is simple and easy for students to understand.	1	1	1	3	1	1

4	Text formats such as italics or bold are consistent	1	1	1	3	1	1
5	Instructions in each learning activity in the module are clear and not confusing.	1	1	1	3	1	1
	Total	5	5	5	15	5	5

Based on Table 3. obtained S-CVI/Ave = Number of Expert Agreemnt/(Number of Items x number of experts) = 15/15 = 1. Then based on Table 3. also obtained S-CVI/UA = Number of UA/Number of Items = 5/5=1. Based on the S-CVI/Ave and S-CVI/UA scores, it can be concluded that the Integer Module is valid in terms of language.

Table 4. Integer Module Media Validation

No	Item	Expert 1	Expert 2	Expert 2	Expert Agreement	I-CVI	UA
1	The material is arranged sequentially so that it is easy for students to understand.	1	1	1	3	1	1
2	The material is arranged logically to support students' understanding of the mathematical concepts being studied.	1	1	1	3	1	1
3	The use of images, tables, or diagrams supports the explanation of the material.	1	1	1	3	1	1
4	Presentation of material in accordance with the learning objectives to be achieved.	1	1	1	3	1	1
5	The examples given are relevant and help students understand the concepts.	1	1	1	3	1	1
6	Examples and practice questions according to student abilities	1	1	1	3	1	1
	Total	6	6	6	18	6	6

Based on Table 4. obtained S-CVI/Ave = Number of Expert Agreement/(Number of Items x number of experts) = 18/18 = 1. Then based on Table 4. also obtained S-CVI/UA = Number of UA/Number of Items = 6/6=1. Based on the S-CVI/Ave and S-CVI/UA scores, it can be concluded that the Integer Module is valid in the presentation aspect.

Table 5. Integer Module Media Validation

No	Item	Expert 1	Expert 2	Expert 2	Expert Agreement	I-CVI	UA
1	The module design display is attractive and makes it easier for students to understand the material.	1	1	1	3	1	1
2	The module design display is consistent across all sections.	1	1	1	3	1	1
3	The type and size of font used in the module is clear and easy for students to read.	1	1	1	3	1	1
4	The use of bold, italics, or color in text is appropriate to highlight important information in the module.	1	1	1	3	1	1

5	The color combination in the module supports readability and does not distract students' focus.	1	1	1	3	1	1
6	Instructions and navigation within the module are easy to understand and follow.	1	1	1	3	1	1
7	The presentation of material in modules makes it easier for students to learn gradually.	1	1	1	3	1	1
8	Design elements such as margins, headings, and spacing are used consistently throughout the module.	1	1	1	3	1	1
9	There is consistency in the use of colors, fonts and images across modules	1	1	1	3	1	1
10	The level of titles is clear, consistent and proportional	1	1	1	1	1	1
11	Graphs, diagrams, or illustrations in the module are easy to understand.	1	1	1	3	1	1
12	Graphs, diagrams, or illustrations in the module are presented consistently.	1	1	1	3	1	1
13	The image size and quality are clear and relevant to the material.	1	1	1	3	1	1
14	Placement of titles, subtitles, illustrations, and image captions supports the learning flow.	1	1	1	3	1	1
	Total	14	14	14	42	14	14

Based on Table 5. obtained S-CVI/Ave = Number of Expert Agreement/(Number of Items x number of experts) = 42/42 = 1. Then based on Table 5. also obtained S-CVI/UA = Number of UA/Number of Items = 14/14=1. Based on the S-CVI/Ave and S-CVI/UA scores, it can be concluded that the Integer Module is valid in the media aspect.

Practicality of STEAM Modules

Tabel 6. shows the results of the practicality of the module from 16 student respondents.

Table 6. Module Practicality Questionnaire Results

No	Item	Mean Score
1	STEAM-based math modules are easy to use without requiring additional explanations.	3.8
2	The instructions in the STEAM based math module are very clear and easy to understand.	3.87
3	AR technology in STEAM-based math modules is easy to access and use	4.13
4	STEAM-based math modules can be used using commonly available devices.	4.2
5	STEAM-based math modules help me understand math concepts more easily.	4
6	The sections in the STEAM-based math module (Let's Observe, Let's Learn STEAM, Let's Try, Let's Practice) make learning easier.	4.1
7	STEAM-based math modules help you understand the steps to solve complex math problems in a sequential manner.	3.93
8	Visualization in STEAM-based math modules helps explain abstract math concepts more clearly visually.	4.2
9	STEAM-based math modules help me understand the relationship between different subjects and math.	4

10	STEAM-based math modules motivate me to be more enthusiastic about learning math.	3.8
11	STEAM-based math modules increased my interest in learning math using technology.	4.13
12	STEAM-based math modules can be used to assist learning in class or independently.	4.1
13	STEAM-based math modules fit my learning needs for learning math.	3.8
14	STEAM-based math modules provide a fun learning experience	3.93
15	STEAM-based mathematics modules support achieving learning goals.	4.1
	Average	4

Based on the results of the validation and practicality test of the module, it can be concluded that the STEAM-based mathematics module is declared very feasible and very practical so that it can be used for learning.

The results of the study on the development of a STEAM-AR-based mathematics module show that this module is declared valid and practical. The validity of this module was obtained through evaluation by material and media experts, who assessed that the content presented was in accordance with the curriculum and relevant to students' needs. The interactive module design, which utilizes Augmented Reality (AR) technology, provides a more engaging and in-depth learning experience for students. With this approach, students not only learn mathematical concepts theoretically, but can also see real applications of these concepts through interactive visualizations, thereby increasing their understanding and motivation in learning mathematics.

This is in line with research conducted by Sweetya Auliya et al. (2024) which shows that the Ethnomathematics E-Module centered on Social Arithmetic through STEAM is valid, practical, effective, and successful in improving students' problem-solving abilities. E-modules are modules in electronic form that can be accessed and used via electronic devices such as computers, laptops, tablets or smartphones. (Pasaribu et al., 2024). At the Expert Review stage, the E-Module underwent a validation assessment, obtained a score of 91.3% and was included in the very valid category. The practicality of the E-Module was assessed through individual and small group evaluations resulting in a student practicality score of 98.3% in individual sessions and 98.2% in small groups indicating high practicality. Research that developed STEAM-based modules was also conducted by Rahardjoni and Mashuri (2022) explaining that the teaching materials had met the suitability of the characteristics. The results of the validity test showed a percentage of 89.3%. The results of the readability test showed a percentage of 74.8%. The results of the pretest and posttest analysis showed that the teaching materials could improve students' mathematical creative thinking skills with an

N-Gain value of 0.34 in the moderate category. Therefore, the developed Science, Technology, Engineering, Art, and Mathematics (STEAM)-based teaching materials meet the requirements.

In comparison with other studies that also developed STEAM-based modules, such as those conducted by (Hsiao & Su, 2021), this STEAM-AR module showed advantages in terms of interactivity and student engagement. Other studies, although also producing valid and practical modules, tend to focus more on the use of traditional media and multimedia without AR integration. This shows that the STEAM-AR module not only meets the standards of validity and practicality, but also offers innovation in learning that can improve the quality of mathematics education (Sylvestre, 2024). Thus, the development of STEAM-AR-based modules can be an effective model to be implemented in schools, encouraging the integration of technology in learning and preparing students to face challenges in the digital era.

CONCLUSION

This study produced a STEAM-based module, namely the integer material module. The quality of the STEAM-based module developed is seen from two criteria, namely validity and practicality. The validity criteria for the STEAM-based module can be seen from the validation of the material which includes aspects of feasibility, linguistic aspects, presentation aspects, and media validation. The practicality criteria can be seen from the student practicality questionnaire. Based on the validation results from media, language, and material experts, the STEAM-based module developed was declared very feasible. In addition, the STEAM-based module on the integer material used can be declared practical based on the results of the practicality trial. Therefore, the STEAM-based module can be used by teachers for classroom learning and can help students improve their mathematical abilities in the learning process.

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