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Validity of STEM-CT Based Textbooks to Improve Students Multi-Representation Ability

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Abstract: This research aims to describe the validity of STEM-CT-based textbooks in improving multi-representation abilities in MTs students. This study used the Research and Development (R&D) method using the 4D model, which consists of four stages, i.e., Define, Design, Develop, and Disseminate. However, this study only discussed preparing textbooks' Define, Design, and Develop stages. The research participants were teachers of the Science MGMP in Banyuwangi. The data collection techniques used in this research were interviews, questionnaires, and validation sheets. The analysis used in this research was descriptive and qualitative. The data processing results for STEM-CT-based textbooks to improve multi-representational abilities in MTs students obtained a validity value of 82.86 in the very valid or usable category. The validation results showed that the STEM-CT-based textbooks developed could be used for classroom learning to improve students' multi-representation abilities.

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Introduction

Science and technology that continues to develop is a condition that cannot be avoided. Science and technology certainly do not develop alone but are always accompanied by changes in various other aspects of life. It would help to have an intelligent and wise mindset to keep up with increasingly massive developments and changes. Because of this, education and learning are needed as the first step in creating patterns of thinking that align with current developments in science and technology (Sharma & Ankit, 2023).

The Republic of Indonesia Law no. 20 of 2003 concerning the National Education System Chapter I Article 1, paragraph 20, states that learning is a process of interaction between students and educators and learning resources in a learning environment. Thus, in the learning process, three components, namely educators, students, and learning resources, interact with each other. Learning resources are all various sources in the form of data, people, methods, media, and places where learning takes place, which are used by students to make learning easier (Samsinar, 2019), therefore selecting, developing, and using appropriate learning resources is one of the factors important in the success of learning.

One type of learning resource commonly used in schools today is textbooks. *Textbooks* are teaching manuals in each branch of study (Cahyani & Perdana, 2019), which are used as a basic source of teaching in many countries to facilitate students' understanding and teacher teaching (Yang & Sianturi, 2017). The orientation of providing textbooks is increasingly developing as time goes by. Textbooks are expected to help students reproduce knowledge, think critically, analytically, reflectively, and develop character

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(Muyassaroh & Sunaryati, 2021). It is believed that the use of textbooks in schools can provide benefits such as increasing students' interest, attitudes and performance (F. Li & Wang, 2024), developing work independence and independent knowledge construction (Bokova & Markova, 2021), as well as increasing students' understanding and thinking skills (Lubis et al., 2023).

In Indonesia, the government provides textbooks for students and teachers' books. However, several studies have found weaknesses in textbooks the government provides. Research conducted by Candra et al., (2020) evaluated natural science (IPA) textbooks provided by the government. The evaluation results found inaccuracies regarding concepts, principles, and illustrations. In line with research by Candra et al. (2020), research conducted by Behnke (2018) and Mariani & Usmeldi (2019) also found inaccuracies in textbooks in circulation. Other research conducted by Nursyahrifa et al., (2019) and Pasaribu (2022) provides recommendations for textbooks currently circulating to improve their appearance and content and add elements of real experience for students to reach the appropriate expected taxonomic level.

The research recommendations of Nursyahrifa et al., (2019) and Pasaribu (2022) are to add elements of real experience for students, one of which can be realized by integrating the STEM approach into textbooks. STEM (Science, Mathematics, Engineering, and Technology) is an approach that aims to combine science, mathematics, engineering, and technology by facilitating holistic learning so that it can help students gain knowledge independently and skillfully (Lafifa et al., 2023; Uzun & Şen, 2023). Ng (2019) revealed that STEM competencies include 'know-what' (knowledge, attitudes, and values related to scientific disciplines) and 'know how' (skills to apply that knowledge, taking into account attitudes and ethical values so that one can act appropriately and effectively in a particular context). As an interdisciplinary approach, STEM plays a role in improving critical thinking and collaboration skills, triggering students to utilize their creativity to solve complex problems, fostering deeper engagement with the subject, and sparking enthusiasm for learning (Eshaq, 2024; Gürsoy et al., 2023).

STEM is undeniably a holistic and forward-thinking approach to the 21st century. STEM promotes an interdisciplinary mindset that helps students recognize the interconnectedness of STEM in real-world applications. Including practical examples increases students' motivation to learn and equips them with the skills to face global challenges and adapt to continually evolving conditions (Eshaq, 2024). Another skill that can be improved by applying STEM is multiple representation abilities. Learning by integrating STEM requires students to analyze technology techniques using various representations. As a result, students understand concepts well and can familiarize themselves with various representations, which impacts improving multi-representation skills (Tenti et al., 2020). Representational skills are the ability to present information without losing the initial information from an object into another form of representation. It can be seen in a person's skills in drawing, making graphs, making tables, and elaborating objects to simplify them so they can be understood well (Zubaidah et al., 2023).

The explanation of the weaknesses of currently circulating textbooks and STEM as an approach that can cover the weaknesses of these textbooks has inspired researcher to develop STEM-CT-based textbooks. STEM-CT integrates STEM (science, technology, engineering, and mathematics) and CT (computational thinking). The integration between CT and STEM is new but very important for educating students. This integration has a very open topic and leads to very broad cross-disciplinary collaboration (Li et al., 2020). In the STEM approach,

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computational thinking (CT) is a cognitive skill set that allows students to identify patterns, solve problems, organize and create solutions, and build data representations through simulations (Tekdal, 2021). Computing has the potential to provide new, profound, and highly impactful literacies that will impact all STEM disciplines at their core, but especially in terms of learning (diSessa, 2018). Therefore, this research aims to describe the validity of STEM-CT-based textbooks in improving multi-representation abilities in MTs students. It is hoped that the results of this research can enrich learning resources that can help improve students' multi-representation abilities.

Research Method

This study used a research and development (R&D) method because it aims to produce and develop a product that is suitable for use and suits the needs of students (Nurmalasari et al., 2022). The resulting product was a STEM-CT based textbook. The development model used in this research was the 4-D development model (Define, Design, Develop, and Disseminate) developed by Thiagarajan. This study only discusses preparing textbooks' Define, Design, and Develop stages. At the define stage, activities were carried out to determine the need for textbooks and carry out concept analysis. At this stage, it was also decided that the material in the textbook was light with the sub-material of reflection and refraction of light. At the design stage, activities were carried out to design learning tools to obtain a textbook prototype. After producing a prototype, the next stage is the development stage. In the development stage, validation was carried out on the resulting prototype. Validation is carried out by three experts who will provide a score on the product's validity and suggestions for improvement or further product evaluation. The validator will give a score ranging from 1-5 to the six validation aspects in the validation sheet provided.

$$V = \frac{T_{se}}{T_{sh}} \times 100\ \%$$

The scores obtained were then analyzed using the formula, where V is the percentage of validity, Tse is the number of scores obtained, and Tsh is the maximum number of scores (Amalia et al., 2022). Then, the obtained validation results are transformed according to the textbook validity criteria listed in Table 1.

Table 1. Textbook Validity Criteria

No	Percentage (%)	Validity Criteria
1	81,00-100	Very valid or can be used without revision
2	61,00-80,00	Valid, usable with minor revision
3	41,00-60,00	Valid enough to be used with moderate revision
4	21,00-40,00	Not valid, recommended not to be used, needs major revision
5	00,00- 20,00	Invalid or may not be used

(Akbar, 2013)

Results and Discussion

Define Stage

The defining stage was realized through interviews conducted with several science teachers in the MGMP group in the Banyuwangi area. The results of interviews found that teaching materials such as textbooks, worksheets and textbooks used in learning, especially textbooks, usually contain material reviews with sentence descriptions and do not display pictures, diagrams and graphs. He also explained that textbooks were used more for practicing questions than helping students understand the material. As a result, the learning

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process in class is not optimal. The textbooks used usually contain reviews and few pictures. The problems regarding textbooks experienced by Banyuwangi MGMP teachers are not a new problem. Similar problems were also found in several previous studies. Rochim et al., (2019) explained that according to class VIII science teachers at SMPN 1 Ngadiluwih and SMPN 7 Kediri, they stated that the textbooks (student books) currently being used were still difficult for students to understand in terms of the use of language and images. Aregehagn et al., (2023) found similar results in that the topic of geometric optics was considered difficult by students because of the representation in textbooks. They also explain that although textbooks sometimes contain clear, integrated explanations that clarify images, they also contain implicit, missing, incorrect verbal representations and unclear images. In addition, textbooks rarely show alternative representations that complement problematic representations, limiting mis-interpretation.

Design Stage

The product developed and validated in this research is a STEM-CT-based textbook to improve multi-representation abilities in MTs students. The book consists of 58 pages in total. The developed textbook has several components that can be classified into three large parts: introduction, content, and conclusion. The introductory section consists of several components: the cover, title page, foreword, instructions for use, and table of contents. The content section consists of pages that review STEM-CT and multi-representation, concept maps, learning units 1 and 2, and STEM-CT challenges. The closing section consists of a glossary and bibliography. The appearance of the textbook being developed is shown in Figure 1.

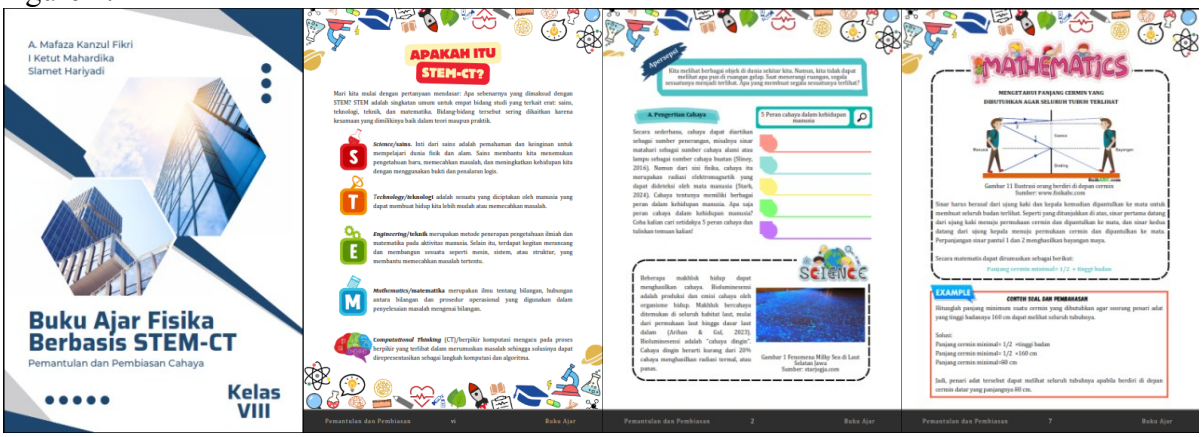

Figure 1. Display of STEM-CT Based Textbooks

In addition to compiling the book, a validation sheet is prepared at the design stage, which three experts will complete.

Develop Stage

The textbook prototype prepared for the design stage was validated at the development stage. Validation means testing whether a method can provide the expected results (Schmitt et al., 2015). If converted into this research, validation is carried out to test whether the developed textbook can improve students' multi-representation abilities. Validation is important because it provides evidence for critical assessments and decisions regarding existing gaps (Cook & Hatala, 2016). Three experts carried out textbook validation. The validation results by three experts are listed in Table 2.

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Table 2. Validation Results of Three Experts

Validator 1	Validator 2	Validator 3	Average (%)	Validity Categoy
86,77	80,04	81,76	82,86	Very Valid

The data in Table 2 show the results of three experts' textbook validation. The data processing results show that the average of the three validators has a validity level of 82.86. Obtaining this value means that the textbook developed is in the very valid category. Three experts validated six aspects of textbook development: design, content appropriateness, presentation appropriateness, graphic appropriateness, linguistic appropriateness, and function and benefit. The validation results for each aspect are listed in Table 3.

Table 3. Validation Results of Each Aspect

No	Aspects	Value of Each Validator (V)				Validity Category
		V1	V2	V3	Average (%)	
1	Design Aspects	86,67	83,33	83,33	84,44	Very Valid
2	Content Feasibility Aspect	84,62	80,00	81,54	82,05	Very Valid
3	Aspects of Feasibility of Presentation	87,69	76,92	81,54	82,05	Very Valid
4	Graphic Feasibility Aspects	86,67	80,00	76,67	81,11	Very Valid
5	Linguistic Aspect	90,00	80,00	87,50	85,83	Very Valid
6	Function and Benefit Aspects	85,00	80,00	80,00	81,67	Very Valid

The data in Table 3 shows the validation obtained by three validators for six aspects of textbook development. The design aspect obtained an average validity level of 84.44; the content feasibility aspect obtained an average validity level of 82.05; the feasibility aspect of presentation obtained an average validity level of 82.05; the graphic feasibility aspect obtained an average validity level of 81.11; the linguistic aspects obtained an average validity level of 85.83; and the function and benefit aspects obtained an average validity level of 81.67. Thus, all aspects of textbook development are included in the very valid category. With this category, it can be interpreted that the textbooks developed can be applied in learning activities and can influence students' multi-representation abilities.

Elvionita et al., (2019) revealed that the quality of textbook content can be seen from three main criteria: suitability of the material to the curriculum, accuracy of the material, and presentation of supporting material. The suitability of the material to the curriculum can be assessed based on its completeness, breadth, and depth. The accuracy of the material can be assessed based on the accuracy of concepts, definitions, principles, procedures, examples, facts, and illustrations. The presentation of supporting material can be assessed based on its suitability to educational and technological developments, advances in characteristics, examples and references, reasoning, problem-solving, concept linkages, communication, motivation, and presentation of enrichment material. Murtadho et al., (2024) revealed that if the content of textbooks is not relevant or interesting for students, this can cause disinterest and impact students' motivation and interest to learn. Additionally, if textbooks are poorly designed and structured, students may have difficulty following the material and become frustrated with the learning process. These negative experiences can lead to decreased self-confidence and willingness to engage with the material, ultimately hindering their academic progress.

The textbook developed in this research contains several components such as the application of S-T-E-M-CT components in everyday life, multi-representation questions, an

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"important" column that contains highlights in a discussion, as well as a "lets go STEM-CT challenge" component which contains STEM-CT based activities that teachers can do with students. Textbooks are also developed to include colored pictures and illustrations. For students, interesting and attractive pictures and illustrations can make it easier for students to understand the material (Akhmad et al., 2022), while for teachers, pictures and illustrations in textbooks can make learning activities more lively, interesting, and useful by using the pictures contained in textbooks (Hussain & Khan, 2022). By obtaining validation results with a very valid category and several components contained in the textbook, teachers can use this textbook in classroom learning activities that can build new teaching and learning environments and inspire learning and creativity.

Conclusion

Based on data obtained from validation and discussion results, it was concluded that STEM-CT-based textbooks to improve multi-representational abilities in MTs students received a validity value of 82.86 in the very valid category or can be used. In this way, the textbook developed is declared valid for use in learning.

Recommendation

This research is still being carried out at the development stage related to the textbook preparation process and has not yet reached the dissemination stage. Therefore, a dissemination stage is necessary to obtain more points of view and input to improve the quality of this textbook. Furthermore, to improve the quality of STEM-CT-based textbooks, their content can be made more varied in appearance by adding more interesting illustrations, examples, and activities. At school, teachers must be able to develop textbooks that are as interesting as possible to build students' multi-representational thinking abilities.

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