RESEARCH ARTICLE

Developing of STEM-based charta learning media to improve critical thinking ability student on plant structure and function material

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Abstract: This research was motivated by several obstacles, including teachers in the learning process only focusing on thick textbooks and the student worksheets provided by the school were less interesting and effective. The aim of this research is to develop chart learning media based on Science Technology Engineering Mathematics (STEM) to improve critical thinking skills. This development research was carried out at Junior High School 7 of Bengkulu, Bengkulu Province - Indonesia using the Thiagarajan 4-D model which consists of four stages. The instruments used were media suitability validation questionnaires, teacher responses, student responses, and students' critical thinking ability tests on STEM-based graphic media. Data from questionnaire analysis by calculating the percentage of achievement for each component is 86.6% (material expert), 100% (linguist), 98.75% (media/design expert), and 88.3% (test question expert) with the category suitable for use. The practicality of graphic learning media based on student response data and science teacher responses conducted in limited trials shows that STEM-based graphic learning media on Plant Structure and Function material includes very practical criteria for use without revision with percentages of 92, 80%, and 94%. The effectiveness of media has an important role and helps students develop their potential in the learning process. The conclusion of this research is that the media developed has been practically and effectively used as a learning medium in supporting the teaching and learning process on the structure and function of plants in improving the critical thinking skills of class VIII junior high school students.

Keywords: chart; critical thinking skills; STEM

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Introduction

Science is one of the subjects in school that is devoted to teaching natural science and the environment (Jumriani & Prasetyo, 2017; Pollard et al., 2018). In science learning, teachers need learning tools that can support continuity and make it easier for students to understand what the teacher sees, and can involve students to actively participate in ongoing learning activities (Grau et al., 2021). It is hoped that this can be achieved if choosing the right learning media can improve the quality of learning so that students easily understand the material being studied (Arda et al., 2015; Sulisetijono et al., 2023). Learning media can be understood as materials, and equipment, the learning process will be successful if students are motivated to learn with the help of learning media (Bender & Sung, 2020; Dukut, 2019).

In the learning process, teachers have used chart media in the learning process on the structure and function of plants, but this media is still too rigid in learning and less interesting because media design is quite behind technological developments. Apart from that, the learning process in schools still predominantly uses printed books and student worksheets whose contents do not optimally stimulate students' critical thinking. This situation has a broad impact on ineffective learning. In other words, the

material taught is less efficient and many students do not comprehensively understand the material being taught. Therefore, a solution is needed to overcome this problem by developing chart learning media that makes it easier for students to understand the material and improve their critical thinking skills (Ihsan et al., 2019).

The chart is one component that has an important role in the learning process. The use of charts, according to several researchers, can help students obtain information about learning material. Charts that are designed systematically and attractively are considered to be able to convey messages and optimize the expected potential according to the needs of their users (Wahyuningsih, 2021). Apart from that, the scientific content in it can make it easier for students to learn independently with a little teacher's help. Chart media based on science technology engineering mathematics (STEM) integrates problems and concepts by linking it to scientific disciplines in related sciences (Rohmah & Fadly, 2021). Furthermore, at the junior high school level, students need to be challenged to carry out authentic tasks as a complement to science learning through learning activities that integrate science, engineering, technology, and mathematics (Gusmawan et al., 2021).

STEM allows students to learn academic concepts comprehensively using a multidisciplinary approach (Julia, 2020). According to several researchers, the integration of the STEM approach has several characteristics, including technology-based, performance-based, inquiry-based, and problem-based learning (Prismasari et al., 2019). The STEM approach integrates more than one related field of science in solving problems that are contextual to real life. The use of STEM in the learning process can be applied in the form of models or learning media, one of which is charta media (Lafifa et al., 2022; Pitt et al., 2019). The integration of STEM-based Charta media is expected to improve students' critical thinking skills, namely reflective thinking skills that focus on how to make decisions about what to believe and what to do (Dewanti & Santoso, 2020).

Several research results using digitalization methods in learning are efficient and optimal for research student learning outcomes (Saputra & Filahanasari, 2020). The use of flipbooks in learning also plays an important role in improving student learning outcomes (Aprilia, 2021). This is also reinforced by Bender and Sung (2020); Bray and Tangney (2016); and Weng et al (2022) who stated that by using learning media, especially digital media, the learning process becomes more active and students have an important role during the learning process, in order to improve their learning outcomes. Therefore, this research was conducted to develop appropriate and interesting STEM-based Plant Structure and Function material to improve students' critical thinking skills. As for the positive impact obtained from this research, it is hoped that as a learning resource for students, it can be used as a further reference to emphasize STEM-based learning as well as motivate and inspire educators to use STEM-based charts to improve critical thinking skills.

Method

This research and development (R&D) design uses the 4D development model by Thiagaradjan. The four stages of development are carried out starting from definition, design, development, and distribution (Thiagarajan et al., 1976). This research and development is carried out to test and improve the quality of the media produced, including the function or validity of the product. Media development in a broad sense can take the form of updating existing products (to make them more practical, efficient and effective) or creating new products that have never existed before.

The population in this study was 186 students, consist of 97 male and 86 female, in class VIII Junior High School (JHS) 7 of Bengkulu City, Bengkulu Province, Indonesia. The sampling technique used during the trial used a random sampling technique. The reason for using this technique is to reduce data bias. Because random sampling is carried out by selecting members of the sample and population at random without paying attention to the strata in the population. Based on the random sampling technique, the researcher took a sample of two classes which will be used as an experimental class that uses media and a control class that does not use media, namely students in classes VIII E and VIII F.

The data collected by researchers in this study came from different data sources. The purpose of using multiple data sources is to ensure that the information available is useful. Data collection techniques include observation, interviews, questionnaires, tests, and documentation. Identify product feasibility using measurements on a Likert scale. The data obtained through distributing questionnaires from material, language, and media experts is quantitative (assessment) which will be interpreted qualitatively. Next, a validation sheet is prepared to obtain an assessment from the validator of whether STEM-based learning graphic media can improve critical thinking skills. The learning media developed is tested by language experts, material experts, and media/design experts. The data obtained by the validator is then analyzed and used to revise the training material. Quantitative data validation questionnaires can be processed in the form of percentage representation using a Likert scale as the measurement scale. The Likert scale is an attitude scaling method that uses response distribution as the basis for determining

scale values and determining critical thinking ability values using SPSS calculations.

Results and Discussion

Definitions in product development are carried out to find the root of existing problems such as students' needs for interesting learning (Agatha et al., 2018; Sari et al., 2022). It is done to ensure chart development is in accordance with the learning needs and characteristics of students as users (Van Eijk et al., 2012). The results of the identification that have been carried out are the basis for selecting applications such as Canva to help edit and design chart media and after that select materials for printing chart media. This activity enters the design stage. The product development stage is carried out by reviewing and conducting feasibility assessments by experts, namely material experts, linguist, and media experts, as well as receiving input in the form of student evaluations. The final stage in this development is product distribution within schools only.

The results of material, language and media experts' assessments of STEM-based chart media are as explained in Figure 1. The results of the experts' assessments show a percentage above 85%. In other words, the charts developed are very suitable for use as learning media in schools. The practicality test results also show that STEM-based chart media received an assessment percentage above 90.00%, both from teacher assessments (94.00%) and student assessments (92.06%). The results of the product practicality test are as described in Figure 2.

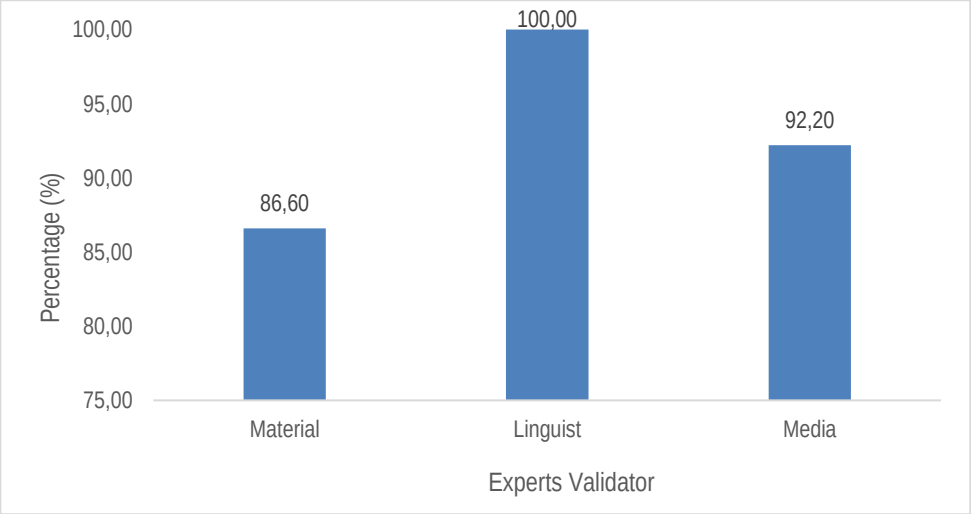

Figure 1. The results of experts' validation

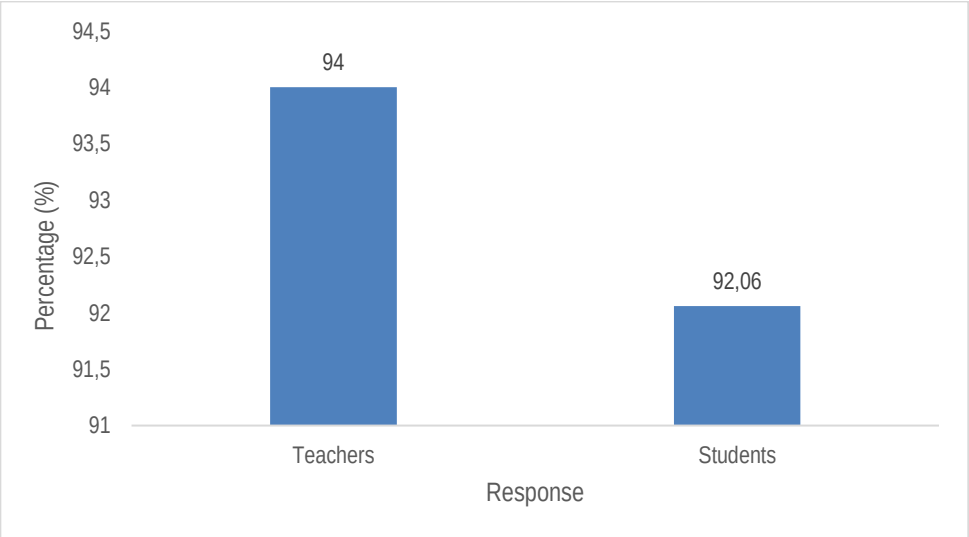

Figure 2. The results of product practicality test

The results of charta media testing in classes VIII-E and VIII-F showed significantly different results. Class VIII-E students obtained an average result of 79 and class F only 77.9. In this case, class VIII-E is taught using charta media while class VIII-F is not.

This research produces learning media in the form of graphic media to support learning activities on STEM-based plant structure and function material. In the define stage of media development, which begins with analyzing student needs, the aim is to determine the needs of class VIII students for charta learning media (Fatimah et al., 2018; Nurafifah et al., 2017). Based on the results of the analysis of student needs, it can be seen that some students have handbooks as learning materials that they use (Chinedu & Olabiyi, 2015), but students experience difficulties because the presentation of books and worksheets is still monotonous and less effective (Siagian et al., 2014). Finally, students feel bored in the learning process. With the media, teachers are expected to be able to refer to independent practice questions and provide assignments to improve critical thinking skills (Handayani, 2020; Smith et al., 2022). The curriculum used in media training is the 2013 curriculum. The content contained and the learning objectives to be achieved in the media are adjusted to the curriculum and lesson plans used by the teacher.

At the design stage, the researcher designs the framework of the media frame, including preparing an outline of the material to be included, selecting the writing format, image placement patterns, and displaying media graphics (Sari et al., 2022; Sofiani et al., 2018). The media consists of one material, namely plant structure and function material, adjusting the number of core skills in the syllabus. The next stage carried out is development, at this stage, the media project that has been prepared is validated by experts including material, language and media/design experts (Dewanti & Santoso, 2020; Narulita et al., 2019). The validation results from experts in the form of comments and suggestions are used as media suitability. Apart from expert validation, the media was also tested on students as media users with the aim of knowing students' responses to the media that had been prepared by providing a media evaluation questionnaire. The final step carried out by researchers was disseminate, at this stage the media that had been validated and declared suitable was disseminated to teachers and students of class VIII JHS 7 of Bengkulu City. Printed media is only distributed to science teachers as product examples. Meanwhile, as a means of media dissemination by teachers, researchers provide softcopy media so that they can be reproduced independently by both teachers and students.

Based on the results of the analysis of teachers' and students' needs to understand problems in the field, an initial product was obtained whose preparation developed material. The media developed aims to explain material about the structure and function of plants by linking independent problem-solving to it (Astra et al., 2020; Thompson, 2011). The results of the research show that in the assessment of material experts, language experts, STEM media/design experts, and test question experts, it can be seen that in general the media being developed is in the very feasible category. This STEM-based graphic media can be said to be very suitable for use because it meets the minimum criteria. However, there were several comments and suggestions given by the validator regarding the suitability of the material, appearance of the cover design, coloring, source, punctuation, and writing (Baran et al., 2016; Borchardt et al., 2019). However, this media is very suitable for use by researchers so the media developed can be said to be suitable for testing in schools. It is supported by Hendri et al (2021) who stated that the development of STEM-based learning media must contain construct validation which includes material, media, and language that have criteria that are very worthy of being studied because the content of the material in the media is appropriate and easy to understand, so it can be used as a learning tool in secondary schools.

The results of the practicality test by looking at the responses of science teachers and students to the media, showed that the practicality of the learning media was very good so that it received a very practical category, as did the teacher's response to the practicality of the learning media. The charta learning media used can make it easier for students to understand the lessons taught by the teacher, especially regarding the structure and function of plants, apart from that, with the charta learning media, teachers can be helped in explaining the learning material more practically and clearly (Kundariati & Rohman, 2020; Milala et al., 2021). This is supported by Cahyani and Sari (2020) that the practicality of STEM-based learning media for student responses can be said to be very good because the media taught can make it easier for students to understand learning because students are quicker and grasp understanding of the material being taught. Furthermore, it can arouse students' curiosity and activate creative imagination and critical thinking. Cahyani and Sari (2020) also states that practice media can stimulate students to be more active in learning and the media developed can be used to motivate students to study science material during learning (Criollo-C & Luján-Mora, 2019; Saribas, 2015).

The use of charta learning media accelerates the teaching and learning process. This can happen because learning runs more effectively and efficiently (Rajendra & Sudana, 2018; Siagian et al., 2014), thereby providing a conducive atmosphere because it can make students understand more quickly (Ouyang et al., 2022). On the other hand, learning that does not optimize the use of media is only

monotonous and uninteresting. The integration of the STEM approach in charta also provides students with the opportunity to grow their understanding of the relationship between students' curiosity and can improve students' critical thinking in solving problems faced during learning (Budiarti et al., 2016; Handayani, 2020), for example contextual questions given by the teacher. Therefore, the existence of STEM-based graphic learning media can improve students' critical thinking abilities. Students are also more active and enthusiastic in learning, especially developing high potential and curiosity.

Sari et al (2022) believes that learning media can be said to be effective and efficient, because the understanding of the material explained using learning media is clear and easy to understand by the students concerned. Apart from that, this learning media cannot be separated from the STEM approach (Idris et al., 2022; Wahyuni et al., 2022), therefore with this approach the teaching and learning process can take place more easily because this approach can direct students to find solutions to the problems they face, and can also improve students' critical thinking skills in order to solve problems (Ouyang et al., 2022; Purwaningsih et al., 2020), such as questions and group discussions in class. Lafifa et al (2022) also argue that with the existence of learning media, the quality of student learning can increase because not only teachers are active in providing material to students, but students can also be active in learning. The STEM approach also plays an important role in supporting learning and can increase students' curiosity (Lou et al., 2017) and can improve students' critical thinking skills during the teaching and learning process (Alkautsar et al., 2023; Dewanti & Santoso, 2020; Widya et al., 2019).

Conclusion

Based on the data obtained, the results and discussion of the development of STEM-based graphic learning media can improve critical thinking skills on the structure and function of plants. The development test results show that charta media has been validated and is suitable for use in the science learning process.

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Author Contributions

A. Topano: Writing – review and editing. **D. Kurniawan:** Writing – review and editing.**E. A. Saputra:** Writing – original draft and editing; methodology; analysis.

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