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Development of JHS STEAM-based mathematics teaching material to enhance students' mathematical connection ability

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Abstract

One of skills needed in the disruption era is the mathematical connection ability. However, this ability has not been optimally facilitated through learning process. In fact, the disruption era also encourages renewal, one of which is through the provision of quality learning resources both in terms of content and approach. In addition, the disrupstion era has also led to various approaches that more suitable with existing developments and changes, such as the STEAM approach. Therefore, it is important to develop a qualified STEAM-based mathematics teaching material to improve students' mathematical connection abilities. The development of this teaching material uses a modified Borg and Gall model of research and development (R&D) method. There are ten stages that aim to develop and describe the quality of STEAM-based mathematics teaching materials in three indicators, namely validity (characteristics suitability and feasibility), practicality (readability), and effectiveness in improving students' mathematical connection abilities. The final results are STEAM-based mathematics teaching materials that are valid (meet the teaching materials characteristics suitability and include in the very feasible category with feasibility score of 89,09%), practical (easy to understand with readability score of 67.13%), and effective in improving students' mathematical connection abilities with moderate improvement category (with gain normalization index score of 0.395).

1. Introduction

The era of disruption confronts humans with various changes and increasingly complex challenges in various fields of life, including the field of education. These changes have brought the world into a volatile, uncertain, complex, and ambiguous (VUCA) condition (Latha & B., 2020). Therefore, a more comprehensive capability is needed to be able to take advantage of the advantages of the era of disruption and minimize its negative impacts. One of the important skills to develop is the ability to connect or build connections. The ability to build these connections becomes an important basis in the problem solving process. This ability will provide a complete picture of various aspects and their relationships so that the solutions taken are more appropriate. In mathematics, this ability is known as the ability of mathematical connections.

The mathematical connection ability of students in Indonesia is still in the low and medium categories (Hasbi, Lukito, & Sulaiman, 2019). This is based on the results of assessments both at the national and international levels. At the national level, the results of the National Examination (UN) and the Indonesian Student Competency Assessment (AKSI) show that mathematics occupies the lowest position in the subjects tested and its absorption capacity is still low. (Puspendik, 2019a; Puspendik, 2019b). At the international level, the 2018 Program for International Student Assessment (PISA) results show that only 28% of Indonesian students are able to represent simple problems mathematically (OECD, 2018). In addition, the results of the Trend in International Mathematics and Science Study (TIMSS) 2015 show that

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Indonesia is ranked 44th out of 49 participating countries which shows the low mathematical ability of students in Indonesia, including students' mathematical connection abilities (Mullis et al., 2015). Therefore, it is important to develop mathematical connection skills continuously, especially mathematics is a subject that is always present at every level of education. This development can be done by taking advantage of the challenges and new trends in education generated by the era of disruption.

One of the challenges of the era of disruption in the field of education according to Totok Supriyatno, Ph.D. is the renewal of learning resources both in terms of content and approach (Lubis, 2019). The learning resources that are easiest to use are teaching materials in the form of books. Teaching materials in the form of books are a driving force for the creation of independent learning for students. With the advantages of being easy to find, adapt, and use, teaching materials in the form of books also have disadvantages in approaches that are often not adaptive to developments and changes that occur (Mayembe & Nsabata, 2020). This causes books to tend to be unattractive and less relevant to students' everyday lives. This can actually be circumvented by updating the approach used in the book and developing the content of the book to be more relevant to everyday life. The STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach, which combines the objective and logical nature of STEM (Science, Technology, Engineering, and Mathematics) with the subjective and intuitive nature of art, can be used as an alternative approach to material innovation. teaching in the form of books (Kang, 2019).

The STEAM approach is an approach that is being developed and is becoming a trend in the world of education. This is because the STEAM approach provides students with opportunities to innovate and solve problems through planning, teamwork, design, and communication (Ramadani, 2020; Ruangsiri et al., 2020; Ata-Aktürk, A., & Demircan, H. ., 2017). In addition, the STEAM approach also focuses on creating community value and empathy through design and art (Choi & Hwang, 2018). So that the STEAM approach is able to accommodate the shortcomings of teaching materials in the form of books.

Based on the description above, it is important to develop a mathematics teaching material based on the STEAM approach to improve students' mathematical connection skills which are still low. The materials selected in this development are quadrilaterals and triangles in class VII semester 2. This research and development aims to develop and describe the quality of STEAM-based mathematics teaching materials on quadrilaterals and triangles in three indicators, namely the validity indicator (related to the suitability of the characteristics of teaching materials and the validity level), practicality indicators (related to the readability of teaching materials for students), and effectiveness indicators (related to increasing students' mathematical connection abilities). This research has benefits as an effort to provide alternative learning resources that are feasible, practical, and effective, and able to accommodate essential abilities in this era of disruption.

2. Methods

The method that will be used in this research is the modified Borg and Gall model of Research and Development method. Research and development methods are research methods used to produce a product and test its effectiveness (Sugiyono, 2017). This research has ten steps that can be seen in the figure 1 below.

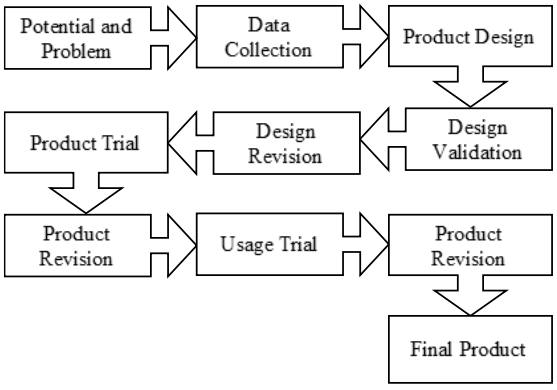

Figure 1. Steps of this research

This research has five stages. The first stage is design stage that include the three first step namely potential and problem, data collection, and product design. In this stage, the preliminary analysis was carried out before designing the teaching and material, then the teaching material was designed in this stage. The second stage is validity stage that has two steps namely design validation and design revision. In this stage, the design be tested by validator, then the design was revised when it needed. The third stage is practicality stage that has two steps namely product trial and product revision. The valid design then be tested in the form readability test by students as subject. The fourth step is effectivity stage that has two steps namely usage trial and product revision. The valid and practical design then be tested to know the effectiveness for improving students mathematical connection ability. The last stage is final product. When the design has been stated as a valid, practical, and effective then the design was submitted to get the copyright.

3. Results & Discussions

3.1. Potential and Problem

This step was carried out by conducting observations and interviews at SMP Negeri 4 Belik. Based on the results of observations and interviews, it was found that student learning resources were still limited and had not facilitated STEAM examples and problems. Other information obtained from the interviews is the lack of attention to the development of students' mathematical abilities, one of which is the ability to connect mathematically. In fact, mathematical connection skills are important to be able to support students' abilities in solving problems related to previous knowledge, other mathematical material, other disciplines, and everyday life. From the two problems above, it can be concluded that it is necessary to develop STEAM-based innovative teaching materials. The material taken is quadrilateral and triangle material in Class VII SMP Semester 2.

3.2. Data Collection

After finding the potential and problems in the field, the next step is data collection. The data collection consists of two analysis, namely analysis of competencies and analysis of learning resources. The competencies analysis is carried out based on the Regulation of the Minister of Education and Culture (Permendikbud) number 37 of 2018 concerning core competencies and basic competencies. According to Permendikbud, the basic competencies related to quadrilaterals and triangles are basic competencies 3.6 and 4.6. From these basic competencies, then four competency achievement indicator are developed. Learning resources analysis was carried out by collecting all ideas, concepts, and information related to the quadrilateral and triangle material. This analysis gave the ‘raw material’ for the net step called as product design.

3.3. Product Design

This step has three main stages. The first stage is book display design that aimed to design the appearance of the book starting from the cover until its’ final part. The second dtage is material content design that aimed to develop the ‘raw material’ from the data collection step to fullfil the competency achievement indicator. The third stage is complete product design that aimed to produce the STEAM-based teaching materials on quadrilateral and triangle. Teaching materials are made with ISO size teaching materials, which are A4 (21 × 29.7 cm) (Kusjuriansah & Yulianto, 2019; Niam & Asikin, 2020). The final result of this stage is an initial draft of STEAM-based teaching materials on quadrilaterals and triangles that are ready to be validated.

3.4. Design Validation

The design validation was carried out using two types of tests, namely the suitability test for the teaching materials characteristics and the validity test for STEAM-based mathematics teaching materials. Both tests were carried out simultaneously. The validation process involved 14 validators consisting of 10 junior high school teachers in Pemalang Regency, three UNNES Mathematics Education lecturers, and one UNNES Mathematics Education Masters student. The result of the design validation can be seen in the following figure.

Table 1. Validation result

Validator	Characteristics Suitability		Validity of Teaching Material	
	Category	Revision	Score (%)	Category
1	Suitable without revision		85,77	Very Feasible
2	Suitable with revision		84,25	Feasible
3	Suitable with revision		79,46	Feasible
4	Suitable without revision		92,65	Very Feasible
5	Suitable without revision		92,65	Very Feasible
6	Suitable without revision		92,26	Very Feasible
7	Suitable without revision		92,26	Very Feasible
8	Suitable with revision		93,29	Very Feasible
9	Suitable with revision		92,80	Very Feasible
10	Suitable with revision		92,20	Very Feasible
11	Suitable with revision		97,05	Very Feasible
12	Suitable with revision		83,42	Feasible
13	Suitable with revision		89,15	Very Feasible
14	Suitable with revision		83,89	Feasible

Based on the results of the characteristic suitability test, it was concluded that STEAM-based innovative teaching materials on quadrilaterals and triangles had met the suitability of characteristics as teaching materials, but still needed to be revised according to nine of the 14 validators. In line with the results of the suitability test of characteristics, the results of the feasibility test of teaching materials also showed that STEAM-based innovative teaching materials on quadrilateral and triangle materials obtained a very feasible validity level with a final score of 89.09%. The value of the feasibility of teaching materials from each validator is also in the range of feasible to very feasible levels of feasibility. This shows that teaching materials can already be used in learning but still need a little revision. Teaching materials are then revised according to these inputs so that the quality of teaching materials is getting better. After the teaching materials are revised, the teaching materials are ready to be used to be tested at the next stage, without repeating the design validation, because the feasibility value of the teaching materials is not less than or equal to 70% (Niam & Asikin, 2020; Utami et al., 2018).

3.5. Design Revision

Based on the results of design validation, STEAM-based teaching materials need to be revised to improve the quality of teaching materials. From design validation results, the required revision including: (1) the lack of spiritual aspects and attitude aspects, (2) the contextuality and contemporary of some materials need to be considered, (3) the affirmation of the learning model used, (4) the development of aspects of attitude that need to be added as well as the assessment that has not adequately accommodated the assessment of mathematical connection abilities, (5) the absence of prerequisite, improvement, and enrichment materials, (6) the number of students activity is still less, and (7) the less effective and lacking readibility sentence, and also the inappropriate use of terms and symbols. The STEAM-based mathematics teaching materials then be revised. The results of the design revision are then ready to be used in the next stage.

3.6. Product Trial

After the valid design of teaching material has revised, then it come to the next stage that is practicality stage. In this stage, the valid design will be tested its readability by gap test. This stage involved twenty students from SMP Negeri 4 Belik as the subject. The result of this stage can be seen in the figure below.

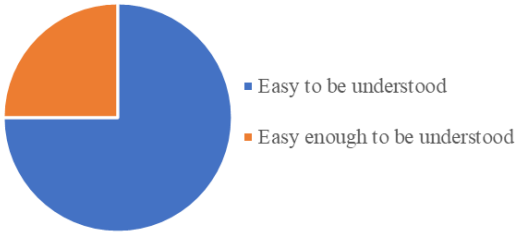

Figure 2. Practicality result

Based on the result, the STEAM-based mathematics teaching material is easy to be understood with average score of readibity test is 67,13%. This means that STEAM-based mathematics teaching materials are practical and easy to understand by students (Niam & Asikin, 2020). In addition, the results of the readability test of STEAM-based mathematics teaching materials show that students can understand the content of teaching materials both related to concepts and solving problems related to STEAM (Gustiani, 2017; Asikin, Nurhidayat, & Ardiansyah, 2021). STEAM-based mathematics teaching materials are also able to foster good reading interest from students based on the results of the readability test (Kusjuriansah & Yulianto, 2019; Niam & Asikin, 2020).

3.7. Product Revision

Since the STEAM-based mathematics teaching material is practical, it means that revision is not required (Kusjuriansah & Yulianto, 2019). Until this step, the STEAM-based mathematics teaching material has been stated as a valid and practical design. Then, it come to the next stage called as usage trial to test its effectiveness.

3.8. Usage Trial

In this step, the STEAM-based mathematics teaching materials will be experimented in the learning activity to test its effectiveness to enhance students' mathematical connection ability. The model of the experiment is one group pretest-posttest that involve twenty four students from SMP Negeri 4 Belik. Then, the pretest and posttest result will be analyzed by using gain normalization index (gain index). The following figure is the result of gain index for both average and each indicator of mathematical connection ability. The mathematical connection ability indicator (MCI) used is a modification of the mathematical connection ability indicator developed by Saminanto and Kartono (2015).

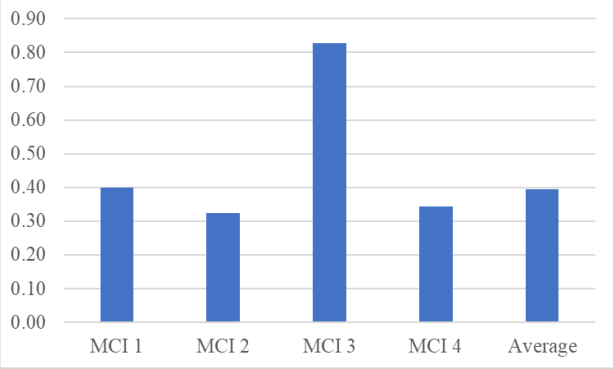

Figure 3. Effectiveness result

Based on the results, it is found that the gain index for MCI 1 is 0.400 and is in the medium category. This means that the use of STEAM-based mathematics teaching materials is able to improve the ability to connect mathematical concepts or principles in the same topic with a moderate improvement category. For MCI 2, the gain index obtained is 0.324 and is in the moderate category. This means, the use of STEAM-based mathematics teaching materials is able to improve the ability to connect the concepts of a mathematical material with other mathematics materials with a moderate improvement category. For MCI 3, the gain index obtained is 0.827 and is in the high category. This means that the use of STEAM-based mathematics teaching materials is able to improve the ability to relate mathematics material to other sciences with a high improvement category. For MCI 4, the gain index obtained is 0.344 and is in the medium category. This means that the use of STEAM-based mathematics teaching materials is able to

improve the ability to relate mathematical material to everyday problems that can be found by students with moderate improvement categories.

Meanwhile, according to the average, the gain index obtained is 0.395 and is included in the medium category. These results are in line with research from Niam & Asikin (2020) and Asikin, Nurhidayat, & Ardiansyah (2021), where the results of the gain normalization test that reached the medium category showed that the use of STEAM-based mathematics teaching materials in learning was able to improve students' mathematical connection skills with moderate category.

3.9. Product Revision

Since the STEAM-based mathematics teaching material is effective, it means that revision is not required (Kusjuriansah & Yulianto, 2019). Until this step, the STEAM-based mathematics teaching material has been stated as a valid, practical, and effective design which means the STEAM-based mathematics teaching material has fulfilled the requirement to be a good learning source. Then, it come to the next stage called as final product.

3.10. Final Product

The valid, practical, and effective design of STEAM-based mathematics teaching materials then be submitted to Directorate General Intellectual Property (DJKI) to get the copyright. The final product of STEAM-based mathematics teaching material is the valid, practical, and effectivedesign that has the copyright with the certificate number is 000306127.

4. Conclusion

Based on the description above, it can be concluded that the product of STEAM-based mathematics teaching materials is a quality teaching material that meets the following criteria: (1) valid, that is, it meets the suitability of characteristics as a learning resource for students and belongs to the very feasible category, (2) practical, which is easy to be understood by students, and (3) effective for improving mathematical connection skills in the medium category. It means this teaching material can be used in learning (Utami et al., 2018). There are several things that need to be considered for similar research: (1) the use of a protractor needs to be introduced first, (2) the use of problem based learning learning models with STEAM-based mathematics teaching materials can be done by adjusting the order of features and changing project activities into questions. discussion, (3) problem selection should be close to students' daily lives, and (4) it is important to test readability not only for students but also for teachers as learning facilitators in the classroom.

References

Asikin, M., Nurhidayat, M. F., & Ardiansyah, A. S. (2021). Development of STEM-nuanced textbook to improve students' mathematical communication skill. *Journal of Physics: Conference Series, 1918*(4), 042064. Doi: https://doi.org/10.1088./1742-6596/1918/4/042064

Ata-Aktürk, A., & Demircan, H. Ö. (2017). A Review of Studies on STEM and STEAM Education in Early Childhood. *Journal of Kırşehir Education Faculty (JKEF), 18*(2), 757–776. Retrieved from https://www.researchgate.net/publication/319702309_A_Review_of_Studies_on_STEM_and_STEAM_Education_in_Early_Childhood

Choi, J. H., & Hwang, B. K. (2018). The Concepts, Strategies and Application of STEAM Education in South Korea. *Proceedings - 2017 7th World Engineering Education Forum, WEEF 2017- In Conjunction with: 7th Regional Conference on Engineering Education and Research in Higher Education 2017, RCEE and RHEd 2017, 1st International STEAM Education Conference, STEAMEC 201*, 466–469. Doi: https://doi.org/10.1109/WEEF.2017.8467045

Hasbi, M., Lukito, A., & Sulaiman, R. (2019). The Realistic of Mathematic Educational Approach to Enhancing Ability Mathematical Connections. *International Journal of Trends in Mathematics Education Research, 2*(4), 179–183. Doi: https://doi.org/10.33122/ijtmer.v2i4.

Kang, N.-H. (2019). A review of the effect of integrated STEM or STEAM (science, technology, engineering, arts, and mathematics) education in South Korea. *Asia-Pacific Science Education, 5*(1). Doi: https://doi.org/10.1186/s41029-019-0034-y.

Kusjuriansah, K., & Yulianto, A. (2019). Pengembangan bahan ajar fisika berbasis i-sets terkomplementasi karakter pada materi hukum gravitasi newton. *UPEJ Unnes Physics Education Journal, 8*(2), 120-132. Doi: https://doi.org/10.15294/upej.v8i2.33314.

Latha, S., & B., P. C. (2020). Vuca in Engineering Education: Enhancement of Faculty Competency For Capacity Building. *Procedia Computer Science, 172*, 741–747. Doi: https://doi.org/10.1016/j.procs.2020.05.106.

Lubis, F. (2019, November). Education in the Disruption Era. *Britain International of Linguistics, Arts and Education (BIoLAE) Journal, 1*(2), 183-188. Doi: https://doi.org/10.33258/biolae.v1i2.85.

Mayembe, E., & Nsabata, S. (2020). Print Based Learning Media. *Journal Educational Verkenning, 1*(1), 001-007. Doi: https://doi.org/10.48173/jev.v1i1.23.

Niam, M. A., & Asikin, M. (2020). The Development of Science, Technology, Engineering, and Mathematics (STEM)-Based Mathematics Teaching Materials To Increase Mathematical Connection Ability. *MaPan, 8*(1), 153. Doi: https://doi.org/10.24252/mapan.2018v8n1a12.

Menanti, H., Sinaga, B., & Hasratuddin, D. (2018). Improve Mathematical Connections Skills with Realistic Mathematics Education Based Learning. *3rd Annual International Seminar on Transformative Education and Educational Leadership (AISTEEL 2018), 200*, 29–35. Doi: https://doi.org/10.2991/aisteel-18.2018.7.

OECD. (2018b). What 15-year-old students in Indonesia know and can do. *Programme for International Student Assessment (PISA) Result from PISA 2018, 1–10*. Retrieved from http://www.oecd.org/pisa/ Data.

Puspendik. (2019b). Laporan Hasil Ujian Nasional. Retrieved from https://hasilun.puspendik.kemdikbud.go.id.

Ramadani, E. (2020). Pengembangan Handout Matematika Berbasis Pendekatan STEAM (Science, Technology, Engineering, Arts, and Mathematics) pada Materi Segitiga dan segiempat untuk Peserta didik Kelas VIII SMP. (Bachelor's Thesis). Universitas Jambi. Retrieved from https://repository.unja.ac.id/id/eprint/10678%0A.

Ruangsiri, K., Nuangpirom, P., & Akatimagool, S. (2020). Promotion of High-Order Analytical Thinking Skills using NCOM Simulator through STEAM Education. *2020 7th International Conference on Technical Education (ICTechEd7), Bangkok, Thailand, 19–23*. Doi: https://doi.org/10.1109/ICTechEd749582.2020.9101305.

Sari, D. I., Rejekiningsih, T., & Muchtarom, M. (2020). Students' Digital Ethics Profile in the Era of Disruption: An Overview from the Internet Use at Risk in Surakarta City, Indonesia. *International Association of Online Engineering, 14*(3), 82-94. Doi: https://doi.org/10.3991/ijim.v14i03.12207.

Sugiyono. (2017). Metode Penelitian Pendidikan. Bandung: Alfabeta.

Syakdiyah, A., Nurmahmudah, F., & Wijayanti, W. (2019). Active Learner Strategies in Era of Disruption: a Literature Review. *Advances in Social Science, Education and Humanities Research, 317*, 165-168. Doi: https://doi.org/10.2991/iconprocs-19.2019.34.

Utami, T. N., Jatmiko, A., & Suherman. (2018). Pengembangan Modul Matematika dengan Pendekatan Science, Technology,Engineering,and Mathematics (STEM) pada Materi Segiempat. *Desimal: Jurnal Matematika, 1*(2), 165-172. Doi: https://doi.org/10.24042/djm.v1i2.2388.

Yakman, G. (2008). STEAM EDUCATION an overview of creating a model of integrative education. Retrieved from https://www.researchgate.net/publication/327351326