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Development of Teaching Materials Based on Two-Column Proof Strategy on Congruent Triangle Materials

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ABSTRACT
The purpose of this study is to produce a evidence-based learning instrument using a two-column proofs strategy on congruence of triangles material that is oriented on student reasoning capabilities that meet valid and practical criteria. Research subject is class IX SMPN1 Palembang. This type of research and development uses ADDIE development models to go through the 5 stages of trajectory covered, analyze, design, development, implementation, and evaluation. The results of the expert validation and one-to-one test suggest that the learning instrument developed reaches valid and practical categories.

Keywords: *Two-column proofs; Congruence of triangles.*

1. INTRODUCTION

Geometry is a branch of mathematics that has long been believed to be a place for students to learn to reason. Geometric standards include a strong focus on developing reasoning and rigorous proofs, using definitions and undeniable facts [1]. Geometry learning has the aim of growing students' confidence in their mathematical abilities, training students to find solutions to a problem, communicating ideas mathematically, and reasoning mathematically [2]. Studying Geometry can also develop advanced mathematical thinking skills [3]. So it is very important for students to master Geometry.

However, the conditions in the Geometry class taught by researchers at the Mathematics Education Study Program, 70% of students had difficulty in compiling proof of the theorems in the Geometry material, as seen from the results of the UTS, Quiz and UAS obtained by students. Meanwhile for high school students, the results of research conducted by [4-6] show that many students make mistakes in principles, concepts, and operations in solving proof problems in geometry such as congruence and similarity materials which end in incomplete learning outcomes. In addition, there are studies which state that high school students still do not recognize mathematical proofs well [7].

Errors in solving problems and the inability of students to prove on this Geometry material are closely related to the level of students' proof construction and mathematical reasoning abilities. If students have low evidence construction and reasoning abilities, then the development of their thinking capacity and disposition in drawing conclusions through the possibilities given and as a tool for solving mathematical problems will be hampered [8].

Therefore, educators need to choose learning strategies that can help students and students develop their mathematical proof construction and reasoning abilities. Referring to research by [9-11], there is a potentially positive way to develop proof construction and mathematical reasoning skills, namely through the application of the two-column proofs strategy in classroom learning. The use of the two-column proofs strategy helps build ideas and evidence as well as accommodate the learning process so that teachers can point out and pay attention to the errors in the proving process made by students [12]. Compared to other strategies, the two-column proofs strategy has qualities

that allow it to facilitate greater flexibility in reasoning and proof [13].

In order for evidence-based learning using the two-column proofs strategy to be effective and able to facilitate the development of students' evidence construction and reasoning abilities, educators need a learning tool that is appropriate to the circumstances and needs of students. The 2013 curriculum used in schools currently requires teachers to prepare learning activity designs that can encourage student activity in learning. However, several studies show that there are still many teachers who have not been able to develop learning tools that are in accordance with the 2013 Curriculum [14-16]. The use of learning tools that are not in accordance with the needs of students can cause students' mathematical reasoning abilities to not develop properly [17]. Therefore, it is necessary to develop mathematics learning tools to assist the process of implementing learning in accordance with the 2013 Curriculum and to facilitate the development of students' evidence construction and reasoning abilities.

Based on the description of the problem above, the researcher is interested in conducting a research entitled "Two Column Proof Strategy Development on Congruent Triangle Material".

The purpose of this research is to produce evidence-based learning tools that use a two-column proofs strategy for valid and practical learning to prove the congruence of triangles. The learning tools developed are lesson plans and teaching material.

2. RESEARCH METHOD

This research is research development or Research and Development that uses the ADDIE development model. The ADDIE development model consists of 5 stages of flow, namely: analyze, design, development, implementation, and evaluation [18]. The use of the ADDIE model in this research is to produce a product in the form of evidence-based learning teaching materials using a valid and practical two-column proofs strategy. The object of this research is an evidence-based learning device using a two-column proofs strategy, while the subjects are class IX students of SMP Negeri 1 Palembang, South Sumatra.

The stages of the ADDIE model development flow can be explained as follows:

2.1. Analyze Stage

At this stage, the researcher analyzes the need for the development of learning tools and analyzes the feasibility and requirements for developing learning tools. This stage includes needs analysis, curriculum analysis, and analysis of student characteristics.

2.2. Design Stage

At this stage, the researcher developed a framework for learning tools and developed an evaluation tool for learning tools. This includes the preparation of learning objectives, learning strategies, learning activities, good feedback, and follow-up.

2.3. Development Stage

At this stage, the researcher realized a conceptual framework into the Prototype I Learning Toolkit. The Prototype I Learning Toolkit was validated by one expert, including content validation, language, and presentation. Furthermore, the Prototype I Learning Toolkit was revised and the Prototype II Learning Toolkit was obtained.

2.4. Implementation Stage

At this stage, the researcher conducted a trial of the Prototype II Learning Tool directly in the field.

2.5. Evaluation Stage

At this stage, the researcher evaluates based on the feedback that has been received from the trial and makes revisions according to the results of the evaluation.

3. RESULTS AND DISCUSSION

In the analyze stage, the researcher analyzes the needs, curriculum and characteristics. Based on the needs analysis, information was obtained that the learning tools used by teachers in schools still tend to be teacher center. teaching material usually only contains a summary of the material and a collection of questions. Based on the curriculum analysis, the researcher determines the basic competencies, learning indicators, and learning objectives that are in accordance with the 2013 curriculum. The selected basic competencies are 3.6 Explaining congruence and congruence of flat shapes, with indicator 3.6.3 testing and proving two triangles are congruent or not, if given Draw two congruent triangles along with some information about the lengths of the sides or the measure of the angles. Based on the characteristics analysis, the students who became the research subjects were grade IX students whose ages were in the range of 13-15 years. At this age range, students belong to the formal operational phase which is already able to reason, think broadly, and construct their own knowledge. So that the use of the two-column proofs strategy on the triangle congruence material is considered appropriate to the students' condition.

After doing the analysis, the next step is to enter the design stage. The researcher prepares and begins to

design how the learning tools will be developed to match the results of the analysis. Researchers determine the format of the learning tools to be developed are lesson plan and teaching material. The lesson plan is designed based on the Free Learning lesson plan format. teaching material is designed based on the principle of the two-column proofs strategy and is oriented to student reasoning.

Entering the development stage, the design of the learning tools is then realized so that the Prototype I Learning Toolkit consists of lesson plan Prototype I and teaching material Prototype I. Then the lesson plan and teaching material Prototype I will be validated by 1 expert to assess the feasibility of content, language, and presentation.

Table 1. Validator result

No.	Validator	Comments/Suggestions
1	Jeri Araiku, S.Pd., M.Pd. (Lecturer of Mathematics Education, Faculty of Teacher Training and Education, Sriwijaya University)	1) The activities of teachers and students in the lesson plan are made separately. 2) Language in teaching material is made more communicative. 3) The two-column proofs strategy is presented in stages to guide students.

After validation, the researcher made revisions according to the validator's comments and suggestions until the Prototype II Learning Toolkit was obtained, which consisted of lesson plan Prototype II and teaching material Prototype II.

RENCANA PELAKSANAAN PEMBELAJARAN

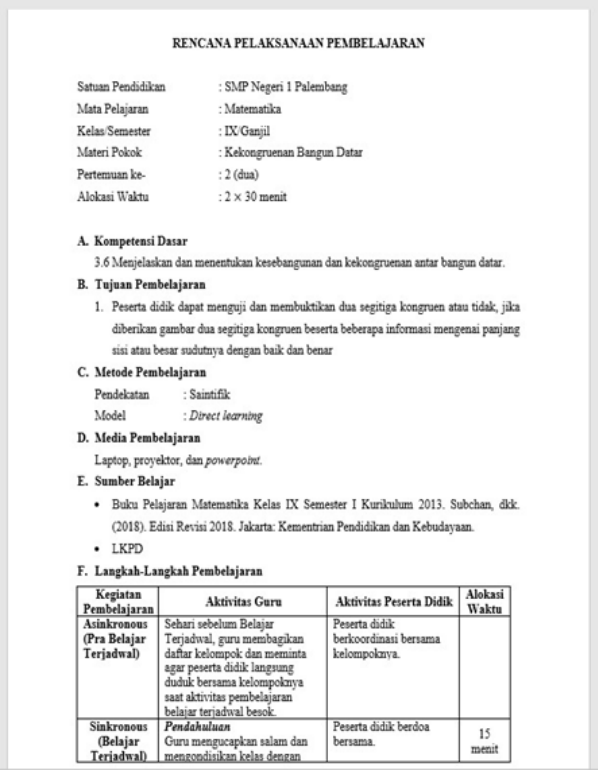
Satuan Pendidikan : SMP Negeri 1 Palembang
Mata Pelajaran : Matematika
Kelas/Semester : IX/Ganjil
Materi Pokok : Konsep Kekongruenan Bangun Datar
Pertemuan ke- : 2 (dua)
Alokasi Waktu : 3 × 30 menit

A. Kompetensi Dasar
3.6 Menjelaskan dan menentukan kesebangunan dan kekongruenan antar bangun datar.
B. Tujuan Pembelajaran
1. Peserta didik dapat memahami konsep kekongruenan pada segitiga dengan baik dan benar.
2. Peserta didik dapat menyebutkan kondisi kekongruenan dua segitiga dengan benar dan lengkap.
3. Peserta didik dapat membuktikan kekongruenan dua segitiga melalui strategi *two-column proofs* dengan baik dan benar.
C. Metode Pembelajaran
Pendekatan : Saintifik
Model : *Blended learning*
D. Media Pembelajaran
Laptop/Hp, internet, *Zoom meeting, Ms. Word,* dan *Powerpoint.*
E. Sumber Belajar
- Buku Pelajaran Matematika Kelas IX Semester I Kurikulum 2013. Subchan, dkk. (2018). Edisi Revisi 2018. Jakarta: Kementrian Pendidikan dan Kebudayaan.
- Youtube
- LKPD

F. Langkah-Langkah Pembelajaran

Aktivitas Pembelajaran	Langkah-langkah Pembelajaran	Alokasi Waktu
Asinkronous (Pra belajar terjadwal)	1. Maksimal sehari sebelum belajar terjadwal, guru membagikan bahan bacaan/tautan video *Youtube* mengenai kekongruenan pada segitiga melalui *Google Classroom/ Whatsapp Group.* 2. Guru menyampaikan kompetensi yang akan dicapai dan tujuan pembelajaran.	

Figure 1 lesson plan prototype I.



RENCANA PELAKSANAAN PEMBELAJARAN

Satuan Pendidikan : SMP Negeri 1 Palembang
Mata Pelajaran : Matematika
Kelas/Semester : IX/Ganjil
Materi Pokok : Kekongruenan Bangun Datar
Pertemuan ke- : 2 (dua)
Alokasi Waktu : 2 × 30 menit

A. Kompetensi Dasar
3.6 Menjelaskan dan menentukan kesebangunan dan kekongruenan antar bangun datar.
B. Tujuan Pembelajaran
1. Peserta didik dapat menguji dan membuktikan dua segitiga kongruen atau tidak, jika diberikan gambar dua segitiga kongruen beserta beberapa informasi mengenai panjang sisi atau besar sudutnya dengan baik dan benar
C. Metode Pembelajaran
Pendekatan : Saintifik
Model : *Direct learning*
D. Media Pembelajaran
Laptop, proyektor, dan *powerpoint.*
E. Sumber Belajar
- Buku Pelajaran Matematika Kelas IX Semester I Kurikulum 2013. Subchan, dkk. (2018). Edisi Revisi 2018. Jakarta: Kementrian Pendidikan dan Kebudayaan.
- LKPD

F. Langkah-Langkah Pembelajaran

Kegiatan Pembelajaran	Aktivitas Guru	Aktivitas Peserta Didik	Alokasi Waktu
Asinkronous (Pra Belajar Terjadwal)	Sehari sebelum Belajar Terjadwal, guru membagikan daftar kelompok dan meminta agar peserta didik langsung duduk bersama kelompoknya saat aktivitas pembelajaran belajar terjadwal besok.	Peserta didik berkoordinasi bersama kelompoknya.	
Sinkronous (Belajar Terjadwal)	***Pendahuluan*** Guru mengucapkan salam dan mengondisikan kelas dengan	Peserta didik berdoa bersama.	15 menit

Figure 2 lesson plan prototype II.

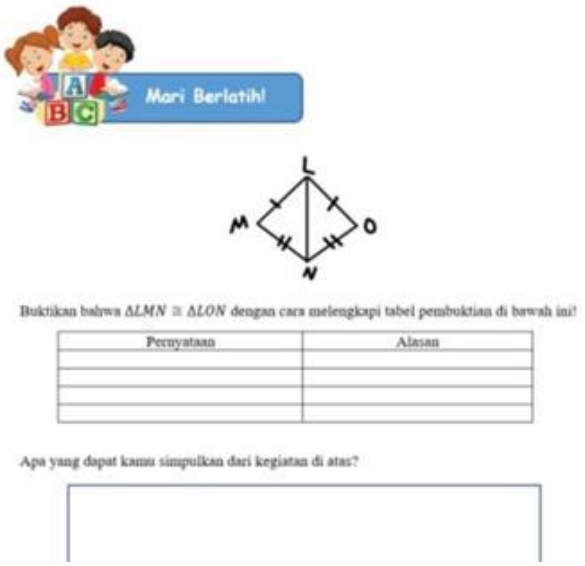


Figure 3 teaching material prototype I.

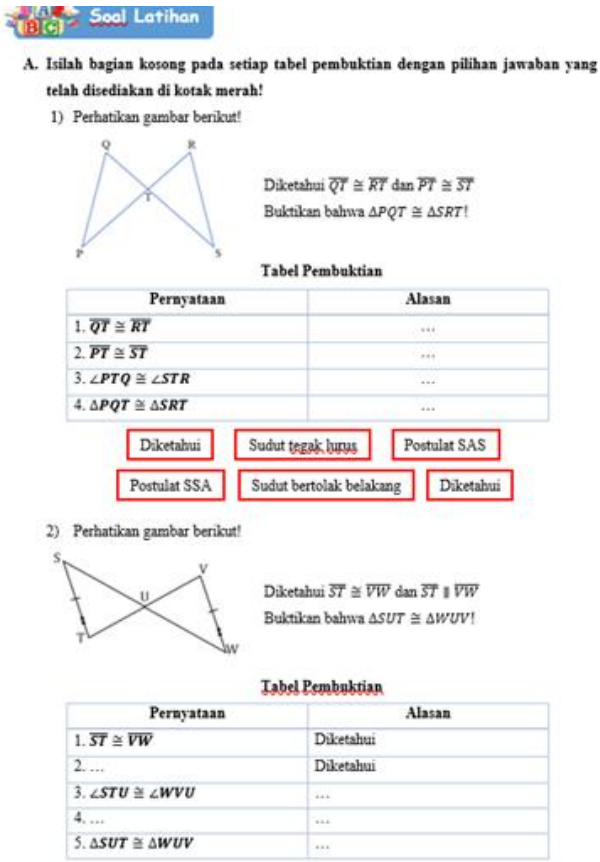


Figure 4 Teaching material prototype II.

Furthermore, through the implementation stage, the researcher conducted a one-to-one trial for students to obtain. comments and suggestions from students on learning tools that have been developed. After undergoing learning using learning tools developed by researchers, most of the students gave a positive response.

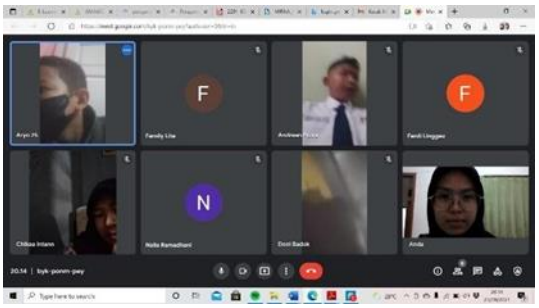


Figure 5 Implementation phase.

Then enter the evaluation stage, based on the feedback obtained from the one-to-one trial, there are several things that need to be improved on the teaching material. Researchers make revisions according to student comments for the perfection of teaching material. Based on the description of the results of the validation of the lesson plan and teaching material as well as student responses to evidence-based learning tools using the two-column proofs strategy on the triangle congruence material developed, it is valid and practical and suitable for use by grade IX SMP students.

4. CONCLUSION

This development research resulted in a learning tool in the form of lesson plans and teaching material on triangular congruence material that applied the two-column proofs strategy. Researchers develop learning tools using the ADDIE model which contains 5 stages of flow, namely: analyze, design, development, implementation, and evaluation. The results of expert validation stated that the learning tools developed were valid. The results of the one-to-one trial show that the learning tools developed are practical.

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