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Development of Constructivism-Based Mathematics Learning Media for Grade IV Students of Elementary Schools

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ABSTRACT

The purpose of this research is to develop valid, practical, and efficient constructivism-based learning media. This developmental research is using a 4-D development model with four stages: 1) define, 2) design, 3) develop, and 4) disseminate. The results of data analysis in this study: 1) Media validity. 95.83% of the syllabus and 92.25% of the Lesson plan validity is in a very valid category. The worksheet validity is considered very valid from several aspects: 90.94% of the didactic aspect is valid, 89.50% of the construction aspect is valid, 91.88% of the language aspect is valid, and 86.07% of the graphic aspect is valid; 2) Practicality. The level of implementation of learning media is 77.2% (well-implemented category). The use of worksheets practicality from students' opinion is 91.80% (very practical category), and in teacher's opinion is 90.63% (very practical category); 3) Effectiveness. Student activeness is 78.04% of all students (very active category), and student learning passing rate is 81.3%.
Keyword: Syllabus, Lesson Plan, Worksheets, Construstivism

INTRODUCTION

Mathematical learning goal in elementary schools is to train students to be capable in several aspects; think logically, find out information from various sources, formulate problems, and collaborate in solving problems in their daily lives. The learning process in schools, based on Regulation of the Minister of Education and Culture (Permendikbud) No. 22 of 2016, must be interactive, inspiring, fun, challenging, motivating students to participate actively, and providing space for their creativity, initiative, and independence following their talents, interests, physical, and psychological developments. In line with the regulation, Kosasih (2014) explained that to achieve effective mathematics learning outcomes, learning activities need to use several principles. These principles must be centered on students, develop their creativity, fun, and challenging. The activities also need to have morals, ethics, aesthetics, logic, and kinesthetics values. Besides, the learning activities have to provide diverse learning experiences through the various learning strategies and fun, contextual, effective, efficient, and meaningful learning models. Thus, to obtain a proper mathematics learning experience, the teacher must set an interactive, inspiring, engaging, and fun learning process to foster students' creativity following the talents, interests, and physical and psychological development of the students.

Before designing mathematics learning activities, math teachers must develop the syllabus. According to the Ministry of Education and Culture (2016), in implementing this syllabus, teachers need to be creative at developing material, managing the learning process, and executing learning methods and models. Teachers also need to adapt the learning activities not only to community situations and conditions but also to the students' abilities development. The developed syllabus becomes a reference for designing lesson plans. The lesson plan is significant in leading the students' learning activities to achieve basic competence. Since the teachers ought to develop and manage the learning activities under the demands of the curriculum and student needs, many preparations are needed. The teachers must have good teaching preparation, effective teaching-learning media, and suitable methods that meet the students' needs. Besides developing syllabus and lesson plans, teachers are required to be able to make other learning media and materials. One major change in the learning principles based on Permendikbud No. 22 of 2016 is about the learning sources. The teacher was the only learning source, and now learning materials can be obtained from various learning resources.

Based on preliminary observations at SDN 77 Pekanbaru in July 2019, students learn mathematics by using textbooks and worksheets. However, the worksheets are not the ones personally made by the

teacher. According to the Ministry of Education and Culture (2016), the utilization of textbooks is still needed to stimulate interest in reading and increase students' creativity. The worksheets are supposed to be arranged by the teacher to give the students creativity, and opportunities to be involved in designing the procedure of learning activities.

Mathematics learning is still teacher-centered learning, and students are less actively involved in learning activities. Teachers tend to present concepts briefly and give examples of mathematics questions. Students merely accept the lesson without discovering how to obtain that concept. Hence, students tend to memorize formulas given. If the students are given questions other than examples given by the teacher, they can not solve it. From the results of a test given by the teacher for basic competence number 3.1, the students' average score was 69.5. The classical mathematics learning passing rate was 46.9%. Therefore, mathematics learning outcomes are relatively low. As suggested by Ahmadi (2010), the learning process today tends to focus on achieving the target of curriculum material. It concerns more about memorizing formula rather than understanding the concept.

The students' worksheets are not interesting. It includes the summary of materials, formulas, the sample of questions, and exercises. The mathematics formula is directly given without involving students to play an active role in developing their knowledge. In the learning process, students tend to memorize the formula without allowing them to construct initial knowledge about the concept. It makes the subject difficult for students to understand. The worksheets do not meet the students' needs and characteristics. Those worksheets do not encourage learning activities, so it makes learning outcomes relatively low. Therefore, it is necessary to develop a worksheet that can encourage students to construct basic knowledge and help them understand the concepts of the material.

One way of learning to stimulate students and help them understand the material is constructivist learning. In the theory of constructivism according to Nur in Trianto (2010), students must discover the knowledge; transform complex information; check new information by using the rules they have learned, and revise the rules if they are no longer appropriate. According to Bettencourt in Suparno (2001), teaching, in constructivism, is not an activity of transferring knowledge from teacher to student, but an activity that allows students to build their knowledge. Teaching means participating in developing knowledge, understanding meaning, seeking clarity, being critical, and justifying. Driver and Oldham in Suparno (2001) describe the steps of constructivism learning as follows:

1. Orientation. Students have a chance to build their motivation in learning by doing some observations on the topic.
2. Elicitation. The students discuss what they have observed. In this step, teachers encourage students to express their ideas through discussion, writing ideas, making posters, etc.
3. Restructuring ideas. In restructuring ideas, the students need to follow these three stages:
    a) Clarifying ideas with friends through discussion or gathering ideas. In doing a clarification with a friend, the students will reconstruct ideas, if they share different ideas. Otherwise, if they share the same ideas, they will be more convinced.
    b) Building new ideas. It happens when the ideas are contrary to other ideas, or the ideas failed to answer their friends' questions.
    c) Evaluating new ideas through experiments. It's good to evaluate the newly formed idea through an experiment or problem-solving.
4. Application of ideas. When the students discover an idea or knowledge, they need to use the ideas in various situations encountered. It allows reinforcement of the conceptss. Besides, it will help students deepen their knowledge and learn more detail information about the concept of the ideas.
5. Review. Reviewing is reflecting on how the idea changed. It can occur in the application of knowledge in everyday situations. When the students obtain the knowledge, they need to review it further, and check concepts. If the students realize how a concept of an idea formed, it is more likely that they will permanently remember them.

Learning, based on constructivism, is students' active process in constructing meaning through texts, dialogues, and experiences by assimilating and relating them with the primary knowledge they have to make that knowledge develop. It is in line with Gunawan's opinion (2017) about constructivism. It is an understanding that obtaining new knowledge is a process of building or constructing a previous experience into a new one. To avoid mistakes in formulating concepts, the teacher can provide direction and guidance for the students by providing opportunities to find out or express ideas and encourage

students to use their strategies in learning. The role of teachers, according to Rakhmawati (2016), is not only to convey information to students but also to facilitate creative learning to all students.

Based on the description above, research on the development of learning media that include syllabus, lesson plan, and worksheets based on constructivism is needed. We need to analyze the syllabus development because it is the reference for planning the learning process in a subject. Lesson plans are also significant to direct learners' learning activities to gain basic competence and learning objectives. Developing constructivism-based worksheets is to foster learning activities and assist students in developing their critical thinking through activities: 1) describing, manipulating objects, and gathering information by linking them to their primary knowledge; 2) exploring the idea by discussing what they observe through writing, drawing or poster; 3) clarifying others' ideas, building and trying the new ideas with different problems; and 4) using the ideas to solve problems. This constructivist-based worksheet makes students easier to learn the topic and further enhance students' activities and understanding. The objective of this study is to produce valid, practical, and effective constructivist-based Math learning media for class IV of elementary school.

RESEARCH METHODS

This research is development research using a 4-D development model. According to Trianto (2010), This model consists of 4 stages of development, namely define, design, develop, and disseminate. Five main steps of the defining stage are front-end analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives. The design phase is to prepare a prototype of a learning device. The development phase is to produce valid learning media. Dissemination stage is the stage of using the developed media on a broader scale, for example in another class, school, or teacher. The dissemination step was not executed since it requires a great amount of time, cost, and numerous schools.

At the defining step, we need to do a **front-end analysis** to figure out the fundamental problems in learning. **The students' analysis** is studying the characteristics of students, including their abilities, background knowledge, and level of cognitive development. To outline the contents of teaching materials in detail, a **task-analysis** is needed. **Concept analysis** is carried out to identify the main concepts, arrange them systematically, and relate the concepts to other relevant concepts. **The formulation of learning objectives** is based on basic competencies and indicators in the curriculum.

In the designing phase, designing constructivism-based learning media, particularly syllabus, lesson plan, and worksheets, is based on the results of the definition stage. Before being used, this device is validated by some experts. The experts are three mathematics and one Bahasa Indonesia lecturers. Then this media was revised based on validator suggestions. After the device is valid, it is ready to be tested. The trial took place in SDN 77 Pekanbaru. This media is made for and given to 32 students of grade IV of Elementary School. The validity of the learning media are presented in table 1. The practicality categories of learning devices by students and teachers can be seen in table 2. Categories of the feasibility of learning media are in table 3. While table 4 shows categories of the students' performance in learning.

Table 1. Validity Criteria of Constructivist-based Learning Media

Percentage (%)	Qualification	Decision
81 -100	VeryValid	The product is ready to use without further revisions.
61 - 80	Valid	The product is ready to use without further revisions.
41 -60	Rather Valid	The Products can proceed with a little revision
2-40	LessValid	Revising the product by looking for weaknesses
0 - 20	Invalid	The products need massive revision

(modified from Riduwan, 2012:29)

Table2. Practicality of the Constructivist-based Learning Media

No	Interval	Category
1	0-20	Very impractical
2	21-40	Impractical
3	41-60	Lesspractical

4	61-80	Practical
5	81-100	Very practical

(modified from Riduwan, 2009:89)

Table 3. Feasibility of the Learning Media

Percentage	Category
0 – 39	Bad
40 – 55	Rather Bad
56 – 65	Good Enough
66 – 80	Good
81 – 100	Very Good

(modified fromArikunto, 2005)

Table4. Categories of Students' Performance in Learning

Percentage	Students' Performance
0 % < P ≤ 25 %	Very Passive
25 % < P ≤ 50 %	Passive
50 % < P ≤ 75 %	Active
75 % < P ≤ 100 %	Very active

Arikunto (2004:54)

RESEARCH RESULT

1. Validation of Learning Media

Some activities to produce valid, practical, and efficient constructivist-based learning Mathematics media at grade IV of Primary Schools are:

a. Defining Phase

There are five steps in the definition stage: front-end analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives. The results of the definition stage are as follows:

1) Front-End Analysis
The front-end analysis shows that the students were inactive and did not understand the materials at learning mathematics in grade IV-A of SDN 77 Pekanbaru. It is clear that the learning outcomes have a low average (69.5) and learning completeness percentage is 46.88%. The method is still teacher-centered. Regarding the worksheets, the teacher did not compose them, and they are not interesting for the students. The material is given without involving students to construct their knowledge and obtain the concepts.
2) Student Analysis
From the student analysis, we know that the students of grade IV SDN 77 Pekanbaru are between 9-11 years old. According to Piaget's cognitive development theory, these students are at the concrete operational stage. At this stage, the students can apply their logical thinking to physical objects and actual problems.
3) Task Analysis
The mathematics learning materials in grade IV are Equivalent Fractions, Changing Fractions, Numbers' Estimation, Estimating fraction operations, the Least Common Multiple (LCM), the Greatest Common Factor (GCF), Polygon, Regular Polygon, and Irregular polygon.
4) Concept Analysis
The main concepts in mathematics in Semester I are fractions, operations of numbers and fractions, the Least Common Multiple (LCM), the Greatest Common Factor (GCF), and two-dimensional figure.
5) Formulation of Learning Objectives

The learning objectives are formulated based on indicators of learning achievement and basic competency.

b. Design Phase

Designing the syllabus is to determine the main competency, basic competence, Learning Materials, Indicators, assessments, learning resources, and time allocation. The syllabus is designed based on the task and concept analysis. The front-end and student analysis are used as a reference for developing learning activities in the syllabus. The activities arrangements are based on the characteristics of constructivism learning.

In designing the lesson plan, the components of the lesson plan are developed based on the results of the definition stage. The main and basic competence, indicators, learning objectives, materials, media, resources, and assessment are developed based on task analysis, concept analysis, and formulation of learning objectives. The learning method is developed based on front-end and student analysis. Learning activities are adjusted based on the characteristics of constructivist learning. Five stages of constructivist learning are 1) **Orientation**. Motivating students to learn the material and let them have an opportunity to figure out the concept; 2) **Elicitation**. Students express ideas through discussion, observation, data or information collection, and data interpretation; 3) **Restructuring ideas**. Students clarify ideas with others to find out whether they share the same ideas and rebuild new ideas when they share different concepts. Then, they test the idea with diverse problems.; 4) **Application of ideas**, students apply the ideas to a problem and solve that problem; 5) **Review**. When students apply their knowledge to real-life problems, they review the ideas by adding and changing them.

The components of worksheets, according to Prastowo (2012), are the title, instructions, objectives, supporting information, assignments, and working and assessment procedure. Constructivism-based worksheets designed includes the components above: 1) title, 2) basic competencies; 3) indicators, 4) Learning Objectives, 5) activity instructions, 6) constructivism-based tasks, or work steps. Those steps are a) orientation, allowing students to develop motivation in learning a topic; b) Elicitation, students express their ideas clearly through discussion, writing, poster making, etc. ; c) restructuring ideas, classifying, building and evaluating new ideas by doing experiments; d) the use of ideas in many situations; e) assessment by doing exercises.

c. Development Phase

This stage is validating the learning media. The validating media include a constructivism-based syllabus, lesson plan, and worksheets. Syllabus Validation Results can be seen in Table 5, Lesson Plan Validation results are in Table 6, and Table 7 shows Worksheet Validation results.

Table 5. Constructivism-based Syllabus Validation Results

Aspect	Persentage	Category
Syllabus component	100 %	Very valid
Basic competency and indicators compatibility	100 %	Veryvalid
Development of indicators based on the learning activities	93,75 %	Veryvalid
The suitability of learning materials with basic competence and the learning indicator	93,75 %	Veryvalid
Appropriateness of assessment with indicators and learning activities	87,50 %	Veryvalid
Average	95,83 %	Veryvalid

The constructivism-based syllabus is very valid and the average percentage of the validity is 95,83%

Table6. Constructivism-based Lesson Plan Validation Results

Aspect	Percentage	Category
Lesson plan component	95,14 %	VeryValid
Formulation of achievement indicators	89,06 %	VeryValid

Aspect	Percentage	Category
Formulation of Learning Objectives	93,75 %	VeryValid
Material Organization	94,44 %	VeryValid
Choice of approach and method	93,75 %	VeryValid
Use of Media	91,67 %	VeryValid
Use of Learning Resources	92,19 %	VeryValid
Types of learning activities	92,50 %	VeryValid
Arrangement of Learning Steps	93,75 %	VeryValid
Choices of ways to organize students in order to participate in the learning process	91,25 %	VeryValid
Carry out learning activities in a logical order	93,75 %	VeryValid
Making assessment tools	91,25 %	VeryValid
Use of language	87,50 %	VeryValid
Average	92,25 %	VeryValid

The constructivism-based lesson plan has the average percentage of validity is 95,83%. The validation result show that the lesson plan is very valid.

Tabel 7. Worksheet Validation results

Aspect	Average Percentage	Category
Didactic	90,94%	Very valid
Construction	89,50%	Veryvalid
Language	91,88%	Veryvalid
Graphics	86,07%	Veryvalid
Average	89,59 %	Veryvalid

The results of the constructivist-based worksheets validity test show that 90.94% of overall didactic aspects are very valid. Besides, 89.50% of all the worksheets' construction aspect is valid, so it makes the construction to be very valid. The results of the validity test show that 91.88% of the language and 86.07% of the graphic are very valid. Overall, the validation test result of a constructivist-based worksheet showed 89.59% of all aspects are very valid.

Before the learning media are validated, the validators need to verify the validity of the test instruments for the syllabus, lesson plan, and worksheet. After the media instrument is indicated as valid, the media need to be approved by four validators: three of them are mathematics lecturers and one language lecturer. Hence, before using the learning implementation observation sheet, student questionnaire responses, teacher questionnaire responses, student activities observation sheets, and results of learning tests need a confirmation from the validators. The validity test results of the media and instruments can be seen in table 8.

Table8. Recapitulation of the Validity Test Results of Media and Instruments

Validated Components	Percentage	Category
Syllabus validity test instruments	93,33 %	Very Valid
Lesson plan validity test instruments	90,00 %	VeryValid
Worksheets validity test instruments	91,43 %	VeryValid
Syllabus	95,83 %	VeryValid
Lesson plan	92,25 %	VeryValid
Worksheets	89,59 %	VeryValid
Learning implementation observation sheet	83,33 %	VeryValid

Student questionnaire responses	97,14 %	VeryValid
Teacher questionnaire responses	97,14 %	VeryValid
Student activities observation sheets	89,58 %	VeryValid
Assessment result	90,93 %	VeryValid

Based on table8the validity of all media and instruments are valid.

2. The practicality of Learning Devices

The practicality data of constructivism-based learning media are from observations of the implementation constructivism-based learning media, questionnaires practicality by students, and questionnaires practicality by teachers. The practicality of the learning media can be seen in table 9.

Table9. Recapitulation of Learning Media Practicality

Media Practicality	Percentage	Category
Implementation learning media	77,20%	Good
Students' response	91,80%	Very Practical
Teacher's response	90,63%	Very Practical

Based on table 9, it can be concluded that constructivism-based learning media is already practical.

3. Effectiveness of Learning Media

The effectiveness of constructivism-based learning media complies with the learning activities and students' learning outcomes. The results of students learning activities observation using constructivism-based worksheets can be seen in Table 10 below.

Table 10. Recapitulation of Student Activities in Learning Mathematics Using Constructivism-based worksheet

Observed Aspect	Meeting					Average (%)	Category
	I	II	III	IV	V		
	%	%	%	%	%		
Working together in groups	69	72	81	78	82	76,4	Very active
Doing the activities following the working procedure in the worksheets	72	72	78	84	91	79,4	Very active
Reading the worksheets	91	84	94	94	94	91,4	Very active
Presenting ideas	56	56	63	69	69	62,6	Active
Doing exercises and tasks in the worksheet	75	72	78	86	91	80,4	Very active
Average (%)						78,04	Very active

Based on observations of students' learning activities using the worksheets, the use of constructivism-based learning media is effective. Students' learning outcomes using constructivism-based worksheets are in Table 11.

Table 11. Recapitulation of Student Learning Outcomes Using Constructivism-Based Worksheets

Tests	Average Score	Number of students passed the test	Completeness
KD 3.3, 4.3	80,4	28	87,5 %
KD 3.6, 4.6	83,0	27	84,4 %
KD 3.8, 4.8	74,7	27	84,4 %
Average	79.4	26	81,3 %

Mathematics learning outcomes of grade IV A SDN 77 Pekanbaru using constructivism-based worksheets are 79.4, and the classical completeness is 81.3%. The development of constructivism-based learning media is effective if more than 80% of students score ≥ 75. Therefore, we can conclude that constructivism-based learning media are effective.

The syllabus, according to Trianto (2010), is one of the curriculum development products containing an outline of subject matter, learning activities, and assessment design. Based on Government Regulation No. 22 in 2016, a syllabus is a reference for the learning framework preparation for each subject material. Based on the definition above, we can conclude that the syllabus is a reference in arranging material, developing learning activities, and designing assessments. A valid constructivist-based syllabus served as a reference in designing the lesson plan for constructivism-based learning.

Based on Regulation of the Minister of Education and Culture (Permendikbud) No. 22 in 2016, the Lesson plan includes the preparation of learning plans, learning media and resources, learning assessment tools, and learning scenarios. Syllabus preparation and lesson plans are arranged based on the learning approach. This constructivism-based lesson plan is valid. Besides, it facilitates teachers in teaching mathematics to students of grade IV elementary school. The value of practicality based on the implementation of the activities, teachers and students' responses is very practical.

According to Prastowo (2012), worksheets in learning generally serve as teaching material that can minimize the teachers' role: stimulates students; help students to understand the material; concise and full of tasks to practice; facilitate the implementation of learning. Likewise, according to Majid (2011), the advantage of having a worksheet is to make it easier for teachers to encourage students so that they can learn independently, understand, and doing written assignments. In line with the two opinions above, the constructivism-based worksheets facilitate students in developing their initial knowledge and building new concepts. In that way, students can understand the concepts they learn and improve their learning outcomes. it can be seen that the students in grade IV A at SDN 77 Pekanbaru passing rate are 81%. There were 26 out of 32 students passed the test. The worksheet makes it easy for teachers and students to learn mathematics. Based on the teacher's and students' responses, the learning material is very practical. Learning math using constructivism-based lesson plans and worksheets improves students' learning activities, understanding of the concepts, and learning outcomes..

CONCLUSION

The development of this learning media is using a Four-D model with the following conclusion: 1) Constructivism-based learning media: Syllabus, lesson plan, and worksheets fit the validity criteria; 2) Constructivism-based learning media fit the practicality criteria. The implementation of the media in learning is considered good, and the learning media is very practical based on the students' and teacher's opinions; 3) The learning device meets the effectiveness criteria. The students' activeness aspect is categorized as very active and has good students learning outcomes with a passing rate of more than 80%. Thus, constructivism-based learning media have been effective.

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