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Development of Problem-Based Learning Device to Grow Students' Mathematical Critical Thinking Ability

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Abstract

This research is motivated by the importance of students' mathematical critical thinking skills and the limited learning tools with problem-based learning models to facilitate students' mathematical critical thinking skills used by teachers (Syllabus, Lesson Plan, and Students Worksheets) as a means of supporting learning in the 2013 Curriculum and fostering the ability to think mathematical critically. This research aims to produce a learning device based on the Model of Problem-Based Learning (PBL) on the probability material that is valid and practical to grow students' mathematical critical thinking skills. The model of development used is the 4D model (Define, Design, Develop, Disseminate). The subjects of one-to-one evaluation in this study were three 9th-grade SMP IT Aufia Global Islamic Boarding School students and six heterogeneous students as small group evaluation subjects. The data analysis technique carried out in this study is the descriptive analysis technique. The instruments used include (1) a Syllabus, lesson plans, and student worksheet validation sheets; and (2) a Questionnaire for student response to Student worksheets. The learning tools that have been compiled are then validated by three validators and revised according to suggestions from the validators. The learning device is said to be valid if the level of validity achieved is at a value of $2{,}50 \leq \bar{x} \leq 4{,}00$. The validation results from three validators show that the syllabus, lesson plans, and student worksheet are very valid, with the average score in a row 3.82, 3.74, and 3.55. Student worksheet practicality shows an average percentage of 92,06% with efficient criteria. The results of this study indicate that the learning based on Model Problem-Based Learning (PBL) on the probability material is very valid and significantly grows students' mathematical critical thinking skills.

Keywords: mathematical critical thinking skills; learning tools; model problem-based learning

I. Introduction

Mathematics has a vital role in developing the intellectual potential of students' thinking. Students are expected to be able to have mathematical competence after gaining experience learning mathematics, especially in developing reasoning and thinking creatively and critically in solving a problem. According to Wahyuni & Anugraheni (2020, p. 73), critical thinking is a person's high-level thinking ability to logically and precisely solve a problem. Critical thinking can build student thinking to provide the right solutions in solving math problems (Apriliana et al., 2019, p. 126).

The ability to think critically and mathematically is essential for students to have. As said by Basri and As' ari (2019, p.746) because with this ability, students can be helped

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to solve problems in various situations. Students with good critical thinking skills will find it easier to solve problems in mathematics because relevant and irrelevant information can be appropriately determined, are also able to weigh various points of view and identify errors that can help students solve problems (Su et al., 2016, p. 199). In line with the opinion of Rahmah, Soedjoko, and Suneki (2019, p. 808), who stated that critical thinking skills are beneficial for students because students will observe and understand problems in more detail.

In reality, students' mathematical critical thinking skills in Indonesia are still in the low category. This low ability can be seen from the results of the international studies of PISA and TIMSS. According to Janah, Suyitno, and Rosyida (2019, p. 907), The questions used in the PISA and TIMSS studies consist of non-routine problems to measure higher-order thinking skills, where to deal with these questions; students are required to have the ability to critical mathematical thinking. According to PISA data for 2018, which was taken based on students aged 15 years, Indonesia's average score in mathematics was 379, with an international standard of 487. A decrease in scores was experienced compared to the 2015 test, with around 1% of students could only make mathematical modeling of problems mathematically complex (OECD, 2019). On the six-level PISA proficiency scale, the mathematical critical thinking skills of students in Indonesia from several participating countries still need to be higher. PISA results show that Indonesia is ranked 72 out of 78 countries. Apart from PISA, the TIMSS international study, tested on grades 4 and 8, also showed that Indonesian students needed more optimal critical thinking skills. In the 2015 TIMSS results record, Indonesia ranked 44th out of the total participation of 49 countries and obtained an average score of 397 from the international standard of 500 (IEA, 2015). The low results of the two surveys were because students needed to be more able to solve non-routine questions requiring mathematical critical thinking skills (Sari, 2020, p. 123).

From the results of Sari (2020, p. 123) regarding the analysis of students' mathematical critical thinking skills on triangles and quadrilaterals, it is known that students' mathematical critical thinking skills are still categorized at a low level. Based on four indicators, namely interpretation, analysis, evaluation, and inference, students who achieve the indicators of critical thinking skills analysis, evaluation, and deduction still need to be at least 50%. In solving essential questions of thinking, several obstacles were found, including students being only able to solve problems at the interpretation stage, students concluding too quickly without analyzing questions, and students not used to being required to solve problems as well as research and evaluate. This is also in line with the observations made by researchers on class VIII MTs Al Muttaqin students; when given practice questions that are routine or the same as those exemplified by the teacher, some students can do the questions, different when given non-routine questions, most students cannot solve the questions given. Based on this, it shows that students' mathematical critical thinking skills are relatively low, even though the importance of mathematical critical thinking skills is needed to train students to get used to solving various mathematical problems. So, a solution is required to grow students' mathematical critical thinking skills so that students are accustomed to solving multiple problems in mathematics.

The effort to improve mathematical critical thinking skills is by carrying out learning that facilitates the mathematical critical thinking skills. It is necessary to prepare before learning by compiling learning tools that contain the bias of implementing mathematical critical thinking skills indicators in learning. Hidajat, Parta, and Muksar (2016, p. 102) state that one factor that can improve students' critical thinking skills is providing learning tools that support these abilities. Learning devices prepared by teachers measure the success of the teacher-teaching

process (Daryanto & Dwicahyono, 2014). Besides, teachers as educators must have pedagogical abilities in designing and managing learning in the student's Worksheetssroom by compiling tools for learning and implementing them during the learning process. Nurhaeny et al. (2020, p. 299) state that learning tools are needed to achieve ideal learning. The Ministry of National Education explains that teachers are expected to have the ability to develop learning tools by paying attention to the level of preparation of material based on student characteristics and the social environment.

Learning tools are essential for the teacher to prepare because (1) they serve as a guide to give direction to a teacher; (2) as a benchmark; (3) as an increase in professionalism, and (4) to make it easier for teachers to carry out learning process activities. However, in reality, several research results show that the learning tools used by teachers still need to be following process standards. Research conducted at SMP Negeri 3 Sawah Lunto by Yustianingsih et al. (2017) found that the activity steps in lesson plans had not directed students to construct their knowledge and Students' Worksheets made by the teacher had not been able to facilitate mathematical critical thinking skills where the questions were still routine. Also supported by observations made by researchers in a preliminary survey at MTS Al-Muttaqin Pekanbaru, it was found that from the learning device documents used by teachers, they still do not fully understand the making of learning tools following the 2013 curriculum, also from the learning tools used, there is no learning model, from the learning activities presented the learning process still focuses on the teacher. Familiar with non-routine questions.

Learning tools have many models, including the Problem-Based Learning (PBL) model. Sulistyani & Retnawati (2015, p. 190) suggest that students can be made to play a role in learning and actively participate in learning by implementing learning tools with the PBL model, and can also train students to grow mathematical critical thinking skills. Applying the PBL model allows students to process critical and analytical thinking in finding solutions to mathematical problems. The success of the PBL model when learning activities has been proven effective for growing students' Mathematical critical thinking skills based on research by Widyatiningtyas et al. (2015) Sulistyani and Retnawati (2015, p. 208). Thus, the previous study concluded that the application of learning tools through contextual problems or with student-focused PBL models is expected to grow students' mathematical critical thinking skills.

Probability material requires students to have mathematical critical thinking skills (Karima, 2018, p. 4). Research conducted by Karima (2018:1-86) showed that students need a relatively long time when given probability questions, even though the questions given to these students are at a level below C5. Septy et al. (2015, p. 17) also said that probability material is challenging for a teacher to teach students. They are also supported through the results of interviews with students, where there are difficulties in solving problems related to a probability related to contextual issues, even though this material is essential to know and to master. However, it is one of the materials included in UN material and is a domain included in TIMSS and content tested on PISA (content uncertainties and data) (Karima, 2018, p. 4).

Based on the explanations that have been explained based on supporting theories and previous research, the fact of low mathematical critical thinking ability of students and the lack of appropriate learning tools to foster the mathematical critical thinking ability of shiva which is the reason for researchers to conduct this development research which aims to describe the validity and practicality of the device PBL-based learning about the probability of cultivating mathematical critical thinking skills for class VIII students of SMP/MTs.

II. Research Method

In this study, the 4-D model is the

development model used by researchers. The 4-D model was developed by Thiagarajan, Dorothy, and Melvin (in T.G Ratumanan & Imas, 2019). Development activities include defining, designing, developing, and disseminating.

In the define stage, several activities are carried out, including (1) front-end analysis to determine the fundamental problems encountered in learning; (2) student analysis (learner analysis) by examining student characteristics; (3) concept analysis to identify the main concepts to be taught; (4) task analysis; (5) specification of learning objectives (specifying instructional objectives) to summarize the results of task analysis and concept analysis to determine the behavior of research objects.

At the design stage, the researcher makes a product design by selecting the media, selecting the format, and making the initial design. The steps taken include; (1) selection of media (media selection) based on the characteristics of the material and learning objectives; (2) format selection, namely examining the format of existing training materials and determining the format of the material to be developed; (3) initial design (initial design) is done by making the initial design of the product to be developed.

A formative evaluation is carried out at the development stage to obtain improvements based on expert appraisal and development testing. Furthermore, this stage was also modified from the opinion put forward by Tessmer (1994); a one-to-one evaluation was carried out as part of the formative evaluation to obtain additional information on product revisions. After an expert assessment or validation of the product and receiving suggestions for improvement from experts, corrections will be carried out according to the experts' recommendations so that the learning tools are easy to use and of high technical quality. At the same time, the development test aims to get criticism and direct suggestions in the form of answers, reactions, and comments from students. as well as observers of the teaching materials that have been prepared. This stage is carried out with trial cycles, revising, and repeated re-testing so that the developed product is said to be consistent and effective.

The instruments in this study are validity and practicality instruments. The validity instrument in this study was a validation sheet containing assessment indicators for the syllabus, lesson plan, and students' worksheets validation processes that were filled in or assessed by the validator. To measure the validity of the syllabus using assessment indicators that are made referring to the syllabus components based on Permendikbud No. 22 (2016) and the suitability of each syllabus component.

Qualitative data were obtained from the advice of supervisors, validators, teachers, and students. Data collection was also taken quantitatively through validation sheet assessments and response questionnaires, each of which was filled in successively by the teacher to determine the validity and student response rates by students for the practicality of learning tools.

Data from validation sheet results and student response questionnaires will then be analyzed. Data analysis carried out in this study was a descriptive analysis technique. The product can be said to have valid criteria if it gets a score of ≥3.25, and the product is displayed to contact practical standards if it receives a score percentage of ≥85%.

Furthermore, the dissemination stage is carried out, namely the dissemination of the developed product to users by communicating the results of development research in the form of marks and products to users and professionals through forums or by writing in magazines or book form.

III. Result and Discussion

This study uses a 4-D model, which consists of four stages: the definition stage, the planning stage, the development stage, and the deployment stage.

At the define stage, the activity is to determine the initial problem encountered so that a solution is needed for the problem. This activity is carried out through literature studies,

observation, and interview techniques. The initial-end analysis is done at this stage, then student and concept analysis, task analysis, and specification of learning objectives. It began with digging up information about learning mathematics to find a problem so that a solution to the problem is needed through literature study.

The Minister of Education and Culture No. 58 of 2014, which states that one of the goals of learning mathematics is for students to be able to solve and interpret and think critically about a mathematical problem, shows that students are expected to have mathematical critical thinking skills. In line with the indicators put forward by Facione & Gittens (2015), students who think critically can understand, analyze, solve problems with strategies, and conclude solutions appropriately. However, the importance of mathematical critical thinking skills is different from the achievement of the mathematical critical thinking skills in the PISA results for Indonesia, which shows that the mathematical critical thinking skills still need to be higher (OECD, 2019). In 2019, PISA results showed that only 1% of students could make mathematical models of complex mathematical problems. The test results show that students' mathematical critical thinking skills are still relatively low. Based on the issue of low students' mathematical critical thinking skills, appropriate tools are needed to achieve the goals of learning mathematics that can facilitate and improve students' mathematical critical thinking skills. The learning tools are the syllabus, lesson plans, and students' worksheets.

Then, based on the information obtained from observations and interview results, it is known that there are problems faced, namely the lack of knowledge possessed by teachers about the 2013 curriculum learning model, learning tools have not been fully guided by Permendikbud No. 22 (2016) and limited learning tools in the 2013 curriculum, especially students worksheets. The lesson plan components used by the teacher during the learning process need to follow the lesson plan format contained in Permendikbud No. 22 (2016), which does not include the subject matter of learning and learning resources. Furthermore, schools refrain from using students' worksheets during the learning process due to limited costs and time in making students' worksheets. Teachers still often apply the lecture method during the learning process and provide some routine questions at the end of the lesson.

In addition, researchers analyzed the characteristics of Grade VIII and IX SMP/MTs students aged between 12 to 16 years. According to Piaget (in Zulkarnain & Heleni, 2014), a student's ability to think abstractly is already possessed by that age. Furthermore, reason logically and conclude. The problems experienced by students are that they have yet to be able to solve problems through mathematical critical thinking skills in everyday life. Based on this analysis, it is necessary to have a learning model that is carried out so that students have mathematical critical thinking skills. The PBL model is one of the learning models that can be used.

Next, in the concept analysis stage, the researcher identifies the concept, details the idea, and compiles the concept that students must have in the probability material. The revised 2017 edition of the 2013 curriculum mathematics book is a reference in concept analysis on Basic Competency (KD) about opportunities. Researchers consider the breadth of Opportunity material, then the learning material is arranged into four meetings with 10 lesson hours (JP); 1 JP equals 40 minutes. Details of learning materials, namely, introduction probability (sample space and sample points) 3 JP, theoretical probability 2 JP, expected frequency 3 JP, and empirical probability 2 JP. Then in the defining stage, task analysis and specification of learning objectives are carried out to compile the GPA of the KD that has been selected and describe the learning objectives.

After the definition stage, initial guidelines are obtained for designing the learning tools you want to develop based on needs analysis, teacher analysis, student analysis, concepts, and assignments. Learning tools are

designed according to the 2013 curriculum. Learning devices are also designed with phases of learning activities according to the PBL model, scientific approach steps, and mathematical critical thinking skills indicators.

At the design stage, successively, the activities include choosing the media, selecting the format, and making the initial design of the learning device. The syllabus and lesson plans are designed according to the stages in the scientific approach, the PBL model, and the mathematical critical thinking skills indicators. The preparation of the syllabus and lesson plan development refers to Permendikbud No. 22 (2016). The didactic, construction, and technical requirements must be met in solving problems in the developed student's worksheets. The researcher designed a learning device consisting of four meetings, namely: (1) an introduction to opportunities (sample space and sample points); (2) theoretical opportunities; (3) the frequency of expectations; (4) empirical opportunity. Besides that, the researcher also designed a validation sheet for the validator.

In the next development stage, the researcher develops a mathematics learning tool according to the initial design of the product made at the design stage. Three validators assess the device to see its level of validity. The device is then analyzed and repaired according to several suggestions from the validator. The results of the validation of learning tools get a score with a very valid category. On the results of the syllabus validity test, which can be seen in Table 1, the average score on the syllabus is 3.82, with very valid criteria. Assessment of the results of the score of 8 aspects, namely identity completeness, syllabus content component completeness, KI and KD suitability, learning materials, GPA suitability, formulation of activities or steps in learning, assessment of learning outcomes, and learning resources, obtained an average score ≥ 3 .25 with very valid criteria.

Table 1.
Syllabus validations result

Aspects	Validators' validation results			Total Average per aspect	Criteria
	1	2	3		
Identity completeness	4,00	4,00	4,00	4,00	Very Valid
Completeness of syllabus content components	4,00	4,00	4,00	4,00	Very Valid
Core Competence and Basic Competence suitability	4,00	4,00	4,00	4,00	Very Valid
Learning content	4,00	4,00	4,00	4,00	Very Valid
Competence Achievement Indicator (IPK) suitability	3,50	3,00	4,00	3,50	Very Valid
Learning activities design	3,67	4,00	4,00	3,89	Very Valid
Learning outcome assessment	3,50	3,00	4,00	3,50	Very Valid
Learning sources	3,33	4,00	4,00	3,78	Very Valid
Total Average for every validator	3,71	3,76	4,00	Very Valid	
Overall Syllabus average	3,82				

The validator still provides suggestions for improvement in several aspects. In formulating learning activities, the validator commented on the suitability of learning activities with the mathematical critical thinking skills indicator steps. Then in the learning resources/tools section, the validator suggests adding the learning tools because they have yet to be included in the syllabus.

In the results of the validity test of the lesson plan in Table 2, it can be seen that the lesson plan developed gets an average total validation score of 3.74 in a very valid category. From the results of the comprehensive lesson plan validity test in 4 meetings, all aspects assessed obtained an average score ≥ 3.25 with a very valid category.

Table 2.
Lesson plan validation results

Aspects	The average score of all three validators toward lesson plans				Total average Per aspect	Criteria
	1	2	3	4		
Lesson plan identity completeness	4,00	4,00	4,00	4,00	4,00	Very Valid
Lesson plan content completeness	3,33	3,33	3,33	3,67	3,42	Very Valid
Competence Achievement Indicator (IPK) clarity	3,67	3,22	3,67	3,56	3,53	Very Valid
Learning goals clarity	3,58	3,75	3,92	3,83	3,77	Very Valid
Learning content	3,80	3,87	3,53	3,67	3,72	Very Valid
Approach, strategy, tools, media, and learning sources	3,44	3,61	3,61	3,56	3,56	Very Valid
Learning activities	3,83	3,83	3,85	3,83	3,84	Very Valid
Learning outcome assessment	3,87	3,60	3,67	3,67	3,70	Very Valid
Total average per lesson plan	3,74	3,72	3,74	3,74	Very Valid	
Overall Average of lesson plans	3,74					

The completeness aspect of the lesson plan identity gets a perfectly average score of 4.00. However, in other factors, it receives a score of ≤ 4.00 but also meets very valid criteria. The lesson plan developed is appropriate, but it still welcomes suggestions for improvement from the validator. Suggestions for improvement include several sections in the learning objectives section, determining media, learning tools and materials, and learning activities in several phases. In addition, there is one aspect of the clarity aspect of the GPA in the results of the lesson plan-2 validation getting a score of ≤ 3.25, which is 3.22, which means that in lesson plan-2 in the items for assessing the suitability of the GPA with KD, the suitability of the GPA with learning materials, and the determination of indicators that used in the clarity aspect of this GPA to get a valid category only.

Several aspects of the lesson plan validity test by the validator also included suggestions for improvement, including the suitability of learning objectives and competency achievement indicators (GPA) in lesson plan-1. There were no visible learning objectives following GPA 4.11.2, learning materials in lesson plan-1 are not included in the lesson plan, and the determination of learning tools still needs to be corrected. Furthermore, giving motivation for learning activities is still unclear (see Figure 1), so after revision, the motivation section is explained more clearly in learning activities (see Figure 2).

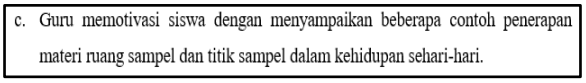
c. Guru memotivasi siswa dengan menyampaikan beberapa contoh penerapan materi ruang sampel dan titik sampel dalam kehidupan sehari-hari.

Figure 1. Motivation stage before revision

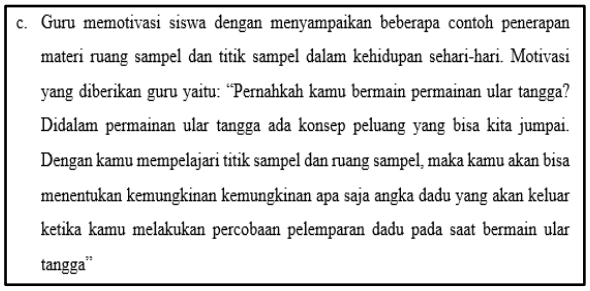
c. Guru memotivasi siswa dengan menyampaikan beberapa contoh penerapan materi ruang sampel dan titik sampel dalam kehidupan sehari-hari. Motivasi yang diberikan guru yaitu: "Pernahkah kamu bermain permainan ular tangga? Didalam permainan ular tangga ada konsep peluang yang bisa kita jumpai. Dengan kamu mempelajari titik sampel dan ruang sampel, maka kamu akan bisa menentukan kemungkinan kemungkinan apa saja angka dadu yang akan keluar ketika kamu melakukan percobaan pelemparan dadu pada saat bermain ular tangga"

Figure 2. Motivation stage after revision

Furthermore, the results of the student's worksheets validation can be seen in Table 3.

Table 3.
students' worksheets validation results

Aspects	Average score from all three validators toward students' worksheets -				Total Average per aspect	Criteria
	1	2	3	4		
Students' worksheets cover the appearance	4,00	4,00	4,00	3,67	3,92	Very Valid
Students worksheets content	3,63	3,83	3,60	3,47	3,63	Very Valid
Students' worksheets relevant towards the PBL model	3,67	3,93	3,87	3,80	3,82	Very Valid
Students' worksheets relevant towards indicators of mathematical critical thinking skill	3,67	3,83	3,67	3,58	3,69	Very Valid
Suitability with didactical condition	3,44	3,50	3,33	3,33	3,40	Very Valid
Suitability with construction condition	3,48	3,67	3,81	3,62	3,64	Very Valid
Kesesuaian dengan Syarat Teknis Suitability with technical condition	3,19	3,19	3,26	3,33	3,24	Valid
Total Average per students worksheets	3,50	3,63	3,57	3,50	Very Valid	
Overall, students' worksheets average	3,55					

The average validation score with a very valid category for the overall students' worksheets in 4 meetings is 3.55.

Overall, the students' worksheets that researchers have developed have complied. Based on the table, 7 out of 8 aspects have a score of ≥3.25, which fulfill the very valid category. However, in the conformity of students' worksheets with technical requirements, an average score of <3.25 or 3.24 means that it only meets the valid category. On the results of students' worksheets 1 and 2 validation on aspects of students worksheets suitability with technical requirements in the assessment items (writing can be read clearly, suitability of text color combinations and compositions, suitability of image sizes, suitability of image color combinations and arrangements, suitability of images with material, conformity image placement, students worksheets cover has an attractive appearance, attractive students worksheets content display and clear instructions for using students worksheets both get an average score of 3.19 with a valid category.

There are several suggestions from the validator for improvement in students' worksheets. In problem-1 presented in students' worksheets-1, the validator suggests that people's names be written in capital letters. Furthermore, in phase 4, developing and delivering the results of work that are not precise on students' worksheets, there is no written phase 5 PBL, namely analyzing & evaluating problem-solving in students' worksheets, and the suitability of the images on problem-2 in students worksheets-2 (see Figure 3 before revision and Figure 4 after revised).

Figure 3. Illustration in students' worksheets 2 before revision

Figure 4. Illustration in student's worksheets 2 after revision

Based on the data from the validation results, the researcher developed a learning device that meets valid criteria with a very valid category. It is feasible to be tested with improvements according to suggestions.

After the learning device was revised, the researcher then carried out a one-to-one trial phase to see the legibility of students' worksheets, and one-to-one became part of a formative evaluation to visit from the perspective of students using students' worksheets. One-to-one trials were carried out on Monday, September 5, 2022, and Thursday, September 9, 2022, consisting of 3 students from SMP IT Aufia Global Islamic Boarding School Riau. Based on the one-to-one trial, the results obtained remained relatively the same. It was found that in the student worksheets, there were typos in the letters in the problem presented, the students' worksheets images needed to be clearer, and several sentences and activity steps in the worksheets needed to be understood by students. Then, researchers tried to give a little explanation of this.

After the learning tools were revised and conducted one-to-one trials, to see the practicality of students' worksheets, the researchers conducted small group trials. The small group trial was conducted with 6 Worksheets IX students at SMP IT Aufia Global Islamic Boarding School who had studied opportunity material. Students participating in small-group trials were selected based on heterogeneous abilities. This trial was carried out on Monday, September 12, 2022, for students' worksheets-1, Thursday, September 16, 2022. For students worksheets-2, Monday, September 19, 2022; for students worksheets-3, and students worksheets-4 on September 23, 2022. The specified time needed for trials on students' worksheets is 30 minutes for each meeting. Student response questionnaires were distributed and filled in by students after doing students' worksheets at each meeting to see the practicality of students' worksheets.

The results of the small group trial to see the practicality of the students' worksheets used by students get a very practical category (can be seen in Table 4).

Table 4.
Small Group's questionnaire responses

Aspects	**Percentage of Student Response Questionnaire Results in students worksheets**				**Total Average Percentage per Aspect**	**Practice category**
	1	**2**	**3**	**4**		
Students worksheets appearance	94,05%	92,26%	92,26%	88,69%	94,05%	Very Practical
Students worksheets content	86,57%	96,76%	93,52%	94,91%	86,57%	Very Practical
Students' worksheets usage practicality	88,54%	90,63%	95,83%	90,63%	88,54%	Very Practical
Percentage of total Average per students worksheets	89,72%	93,22%	93,87%	91,41%	Very Practical	
Percentage of overall students' worksheets average	92,06%					

Of the three aspects of the assessment, overall, the student's worksheets tested in 4 meetings obtained a percentage score of ≥ 85% in the very practical category.

Regarding the students' worksheets' appearance, a score percentage of 91.82% was obtained, which obtained the practicality category, namely very practical. In terms of students' worksheets content/material, the category is very practical, with a score percentage

of 92.94%. Regarding ease of use, students' worksheets scored 91.41% in the very practical category. So that the overall average percentage score obtained is 92.06%; according to the sources, the language used in students' worksheets can be easily understood. According to the respondents, the colors and illustrations used in the students' worksheets are interesting, based on the results of the aspects of the students' worksheets monitor that meet the didactic requirements. There are no aspects in each assessment item that has a practical category with an average percentage score of <85%. All scored in the practical category at four meetings, with the lowest percentage score of 86.57% on the students' worksheets Content/Material aspect at students worksheets-1.

Based on the small group validation and trial results, it was concluded that the very valid and practical criteria met the developed learning tools. With the validity and practicality of learning tools with the mathematical critical thinking skills indicators contained in them and by using the PBL model, it is proof that these devices can facilitate and grow mathematical critical thinking skills through mutually integrated learning steps between the PBL model scientific approach and the mathematical critical thinking skills indicators. This is in line with the results of several studies, which state that valid and practical learning tools that use the PBL model and contain mathematical critical thinking skills indicators in the learning steps can facilitate and can foster students' mathematical critical thinking skills (Setyorini et al. (2011); Satwika et al. (2018); Sianturi et al. (2018); and Haryanti & Febriyanti (2017). Thus, the results of this study are additional empirical evidence that learning tools that are valid and practical with a scientific approach using the PBL model and contain steps for indicators of mathematical critical thinking ability can facilitate and grow students' mathematical critical thinking skills. In addition, these results are also proof that this learning tool is ready for use by teachers and is a positive contribution as a reference in the learning process.

It was concluded that the learning tools that had been researched and developed by researchers by applying the PBL model to the material for opportunities to grow mathematical critical thinking skills met the valid criteria and were suitable for use in supporting the learning process in schools. The advantage of this product is that it can be an alternative teacher-learning tool by the teacher in learning because it meets valid and practical criteria.

IV. Conclusion

This development research produced a product in the form of a mathematics learning device which is composed of a syllabus, lesson plans, and student worksheets and refers to the 2013 curriculum through the application of the Problem-Based Learning model to facilitate critical thinking skills in mathematics for Grade VIII students of SMP/MTs who meet valid and practical criteria. The validation results from three validators show that the syllabus, lesson plans, and student worksheets are very valid, with the average score in a row 3.82, 3.74, and 3.55. Student worksheets practicality shows an average percentage of 92,06% with efficient criteria. The results of this study indicate that the learning) based on Model Problem Based Learning (PBL) on the probability material is very valid and very to grow students' mathematical critical thinking skills.

This study only conducted small student worksheet trials and did not conduct large student worksheet trials, so the researchers suggested conducting large group trials to see the effectiveness of the student worksheets.

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