

DEVELOPMENT STUDENT'S WORKSHEETS SOLID CURVED SURFACE BASED ON AUGMENTED REALITY

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Abstract

The purpose of this research was to develop a good quality LKPD based on three aspects, namely validity, practicality, and effectiveness. This study utilized AR technology and follows the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model to develop student's worksheets on solid curved surface. LKPD and learning outcomes tests were each validated by six experts, consisting of three worksheet experts and three test instrument experts. The result of the development of this student's worksheets had validity score of $3.66 > 3,25$, that indicate very valid. The LKPD was practice due to the score are 3.46 for observing and 3.63 for the response that both were than 3,25 which means fulfilling practical aspect. The average score of learning outcomes was 78, but some students have not pass the exam. In order to gain the effective aspects so that improvements were needed by adding HOTS-type exercises in the LKPD.

Keywords: LKPD (Worksheet); Augmented Reality; Curved Solid

Introduction

The needed of developing teaching materials for mathematics learning materials is increasing nowadays. This is of course in line with technological developments that occur. Teaching materials are one of the important learning tools for students in learning mathematics because teaching materials are a supporting component of learning. Teachers must understand the various ways technology presents learning material and align it with possible learning approaches (Mishra & Henriksen, 2018). Andrs said that if theoretical knowledge learning is complemented by practical training, the learning efficiency achieved is greater (Andrs, 2018). One of the learning components that can integrate theoretical knowledge and practical exercises is the Student's Worksheets (LKPD).

According to Trianto, the Student Worksheet (LKPD) is a guide learners who are used to carry out investigative activities or a solution to the problem (Trianto, 2012). In general, the Student Worksheet (LKPD) is a worksheet in the form of a guide for students who contain information, questions, orders, and instructions from the teacher to students to carry out an investigation or activity and solve problems in the form of work, practice or experiment therein

can develop all aspects of learning. So that through LKPD students can do activities as well as earn a kind of summary of the material on which the activity is based.

The use of LKPD in the teaching and learning process on the material of Curved Solid is still not optimal. Teachers still use conventional LKPD, where the content of LKPD can only provide a 2-dimensional perspective and lack of integration with technology. One technology that can provide more perspective is Augmented Reality. Augmented Reality (AR) is a technology that can directly integrate three-dimensional virtual objects into the real world (Azuma et al., 2001).

The use of AR as the content of a LKPD can be an additional perspective of a material. This is because AR technology has the potential to attract student's attention to visualizing information on real objects using handheld devices such as tablets and smartphones (Han & Zhao, 2015; Majid et al., 2015; Petersen & Stricker, 2015). In previous research, the use of AR was effective in helping students build knowledge and perspectives then showed an increase in student motivation and learning outcomes (Cai et al., 2019; Coimbra et al., 2015; Korenova & Gunčaga, 2018; Sugiyarto et al., 2019). However, based on the tracing of existing research, the AR loading on the curved solid material is minimal, and the packaging of AR content in LKPD is still a little more for mathematics material. So the purpose of this research is to develop an AR-based LKPD on curved solid materials, especially tubes and cones.

Metodh

This development research uses the ADDIE model. ADDIE stands for Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model developed by Dick and Carry can be for various forms of learning product development (Mulyatiningsih, 2012). However, for the implementation phase of this research, only a small trial was carried out due to the limitations of the research caused by the Covid-19 pandemic.

Based on the description above, the procedure to be carried out is to follow the steps in the model. The following is a schematic of the procedures carried out in this study.

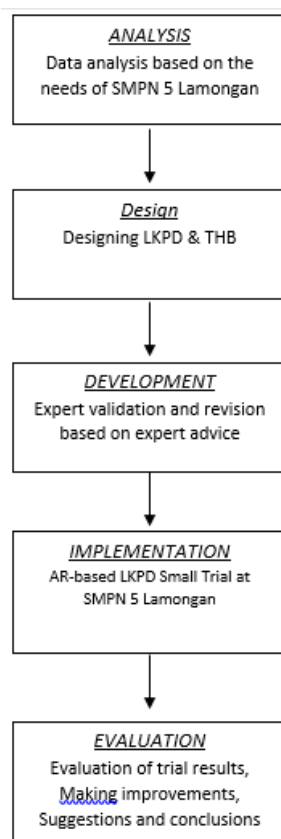


Figure 1 Research Schemes

The first stage of the ADDIE model is called the analysis stage on this stage the analysis carried out in analyzing the search for the main problem in the mathematics learning process at SMPN 5 Lamongan. In this case, learning materials, student characteristics, media/teaching materials used, and learning outcomes where learning assessment must refer to the 2013 Indonesian Curriculum for Junior High Schools (SMP). The results of the analysis at this stage are self-evaluated and refined by evaluation with the supervisor. Then The design stage is the target of analysis stage's results. The design is to ensure that instructional media products can be used to solve the problems obtained in the first stage.

After the problem and design phase is complete, the media is ready to be developed. QR-Generator is used to design markers, while 3D AR objects are created using Geogebra AR. Augmented Reality can be defined as a human-machine interaction tool that presents information generated by computers in the real world using a camera (Majid et al., 2015). The use of cameras can increase student understanding and motivation. Cameras can help teachers in the development of many classroom-based multimedia resources (McHugh & McCauley, 2015). AR technology has the potential to attract students' attention to visualize layers of

information on real objects using handheld devices such as tablets and smartphones (Han & Zhao, 2015; Majid et al., 2015; Petersen & Stricker, 2015).

The AR development phase is realized using Geogebra AR and the available smartphone camera AR Core for this purpose. Furthermore, real-time three-dimensional media can be seen visually using the Android / IOS smartphone camera. After developing LKPD, the next step is to perform validation that state the media is valid or invalid. Media validation was carried out by several experts for LKPD and THB instruments. The validation process is carried out by assessing the media in terms of format, content, language, and appearance for LKPD then content, construction and language for THB. All aspects have been covered in twenty-two questions on a scale of 1-4.

After doing the validation and revision suggested by the validator, the next step is to conduct a trial on the LKPD that has been made. In the trial, an assessment of practical and effective aspects was carried out. Practical aspects can be reviewed through teacher assessment instruments and student response questionnaires, while effective aspects can be reviewed through the THB score results.

In this study, the quality of the LKPD developed was based on three aspects of quality by Nieveen, namely valid, practical and effective (Plomp & Nieveen, 2007). The data will be analyzed to determine the valid and practical aspects of the LKPD which are made based on the criteria in Table 1. The N value is obtained from the average score given by the validator or observer and the responses given by the students. The effective aspect is based on the results of the THB value that meets the Minimum Criteria (KKM) complete or not. LKPD is said to be effective if students reach or exceed the KKM score standardized by SMPN 5 Lamongan, which is 75.

Table 1 LKPD's Assessment Criteria

Score (<i>N</i>)	Validity Criteria	Practical Criteria
$3.25 < N \leq 4.00$	Very Valid	Very Suitable
$2.50 < N \leq 3.25$	Valid	Suitable
$1.75 < N \leq 2.50$	Not Valid	Not Suitable
$1.00 \leq N \leq 1.75$	Very Not Valid	Very Not Suitable

Result and Discussion

Analyze phase

Analysis of needs at SMPN 5 Lamongan is the first step in this research. Researchers analyzed the needs of SMPN 5 Lamongan through observation, interviews, and searching for reference literature. Observations were made directly in one of the classes at SMPN 5

Lamongan when learning mathematics on the material of curved solids with conditions before the Covid-19 outbreak. In these observations, it was found that in the learning carried out, the use of technology in learning was still minimal. After the observations were made, the researcher conducted interviews with the teacher and several students related to mathematics learning that had been carried out.

The analysis was carried out referring to the results of direct discussions with several senior mathematics teachers from SMPN 5 Lamongan. Some problems were found, teachers had difficulty applying technology in learning and difficulties in providing students with more perspectives in the curved solids material. This turned out to be in line with the learning outcomes data of students at SMPN 5 Lamongan in the previous academic year who had difficulty achieving KKM completeness before remedials were held and supported by data by the Ministry of Education and Culture regarding the results of the 2019 National Examination where the percentage of mastery of curved solids was only around 37% - 49 % (Puspendik, 2019).

While the characteristics of the students observed, almost all students in the class have smartphones so they are easy to not focus and do not pay attention to the learning given because they tend to be monotonous in lectures without supporting media or the use of technology such as smartphones. This is in accordance with smartphone ownership data, showing that only 6.8% of students do not own a smartphone (Karmila, 2018). Even though students will be enthusiastic if there is the use of technology that is applied in learning. This should be a potential for teachers to integrate smartphone technology in learning.

Designing Of Worksheet

The design of LKPD using AR technology can be an alternative solution in learning curved solids. The material design is based on the 2013 Indonesian Curriculum, namely Basic Competencies 3.7 and 4.7 (Pendidikan et al., 2013). In this study, the development of LKPD was made for a meeting consisting of two sub-materials, namely regarding the surface area of a cone and a tube with indicators of competency achievement in Table 2. The making of LKPD is based on the rules given by the Ministry of National Education where the devices made must meet the following components : (1) title; (2) learning instruction; (3) competencies to be achieved; (4) subject matter; (5) supporting information; (6) tasks and work steps; and (7) assessment (Depdiknas, 2008).

Table 2 The Material of Curved Solids on the Indonesia's Curriculum of 2013

Basic Competencies	Indicator
3.7 Make generalizations of surface area and volume of curved solids	3.7.1 Identify surface of tube
	3.7.2 Finding surface area of tube's formula
	3.7.3 Identify surface of cone
	3.7.2 Finding surface area of cone's formula
4.7 Solve contextual problems related to surface area and volume of curved solids	4.7.1 Solve contextual problems related to surface area of tube
	4.7.2 Solve Contextual problems related to surface area of cone

Whereas the THB instrument was made to cover basic competencies 3.7 and 4.7 in the K-13 curriculum (Pendidikan et al., 2013). The type of question chosen is a description of 4 items with reference to the lattice that has been made in Table 3.

Table 3 THB's Indicators

Basic Competencies	Problem Indicators	Problem's Form	No
3.7 Generalizing the surface area and volume of curved solid	Presented two pictures of tubes of different sizes, students can determine the surface area of the two tubes.	Essay	1
	Two cone pictures are presented with the condition that the height of the first cone is equal to the radius of the second cone and the height of the second cone is the same as the radius of the first cone, students can compare the surface area of the two cones.	Essay	3
4.7 Solving contextual problems related to surface area and volume of curved solid	Presented a contextual problem related to the tube, students can determine the surface area of a given problem.	Essay	2
	Presented a contextual problem related to cones, students can determine the surface area of a given problem.	Essay	4

Developing Of Worksheet

The design in the LKPD is adjusted to the characteristics of students, where the display design uses the Corel Draw application. LKPD that uses AR technology is developed with the Geogebra Augmented Reality application which is useful for displaying real 3D objects, as seen in Figure 2. Development of AR objects is also assisted by QR Code Maker which QR (Quick Response) codes to links to AR objects that are desired. AR Geogebra was chosen because it is very easy to use to create 3D object spaces without a coding process so that the hope of this study can be used as a reference for teachers in making LKPD using AR content.

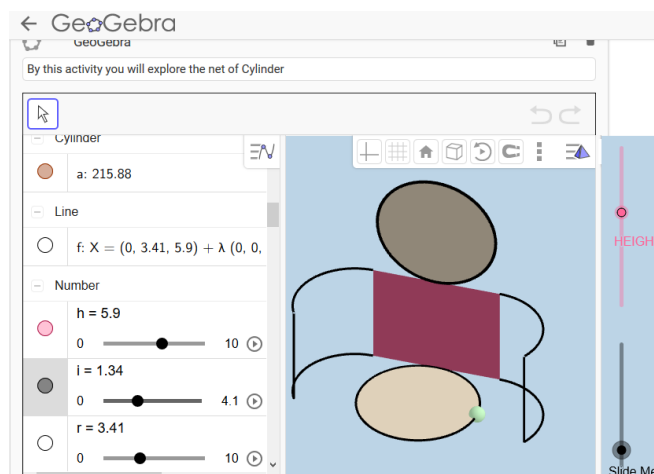


Figure 1 The Process of making 3D object
Augmented Reality

The product of this research is an AR-based LKPD, which can operate on smartphones based on Android / IOS and has an AR Core in it. LKPD provides information about curved solids material through AR objects. AR-based LKPD is divided into two parts, namely an introduction and content. The introductory section consists of a cover as shown in Figure 3. Whereas the content section consists of user identity, subject titles, learning competencies, instructions, guidance steps, marker images, joint exercises, assessment, and motivation. AR-based LKPD consists of 7 pages printed on A4 paper. The pages contain markers that will create an animated visualization of the curved solids through the cellphone camera by pointing the camera on a flat base and the AR object will be displayed according to the scanned marker image as shown in Figure 4.

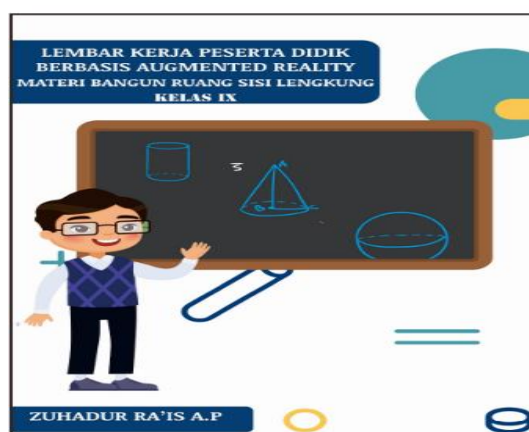


Figure 3 The Worksheet's Cover

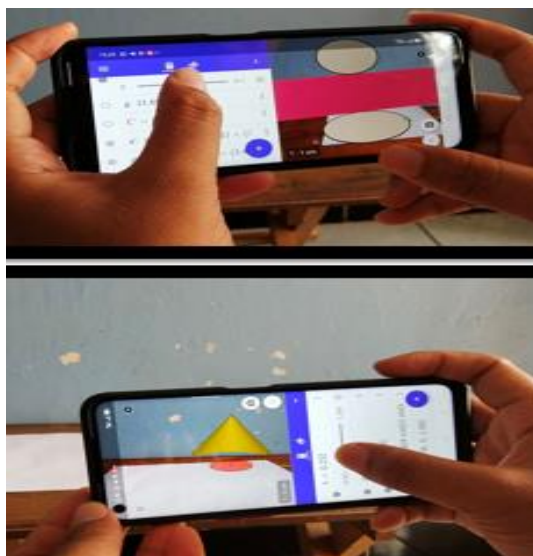


Figure 4 The 3D real time visualization of the media for the curved solids.

Validation of the Media

LKPD evaluation is carried out through a series of validation tests. The LKPD validation test was carried out on four aspects, namely appearance, format, content, and language. For the LKPD Validators, two lecturers of the Mathematics Education Study Program, the Faculty of Mathematics and Natural Sciences, State University of Surabaya, and a high school teacher were selected. The evaluation was carried out twice, where there were design improvements after the first validation. During the assessment, the validator is asked to provide free comments regarding these four aspects. Table 4 shows the suggestions given by the validator during the validation stage.

In this study, two indicators of learning objectives using AR technology were developed. LKPD provides the AR objects of these indicators: the surface area of the tube and the surface area of the cone.

Table 4 Comment and suggestion from the validators

No	Sugesstion
1	Fix language use, sentence structure. The exists are disorderly
2	Make the steps in the activity guide as a guiding step, because existing steps are not guiding.
3	Step number 4 will only confuse the goal to be achieved, please replace it with a table where students can find the formula in scaffolding using it.
4	Add a shared exercise (which shows how to solve problem) in the worksheet.
5	Use contextual problems for realistic mathematics to emerge.

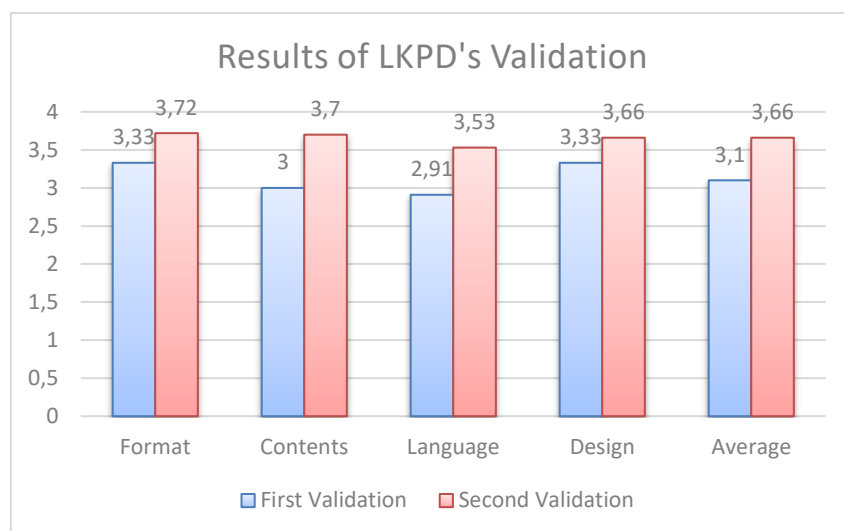


Figure 5 LKPD's Validation Result

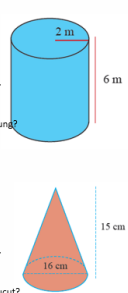
The four aspects of learning media that were assessed by the validator were design, format, content, and language. A total of 22 questions must be scored by a validator covering this aspect of the assessment. Figure 5 shows the score given by the validator. Based on these data, the aspect display is the highest score given by the experts with an average of 3.72 format aspects. The lowest score of 2.91 was observed in the linguistic aspect given by the experts. Then there is an aspect that increases higher than other aspects, namely Content. This is due to a large number of input from the validator who suggested the addition of appropriate guide steps to help the scaffolding process of students as well as adding contextual problems.

In the data comments and suggestions given, the validator wants the use of good language in the preparation of the guide steps provided on the worksheet. Exercise questions (guided and independent) in LKPD are also very necessary. The use of guide steps and contextual problems will assist students in building the knowledge provided by students. This is related to the data research that has been done. (Adu, 2016; Kadera, 2017) explains that learning using guided guidance enables students to develop mathematical concepts and positive attitudes towards learning. Meanwhile, the use of context in problem giving can lead to meaningful learning and increase student self-confidence (Rusmini & Surya, 2017; Widjaja, 2013). The things suggested by the expert can complement the perspective of the AR object contained in the LKPD. The revision of consideration given by the validator is shown in Figure 6 and Figure 7.

Practice Before Revision

SOAL LATIHAN

- Tentukan luas permukaan dari tabung disamping ini
 - Jika jari jari dijadikan dua kali lipat dan tinggi dijadikan $\frac{1}{3}$ kali lipat, Berapakah luas permukaan tabung?
 - Jika jari jari dijadikan $\frac{1}{3}$ kali lipat dan tinggi dijadikan dua kali lipat, Berapakah luas permukaan tabung?
 - Dari soal 1a dan 1b apakah terjadi perubahan luas permukaan tabung? Jelaskan analisismu
- Tentukan luas permukaan dari kerucut disamping ini
 - Jika jari jari dijadikan dua kali lipat dan tinggi dijadikan $\frac{1}{3}$ kali lipat, Berapakah luas permukaan kerucut?
 - Jika jari jari dijadikan $\frac{1}{3}$ kali lipat dan tinggi dijadikan dua kali lipat, Berapakah luas permukaan kerucut?
 - Dari soal 1a dan 1b apakah terjadi perubahan luas permukaan kerucut? Jelaskan analisismu



Practice After Revision

LATIHAN MANDIRI

- Pras adalah seorang siswa kelas IX di SMP Gotong Royong. Suatu hari ia mendapatkan tugas Prakarya membuat celengan berbentuk tabung seperti gambar disamping menggunakan kertas karton. Bantu Pras menentukan bentuk jaring-jaring celengan yang harus ia buat dan berapa luas kertas karton minimal yang ia butuhkan untuk membuat celengan tersebut. (skor: 15)
- Erica adalah seorang kakak yang baik kepada adiknya. Ia membunika topi lucu untuk boneka seperti gambar disamping. Suatu saat ia akan membuat 2 topi dengan ukuran diameter alas 10cm dan tinggi 24cm. Bantu Erica untuk menentukan bentuk selimut topi yang akan ia buat dan luas minimal kertas yang harus dimiliki Erica untuk membuat topi tersebut. (skor:15)




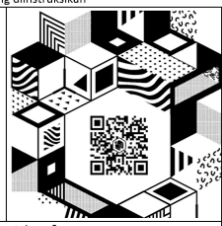
Figure 6 Revised Exercise On LKPD

Step Guide Before Revision

A. Scan Marker yang ada dan buatlah objek sesuai yang diinstruksikan

- Bukalah tabung tersebut, apa saja sisi yang dimiliki tabung?
- Bagaimana mencari luas selimut tabung?
- Ubah jari jari alas dengan berbagai ukuran. Amati perubahan tersebut terhadap selimut tabung, Bagaimana dampaknya?
- Bagaimana mencari luas permukaan tabung?

Jadi, apa yang dapat kamu katakan tentang luas permukaan tabung?



Step Guide After Revision

KEGIATAN 1 (SKOR 35) :

A. Pindai QR Code yang ada dan buatlah objek sesuai yang diinstruksikan.

- Bukalah tabung tersebut, (Gunakan slider yang tersedia)
 - Dari pengamatanmu, lukislah jaring-jaring tabung pada kotak dibawah ini
- Dari soal no 1, dapat diketahui bahwa
 - Sisi Atas berbentuk dan
 - Yang berbentuk ada buah
 - Yang berbentuk ada buah
 - Sisi Selimut berbentuk : dengan panjang yang merupakan : dan lebar yang merupakan :
 - Sehingga luas permukaan tabung = Luas + Luas = 2 x (Luas) + Luas
- Isilah tabel di bawah ini untuk menemukan rumus luas permukaan tabung

Jari - Jari	Tinggi	Luas Tutup	Luas Alas	Luas Selimut	Luas Permukaan Tabung
7cm	10cm	$\pi \times 7 \times 7$	$\pi \times 7 \times 7$	$2 \times \pi \times 7 \times 10$ + +
10cm	14cm	$\pi \times \dots \times \dots$	$\pi \times \dots \times \dots$	$2 \times \pi \times \dots \times \dots$ + +
14cm	...	$\pi \times \dots \times \dots$	$\pi \times \dots \times \dots$	$2 \times \pi \times \dots \times \dots$ + + = 1232 cm ²
...	7cm	$\pi \times \dots \times \dots$	$\pi \times \dots \times \dots$	$2 \times \pi \times \dots \times \dots$ + + = 1386 cm ²
r	t	$\pi \times \dots \times \dots$	$\pi \times \dots \times \dots$	$2 \times \pi \times \dots \times \dots$ + + = 2x +

Figure 7 Revised Guide Step On LKPD

The THB instrument also carried out a series of validation tests. The THB validation test was carried out on three aspects, namely content, construction, and language. For the THB Validator, a lecturer at the Mathematics Education Study Program, Faculty of Mathematics and Science, State University of Surabaya, and two middle school mathematics teachers were selected. The evaluation was carried out twice, where there were design improvements after the first validation. During the assessment, the validator is asked to provide free comments regarding these three aspects which are shown in Table 5.

Table 5 Comments and Suggestions From THB Validator

No	Comments and Suggestions
1	Pay attention to the logic and context in the problems made. Pay attention to unit usage.
2	Clarify the instructions in the question.
3	Don't use additional question words that can obscure the problem.
4	The context in question number 4 is less realistic and too forced to contain the surface area material. Can be replaced with other contexts.

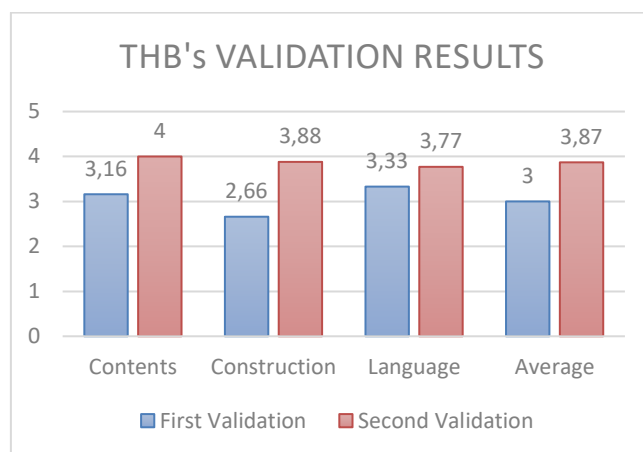


Figure 8 THB's Validation Result

The three aspects of THB that were assessed by the validator were content, construction, and language aspects. A total of eight questions must be scored by a validator covering this aspect of the assessment. Based on the validation results shown in Figure 8, all assessed aspects have increased along with the improvements made by following the validator's input. So that the mean score of THB instrument validation results can exceed the score of 3.25 as the minimum criterion is very valid.

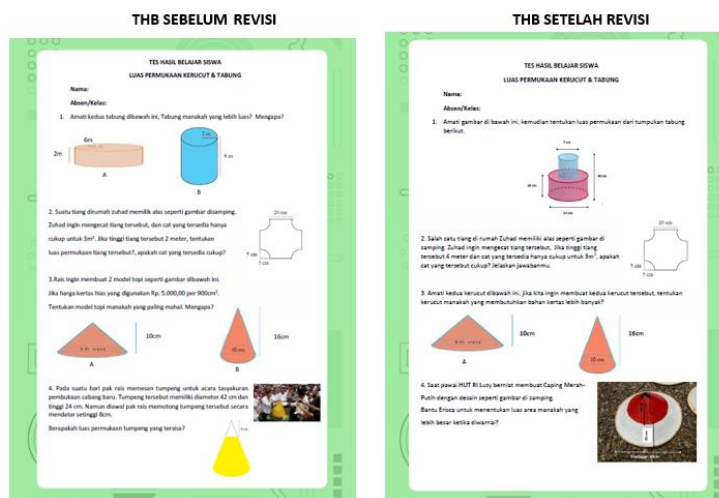


Figure 9 THB Revised

Validation is carried out online via Whatsapp using a closed questionnaire. Besides, researchers also conducted interviews from the results of the questionnaire assessment that had been filled in by each validator. The validity of the learning media that has been developed is determined based on the results of validation by validators who are experts in their fields (Syukri et al., 2018). LKPD validation was carried out twice because in the first validation it had not reached a mean value of 3.25 and from the results of the second validity test the value was 3.66 with a very valid category. Meanwhile, THB validation process was also carried out twice because in the first validation it had not reached a mean value of 3.25 and from the results of the second validity test the value was 3.87. The score obtained is following the target assessment criteria, namely the average value of the validity test results reaches a value of ≥ 3.25 . So that LKPD and THB are declared very valid and can be tested.

Implementation Phase

After the LKPD and THB were declared very valid, a small trial was carried out on limited students in class IX SMPN 5 Lamongan. This is a product trial to measure the feasibility of LKPD products. In this small or limited scale field trial, several students were taken to find out the responses and constraints faced by students when using the LKPD. The subjects in this small-scale field trial were 6 representative students, two students representing the lower group, namely students with low achievement, two students representing the middle group, namely students with moderate achievement, and two students representing the high group, namely students with high achievement. This representative sample of students was taken randomly based on the achievement data shown by the class teacher.

The research conducted was limited to small trials due to the Covid-19 pandemic, researchers had difficulty getting permission to take subjects at school. This trial was conducted to determine the practical and effective aspects of the LKPD that had been made. Subjects will apply to learning using LKPD with researchers. The learning implementation carried out was observed by a teacher. After the subject has learned, a response questionnaire is given to see the impression and enthusiasm of the subject in learning, after which a learning outcome test is given to see the learning outcomes after learning based on the Minimum Completeness Criteria (KKM) value. Teacher assessment instruments and student response questionnaires were used to measuring practical aspects. While THB is used in measuring the effective aspects of the LKPD made.

The data shows that the mean score obtained from the assessment data by the teacher on the observation of the implementation of the learning gives a score of 3.46 with the category

"very suitable". While the data from the response questionnaire collected from the subject showed a score of 3.63 in the "very good" category. From the response questionnaire, it can be stated that most of the students who were subject to small-scale group trials strongly agreed with the use of the student worksheet developed by the researcher. Based on the two scores above, more than 3.25, the LKPD made has fulfilled the practical aspects.

The data from the learning outcome test showed that the average score obtained was 78, this indeed exceeds the minimum score criteria (KKM), which is 75. However, out of the 6 students who were tested, 4 students completely met the KKM. If calculated, the percentage of many students who did the trial beyond the KKM was 66.66%.

According to Widoyoko, the amount of this percentage is that the minimum percentage of completeness of the learning outcomes test is said to be effective if $> 60\%$ of many students exceed the KKM (Widoyoko, 2009). However, if based on Trianto, the completeness of learning outcomes is obtained if many students exceed the KKM $\geq 85\%$ (Trianto, 2009). Indeed, students who do not complete (but the score is close to completion) are students in the lower group. However, based on these results, it shows that the LKPD that has been made has not fulfilled the effective aspects and needs improvement.

The improvements made can review the items that have a low score from the answers given by students. Of the 4 questions, question number 4 had a lower score than the majority of students' answers. This question is a HOTS type question, which in the LKPD there is no exercise on HOTS type questions. So that improvements can be made by adding HOTS practice questions.

In this study, some notes need to be considered, that the trials being carried out were still carried out on a small scale on 6 students so that a larger trial was needed to determine its effectiveness comprehensively.

Conclusion and Suggestion

Student Worksheets (LKPD) on the Curved Solids Material were developed using Augmented Reality (AR) technology. The design and development carried out have met the valid and practical categories, but improvements are still needed to meet the effective category. After being repaired, this LKPD can be used in mathematics learning to curved solids for junior high school level. The results of this study can be used by the teacher as alternative teaching material in the curved solids material.

From the research that has been done, it is suggested for further research do (1) The use of AR-based Curved Solids Worksheet can be tested on a large scale to determine its

effectiveness comprehensively; (2) The LKPD is digitized as a form of changing times in 21st-century learning.

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