

## STUDENT WORKSHEET WITH AR VIDEOS: PHYSICS LEARNING MEDIA IN LABORATORY FOR SENIOR HIGH SCHOOL STUDENTS

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### Abstract

Practicum based learning is required to provide opportunities for students in finding and applying concepts by observation. Student worksheets with a discovery learning model and equipped with AR video are needed as a learning tool, so students will be able to have good work in the laboratory and implementation of the practicum is effective. This study aims to produce LKPD (Lembar Kerja Peserta Didik or student worksheet) and AR (augmented reality) media that are videos related to the topic of practicum. The method used in this study is a research and development method with the Dick and Carey model approach. The feasibility test was carried out on the product using a Likert scale instrument. Feasibility test on media experts obtained a score of 89.95%, on material experts, obtained a score of 96.93%, on learning experts at 80% and obtained an average score of 88.96 % with a very proper interpretation. Next, a user trial was conducted on the product with respondents, which are at 54th Senior High School in Jakarta. Trials on teachers obtained a score of 97.61%, and trials on students obtained a score of 87.08%. The limited trials are done by doing pre-test and post-test on students. Limited trial results obtained an average n-gain score of 0.46. Based on the results of the feasibility test, user trials, and limited trials, it can be concluded that the developed student worksheet is very suitable to be used as a learning tool in physics practicum activities in Senior High School in 10th grade.

**Keywords** – Student worksheet, Augmented reality, Physics learning media.

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## 1. Introduction

Physics is the base one of technology development. The study in physics requires a learning activity that provided opportunities for students to discover and apply the knowledge they obtain (Nugraha, Kaniawati, Rusdiana & Kirana, 2016). Efforts to cultivate the skills of students can be done through practicum-based learning in the laboratory. Learning laboratory activities can train students' way of thinking and way of working (Siswono, 2017; Malik, Setiawan, Suhandi & Permanasari, 2017). In laboratory activities, students are actively involved in the processes of observing the object, analyzing, proofing and concluding by themselves about the object or some processes (Nugraha, Utari, Saepuzaman

& Nugraha, 2018; Malik, Setiawan, Suhandi, Permanasari & Sulasman, 2018; Kustijono, Jatmiko & Ibrahim, 2018).

In laboratory activities, student worksheets required as a learning guidance tool that make the activities can be done well. Student worksheet in science learning is needed to develop by the teacher based on learning approach, method, and models so that activities are more directed and structured and able to direct students to find new concepts in learning (Fitriana, Yusuf & Susanti, 2016; Riyadi, Ertikanto & Suyatna, 2018). The discovery learning model is one of the learning models that support practicum-based scientific learning that can be applied in the student worksheet. The discovery learning model allows students to build their own knowledge based on data or information obtained through observation (Kustijono et al., 2018; Wartono, Batlolona & Grusche, 2018). Other research states, student worksheets with discovery learning models can guide students to think critically, innovatively and work independently (Sulistia, 2017; Fitriani, Bakri & Sunaryo, 2017; Azizah, Dafik & Susanto, 2018).

In addition to developing technology, studying physics also involves technologies that developed, Augmented Reality (AR) is one of them. AR creates a real object by bridging the virtual and the real world (Wang, Zhang, Xue & Cai, 2018). AR has been used in education to improve the quality of learning (Cai, Wang & Chiang, 2014; Chiu, DeJaegher & Chao, 2015; Rexa, 2018; Hapsari, Mutiara & Handayani, 2015; Bakri, Pratiwi & Mulyati, 2019). AR attachment in the media learning can be used to practice the higher-order thinking skills (Bakri, Ervina & Mulyati 2019; Bakri, Sumardani & Mulyati, 2019). AR packaging in the form of instructional videos of 3-5 minutes duration related to the topic of practicum can provide an overview of the practicum to be carried out and can improve the ability of students to work in the laboratory (Nadelson, 2015; Akçayır, Akçayır, Pektaş & Ocak, 2016). Based on the explanation above, so this research is developing student worksheets with AR videos for learning physics in the laboratory.

## **2. Design/Methodology/Approach**

The study is the research and development method with the Dick & Carey model approach. This selection is following the statement of Borg & Gall that the educational development model that can be used is the development model of Dick & Carey (Gall et al., 2003). The Dick and Carey model consists of 10 steps, but this research is limited up to the eighth step (Dick, Carey & Carey, 2015). The steps of this research are: analyzing the need to identify general objectives, analyze learning, analyze characteristics of students, formulating specific learning goals, developing assessment instruments, developing learning strategies, develop products in the form of student worksheet and AR applications, carry out validation, and revising the product. Product development is carried out in the basic physics laboratory and digital media laboratory, Universitas Negeri Jakarta. Product validation is carried out by three experts; media experts, material experts, and learning experts. The product through a limited trial at 54th Senior High School Jakarta.

## **3. Result and Discussions**

### **3.1. Student Worksheet with the Discovery Learning Model**

The result of the student worksheet focused on the Material and Unit Quantities with the practicum title “Measurement”. Figure 1 shows the front, inside and back cover of the student worksheet. The front cover contains the student worksheet title, student worksheet designation, the name of the author, the logo of the agency, and illustrations that illustrate the topics contained in the student worksheet. The inside cover contains the title of the material, practical illustrations, and basic competencies that must be achieved. The back cover contains a synopsis of the whole contents.

A student worksheet is arranged in three stages, namely the preliminary stage, the practicum stage, and the post-practicum stage. A student worksheet is arranged by the discovery learning model based on concept discovery. The steps of the activities compiled in student worksheets are presented in Table 1.

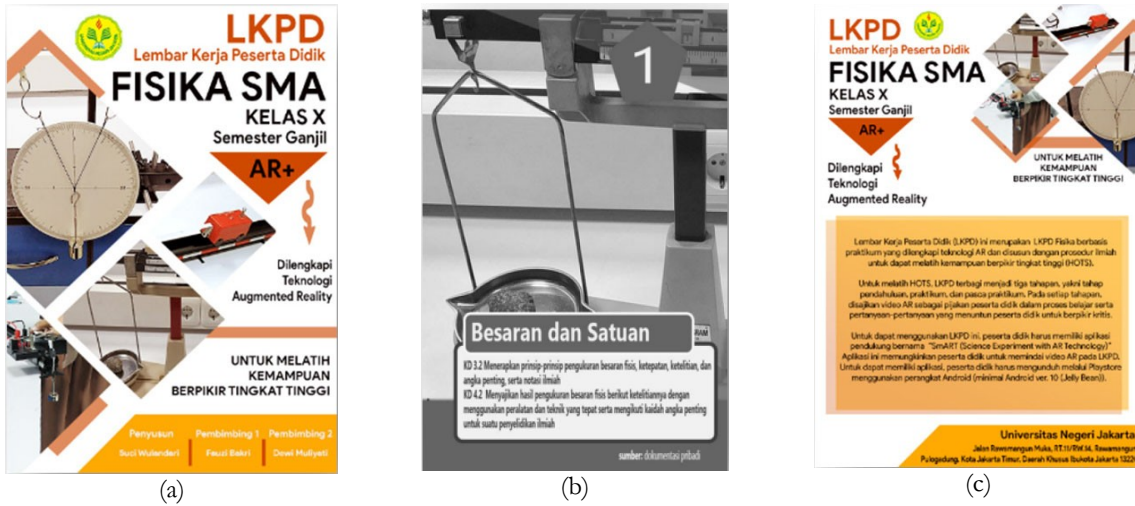



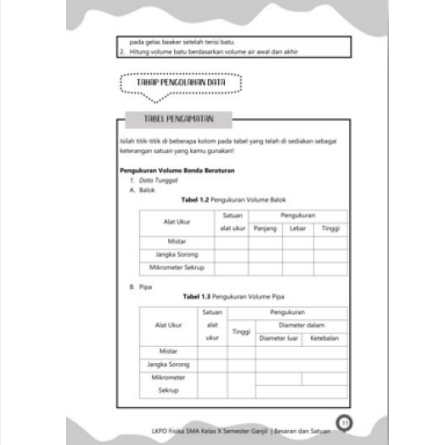
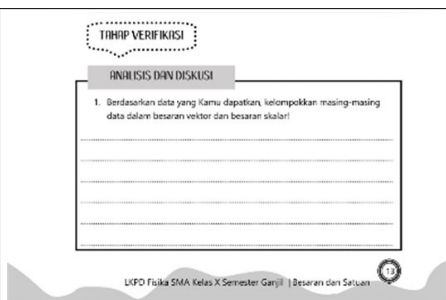


Figure 1. The cover view (a) front cover, (b) inside cover, (c) back cover of the student worksheet

Syntax/Step	Display	Activity
<b>Preliminary stage</b>		
Preliminary	<p><b>TUJUAN PRAKTIKUM</b></p> <ol style="list-style-type: none"> <li>1. Setelah melakukan praktikum, peserta didik dapat melakukan pengukuran secara tepat dengan alat ukur panjang dan alat ukur massa</li> <li>2. Setelah mendapatkan data, peserta didik dapat mengkonversi besaran dan satuan, serta dapat mengaplikasikan konsep angka penting dan notasi ilmiah dalam menyajikan hasil pengukuran.</li> <li>3. Setelah menyajikan hasil pengukuran, peserta didik dapat menentukan nilai densitas berdasarkan data hasil pengukuran yang didapat.</li> <li>4. Setelah mendapatkan nilai densitas, peserta didik dapat menganalisis data hasil pengamatan serta hasil perhitungan yang didapatkan.</li> <li>5. Setelah menganalisis data yang didapatkan, peserta didik dapat menganalisis kesalahan-kesalahan yang terjadi selama pengukuran.</li> <li>6. Setelah melakukan analisis secara keseluruhan, peserta didik dapat menjelaskan prinsip-prinsip pengukuran dan penerapan kegiatan pengukuran dalam kehidupan sehari-hari.</li> </ol> <p>LKPD Fisika SMA Kelas X Semester Ganjil   Besaran dan Satuan</p>	Students read and understand the learning objectives which must succeed through practical activities.
Stimulation	<p><b>TAHAP STIMULASI</b></p> <p>Scan gambar AR 1.1 di bawah ini untuk menyaksikan video.</p> <p><b>Gambar 1.1</b> Gambar AR pengantar Pengukuran (Sumber: <a href="http://www.youtube.com/MustangPhysics">www.youtube.com/MustangPhysics</a>)</p>	Students watch AR videos that appear after being scanned. Students are asked to criticize the video and answer questions related to the video in the initial questions section.
Problem statement	<p><b>TAHAP IDENTIFIKASI MASALAH</b></p> <p><b>TEORI DASAR</b></p> <p>Untuk mencapai suatu tujuan tertentu, di dalam fisika, kita biasanya melakukan pengukuran yang diteliti dengan pengukuran. Dalam pengukuran dikenal suatu besaran dan satuan. Besaran dalam fisika terbagi menjadi besaran pokok dan besaran turunan. Untuk melakukan pengukuran suatu besaran dibutuhkan alat yang disebut alat ukur, sedangkan untuk menyajikan hasil pengukuran secara internasional maka pada tahun 1959 para ilmuwan menetapkan satuan yang disebut sistem satuan internasional (SI). Mengonversi satuan-satuan dari berbagai besaran di dalam fisika sangat penting karena di dalam fisika banyak pengukuran dan perhitungan yang memerlukan satuan yang tepat. Misalnya, mengonversi satuan panjang berarti mengubah satuan-satuan panjang yang ada ke satuan panjang lainnya. Menurut sistem satuan internasional ditetapkan satuan dasar yakni meter (m) untuk satuan panjang, kilogram untuk satuan massa, dan sekon untuk satuan waktu. Berikut merupakan contoh beberapa alat ukur panjang dan alat ukur massa beserta bagian-bagiannya dan cara membaca hasil pengukuran.</p> <p>1. Mistar</p> <p>Mistar ukur yang banyak digunakan dalam industri atau pabrik mempunyai skala dalam inci dan metrik. Gambar 1.2 (a) menunjukkan cara pembacaan mistar dalam skala inci, sedangkan gambar 1.2 (b) menunjukkan cara pembacaan mistar dalam skala metrik.</p> <p><b>Gambar 1.2</b> (a) Cara membaca mistar dalam skala inci (b) Cara membaca mistar dalam skala metrik (Sumber: <a href="http://www.ditiprj.ac.id/Enggaku/Litot">www.ditiprj.ac.id/Enggaku/Litot</a>)</p> <p>LKPD Fisika SMA Kelas X Semester Ganjil   Besaran dan Satuan</p>	To support students' understanding of the concepts to be learned, this student worksheet is equipped with information on basic theories that are expected to help students find concepts.

Syntax/Step	Display	Activity
		Some questions presented in this section are related to the video that has been observed, and some questions are related to the concept. Through videos that have been observed and basic theories that have been read, students are expected to be able to answer, state or identify problems related to the material to be practiced.
<b>Practicum</b>		
		Students are directed to discuss the tools and materials used in practicum activities following the information in the table.
Data collection		Students are asked to scan an image with an AR logo to bring up a video that contains an instructional guide to the introduction of tools, the design or preparation of tools and materials, and the operation of tools. After identifying the tools and materials, students work according to the directions in the Practicum Procedure. At this stage, students begin to work to investigate until they find the concept of physics independently by working together in groups.
		During practicum activities, students read all the data obtained in the Observation Table. Students group, process, and calculate data obtained during the practicum. The data obtained contains the amount and mass of the irregular objects, as well as the mass and volume of the irregular objects. Students process these quantities to determine the density value of objects.
Data Processing		
<b>Post- practicum</b>		
		After getting the data, students can determine the measurement data, compare data, declare data in diagrams or graphs, do data calculations, determine measurement errors that might occur, and find concepts based on data.
Verification		


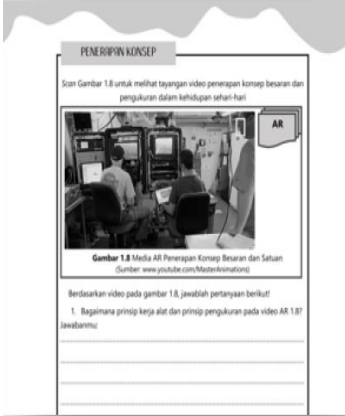
Syntax/Step	Display	Activity
Generalization		<p>After analyzing the data by discussion, students are directed to make conclusions related to the measurement concepts obtained through practicum activities.</p>
		<p>Students discuss images with an AR logo until a video appears related to the application of the concept of measurement in everyday life. Students improve to criticize the video based on measurement principles that have only recently been discovered through practical activities.</p>

Table 1. The steps of discovery learning in the student worksheet

### 3.2. AR Video

To be able to use AR, a minimum Android smartphone device v.4.0 (Jelly Bean) is required with an application called “Science Experiments with AR Technology (SmART)” installed. Figure 2 shows the viewing of the SmART application.

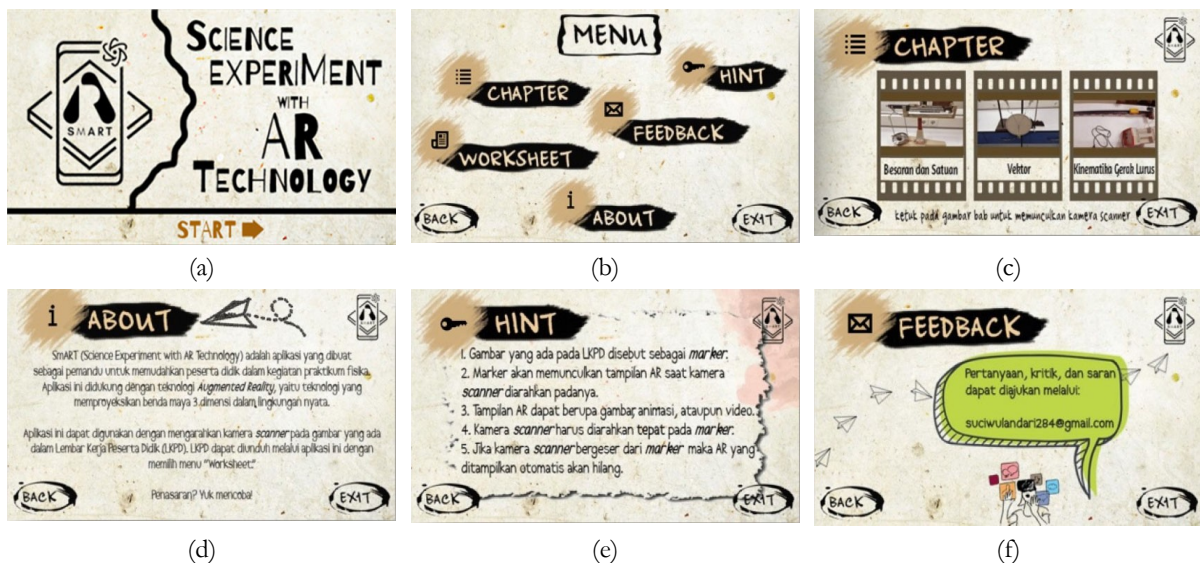


Figure 2. (a) start page, (b) menu page, (c) chapter main page, (d) about page, (e) hint page, (f) feedback page



AR videos can be raised by scanning images called markers. The scan is done by activating the SmART application camera namely on the Chapter Page, Magnitude, and Unit menu. The marker image is included in the student worksheet with the AR mark in the upper right of the image. The video display that appears on the smartphone screen of the students is arranged so that the video can be paused, played back and forth, or played repeatedly, shown in Figure 3.

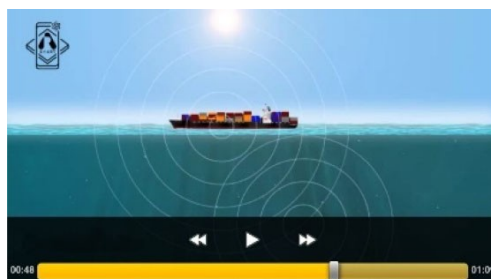


Figure 3. Video display that appears on the smartphone screen after scanning the marker

The video obtained in this student worksheet returns as many as three; located in the introduction, core, and cover. Each video has a duration of + 2-5 minutes. AR video display presented at the student worksheet is discussed in Table 2.



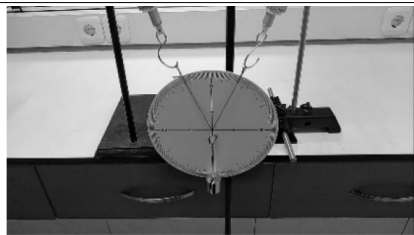
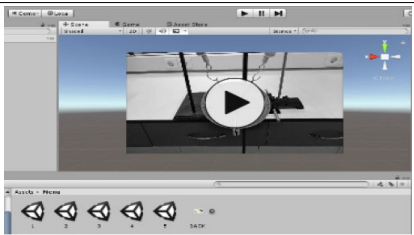


Material: Vector			
Topic of practicum: The result of force vectors			
Total image		10	
Total <i>marker</i>		3	
Total videos		3	
No	Object name	Marker	The process of making in Unity
1	Push the car and paddle		
Purpose: The video serves as an apperception so that students understand the concept of values and direction on force, and the movement in the phenomenon of pushing cars and rowing on white water rafting.			
2	Practical instruction		
Purpose: Students can recognize tools and materials and know how to assemble these tools and materials.			
3	Spider-cam		
Purpose: Students can deepen the working principle of spidercam in soccer matches			

Table 2. The details of video AR

### 3.3. Formative Evaluation Test

The student worksheet and AR video developed have passed the feasibility test or validation by media experts, material experts, and learning experts. The results of validation by experts are shown in Table 3.

No.	Aspects Measured	Presentation Score	Interpretation
Media Expert Validation			
1	Cover size	93.85%	Very Good
2	Cover layout	100.00%	Very Good
3	Cover typography	80.00%	Very Good
4	Component of the student worksheet	96.00%	Very Good
5	Layout of worksheet	85.71%	Very Good
6	Typography of contents	84.00%	Very Good
7	Illustration of contents	80.00%	Very Good
8	Interface of AR	100.00%	Very Good
9	Function of AR	90.00%	Very Good
Average of all aspects		89.95%	Very Good
Material Expert Validation			
1	Material content	93.85%	Very Good
2	Writing Language	100.00%	Very Good
Average of all aspects		96.93%	Very Good
Learning Expert Validation			
1	Didactic aspect	80.00%	Good
2	Construction aspect	80.00%	Good
3	Technical aspect	80.00%	Good
Average of all aspects		80.00%	Good

Table 3. The validation results of media experts and learning materials

Based on the results of media validation, an average score of 89.95% was obtained with a very decent interpretation. It means, student worksheet and AR video developed are following the standard both in terms of size, layout, and typography, the color mix presented is also good, the illustrations that are displayed are following the practicum context and the SmART application that is developed functions well and can be integrated with student worksheet. Suggestions and input delivered by media experts is an improvement in the sound quality of the video. Based on the results of the material validation, an average score of 96.93% was obtained with a very decent interpretation. The material presented is considered to be by scientific principles, contains mathematical equations needed to help students, accompanied by illustrations that can clarify the material and is presented in a communicative and effective language. Based on the results of learning validation, an average score of 80% is obtained with a proper interpretation. According to learning experts, the language used in student worksheet is following the level of thinking of students, the illustrations that are presented are already appropriate, and the syntax/steps of the learning model of discovery learning are visible. Suggestions/input provided by learning experts are examples of pictures and cases presented in basic theory are contextual examples, the discovery learning syntax is included in writing in student worksheet and is marked on each subtitle, and brief information about ar is presented at the front of the student worksheet.

After the feasibility/validation test was carried out, the student worksheet was tested on the user, the physics teacher and X MIPA 3 students at 54<sup>th</sup> Senior High School in Jakarta. The results of the user trial are stated in Table 4.

No.	Aspects Measured	Presentation Score	Interpretation
User trial (teacher)			
1	Material Content	93.33 %	Very Good
2	Display and Typography	100.00 %	Very Good
3	Writing Language	97.14 %	Very Good
4	<i>Augmented Reality</i> (AR)	100.00 %	Very Good
Average of all aspects		97.61 %	Very Good
User trial (students)			
1	Display of student worksheet	88.33%	Very Good
2	Content of student worksheet	85.00%	Very Good
3	Function of AR	81.67%	Very Good
4	Interface AR	93.33%	Very Good
Average of all aspects		87.08 %	Very Good

Table 4. User Trial Results (Teachers and Students)

Based on the results of product trials by users, a score of 97.61% obtained by teachers in the field of Physics studies with a very decent interpretation. Student worksheet products and AR videos produced have fulfilled teacher satisfaction both from the appropriate material aspects, aspects of appearance, typography, linguistic, and the appearance of smart and AR video applications. Suggestions and input delivered are accuracy in typing agar. Based on the results of product trials by students, a score of 87.08% was obtained with very proper interpretation. Students consider that based on the student worksheet display, the contents of the student worksheet, the SmART application display, and the functioning of the application, the product developed is very interesting and is a new experience for students. However, students become less interested because the student worksheet text that is presented is in black and white.

After the product has been validated by an expert and tested by the user, then a revision is made to the product based on the advice and input provided. After a revision, the product is ready to be tested on a limited basis. To assess the success rate of product development, measurement is done by giving a pre-test post-test to students in the limited trial. Before the pre-test and post-test are carried out, the items that will be used as measurement instruments are first tested for eligibility. The feasibility of the problem through 4 types of tests, namely: Validity test, reliability test, difficulty level test, and different power test. As for the results of limited trials conducted on students of class X MIPA 3, an average gain score of 0.46 with a pre-test score of 3.25 and a post-test score of 6.34 from a maximum score of 10.00. Based on this gain score, it can be interpreted that there is an increase in knowledge for students in the medium category. The gain score obtained is not in the high category can occur due to several factors, one of which is due to the use of student worksheets with AR videos that have not been intensive in practicum-based learning and students who are still adapting to learning systems equipped with AR media. However, overall, it can be concluded that the student worksheet developed with AR video is very feasible to use for learning physics in the laboratory.

#### 4. Discussion by Comparing with Other Result

Learning media related to the use of AR consists of video instruction in practicum-based learning conducted by Akçayır et al. (2016) discusses the use of AR technology with objects forming videos, animations, and simulations about the skills and attitudes of students in the laboratory. The object created is related to the topic of physics practicum. The research method used was a quasi-experiment with the control class and the experimental class. This research is conducted periodically for five weeks. The results obtained show how using AR significantly improves student skills in the laboratory. Visualization of the objects presented can help students in practicum and no longer needs to be done manually in the laboratory. They memorize the components and agree to the implementation instructions based on the video agreed by the instructor. When carrying out the practicum, students can carry out the practicum more quickly and need more the role of the teacher or laboratory assistant.



Based on this, an AR video for practicum-based learning is provided, which is integrated with worksheets and compiled using a learning discovery learning model so that students can work more optimally in the laboratory.

## 5. Conclusions

Formative evaluation results show that the Physics Students Worksheet developed with Augmented Reality technology for odd semester X grade high school students has met the criteria in terms of material, media, and learning so that it is declared very feasible to be used as physics teaching material.

## Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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