# Student worksheet based on PhET simulation for parabolic motion: a design worksheet using predict-observe-explain model

**D Muliyati[1, a], M Nurindrasari[1], E Ervina[1], and C Rustana[1]**

Physics Education Departement, Universitas Negeri Jakarta, Jl. Rawamangun Muka No. 1, Jakarta 13220, Indonesia

[a]dmuliyati@unj.ac.id

**Abstract**. This paper presents our research about student worksheets based on PhET simulation for parabolic motion using Predict-Observe-Explain model. This stage of development research consists of define, design, and develop. This research will describe the development process of each stage. The Likert scale instrument is used to measure the feasibility of the student worksheet. The feasibility of student worksheet media is studied by instructional media experts from the Physics Education study program at Jakarta State University. The results of the validation of the feasibility of student worksheets based on PhET simulations using the Predict-Observe-Explain model obtained that the student worksheets are suitable for use as learning media with an average value of 88.5% in the very good quality category.

## 1. Introduction

In the digital era, students are required to play an active role in classroom learning activities. Predict-Observe-Explain (POE) learning model is a learning model that can support the activeness of students and to prove their predictions also [1]. Based on research, using the POE learning model in physics can improve student's high order thinking skills [2], improve student's cognitive learning outcomes [3], and can improve student's understanding of physics concepts [4].

The other factor that needed to support student active learning activities is learning media. The media that used must be following current developments and technology [5]. One example of the use of ICT in learning in schools is the use of interactive simulations. Interactive simulations have been widely used in special learning in physics subjects. Based on several studies, the advantages of simulations in learning physics include increasing students' ability to solve problems [6], increasing conceptual understanding [7, 8], enhance the higher-order thinking skills [9-11], obtaining scientific skills such as problem solving, critical thinking, designing processes, and making measurements [12]. Besides that simulation can also rectify misconceptions that occur during learning [13]. Lately, more and more media have been developed, ranging from paid to free. One of the easily accessible simulation media is PhET Simulation. PhET Simulation is a site that provides simulations of learning physics, biology, chemistry, and mathematics, which provided free of charge by the University of Colorado for classroom learning purposes or can be used for individual learning purposes. The simulation is designed interactive so that users can learn directly. Interactive PhET simulations can be easily accessed for free (http://phet.colorado.edu) [14]. Many studies from various countries have

reviewed the effects of PhET simulations on learning physics in the classroom [15]. Interactive PhET simulations have been wide, several countries as evidenced by many versions of the translation several languages, one of which is Indonesian [16]. The drawback of interactive PhET simulation is the unavailability of guidelines for using simulations and worksheets for students, so teachers must guide the students in learning activities that use PhET simulation media [17].

Student worksheet can be used as a guided learning media. Student worksheets that are arranged can be designed and developed according to the conditions and situations of learning activities that will be encountered [18]. In learning physics, the existence of student worksheets can help teachers in delivering learning topics. Also, the worksheet can help students to obtain notes about the material learned through learning activities and to add information about concepts through integrated learning activities [19]. Based on research, the use of Student Worksheet in learning can improve learning outcomes better than without it [20]. In the preparation of student worksheet, it requires 3 kinds of procedures: didactic means that student worksheet must follow the principles of learning related to considering differences in each student; construction are requirements regarding the use of language, sentence structure, vocabulary, level of difficulty, and clarity which in essence must be appropriate in use that can be understood by students; and technical such as letters, pictures, numbers, etc. [21].

In the previous research, the development of simulation aid student worksheet about parabolic motion was made using the GASING method (Easy, Fun, and Fun). GASING physics learning methods train students to express and solve various problems with words, while the formula can adjust afterward. In this study, the syntax of GASING on student worksheet design starts from a simple dialogue about parabolic motion material, starting with inviting students to imagine the phenomenon of parabolic motion in daily life, followed by various issues that are relevant to published media, presentation of related material, and provide variations of practice questions. The development of GASING-based student worksheet was proven to be able to increase the interest and mastery of high school student material [22]. Subsequent research, student worksheet simulation aided parabolic motion was developed based on the Discovery Learning Model. Learning findings overcome some of the discussion that students can find concepts that can be applied in life. The steps in applying the Discovery Learning Model are Stimulation, Statement of Problems, Data Selection, Data Processing, Verification, and Generalization. The structure of student worksheet is based on simulation based on the discovery learning model itself, including title, tutoring, competencies to be obtained, supporting information, work steps, and results [23].

This paper aims to develop a Student Worksheet that is designed to fulfill the 4C skills of students by utilizing interactive PhET simulation media through the experimental method on parabolic motion. This Student Worksheet was created to make it easier for students to experiment on parabolic motion learning using interactive PhET simulations. The feasibility of the student worksheet was assessed by the learning media expert.

## 2. Method

This research used research and development methods with three stages of development, including define, design, and develop. In general, it will be explained below.

### *2.1. Define*

The definition stage is needed to obtain information and problems that exist. This information is useful as a reference for developing student worksheets.

*2.1.1. Curriculum analysis.* The curriculum used by schools to support the activeness of students in classroom learning is the 2013 curriculum. Then the developed student worksheet will refer to the 2013 curriculum.

*2.1.2. Student analysis.* This student worksheet is made for high-school students. Making must pay attention to differences in individual competencies, so the developed worksheet will pay attention to

the use of language, sentence structure, vocabulary, difficulty level, and clarity to be understood by students.

*2.1.3. Media analysis.* One of the media used in the digital age is simulation. The development of student worksheets is adjusted to the needs when using PhET Interactive Simulation in an experiment.

*2.1.4. Topic analysis.* The subject is limited only to the discussion of parabolic movements with the basic competencies and learning objectives as Table 1.

**Table 1.** Topic analysis.

| | |
|---|---|
| **Basic competencies** | 3.5 Incomplete sentence Analysing the motion of a satellite dish using a vector, the following physical meaning and its application in everyday life.<br>4.5 Present data on the results of parabolic motion experiments and their physical significance. |
| **Indicator of Achievement** | 3.5.1 Analyse the motion of a satellite dish using a vector, the following physical meaning and its application in everyday life.<br>3.5.2 Identifying physical quantities in parabolic motion.<br>3.5.3 Analyse the velocity and position of objects at certain points in the parabolic motion. |
| **Learning objectives** | • After conducting experiments and group discussions, students can identify what physical quantities are in parabolic motion.<br>• After conducting experiments and group discussions, students can analyze the effect of velocity and angle on the position of objects in parabolic motion.<br>• After conducting experiments and group discussions, students can present the discussion results well. |

*2.2. Design*

At this stage, the researchers designed and developed the student worksheet based on a PhET simulation for parabolic motion using POE model by compiling the format and the content. Each part of the student worksheet contents is adjusted to the obtained information at the define stage. The results of this stage are the initial product of student worksheet based on PhET simulation for parabolic motion using POE model, which is ready to validate by the learning media validator. Table 2 shows the content of student worksheet products.

**Table 2.** Draft contents of student worksheet parabolic motion aided by PhET simulation.

| Learning Stage | Contents |
|---|---|
| **Preparation** | Title<br>Name, class, and group column<br>Instructions for using<br>Basic Competencies and Indicators<br>Learning objectives |
| **Predict** | Presentation of phenomena<br>Prediction column<br>The question of developing ideas "What is your idea?" |
| **Observe** | Tools and materials<br>Work steps<br>Observation data (table) |
| **Explain** | Data analysis (analysis question)<br>Presentation of graph<br>The guiding question "Let's think!"<br>Conclusion column<br>Instructions for further activities "Come on Exploration!" |

*2.3. Develop*

After designing a student worksheet based on a PhET simulation for parabolic motion using POE model, the initial design of the student worksheet product was validated by a learning media validate and will be revised as a form of evaluation. The purpose of the developing stage is to produce a student worksheet based on a PhET simulation for parabolic motion using POE model that is suitable for use when learning in class. The too many nouns following is a lattice instrument validation instrument for student worksheet products that were developed.

**Table 3.** Student worksheet validation grating instruments.

| No | Rated aspect | Questions |
|---|---|---|
| **1.** | Content | 8 items |
| **2.** | Language and Image | 7 items |
| **3.** | Presentation | 6 items |
| **4.** | Finesse | 5 items |
| | **Total** | **26 items** |

## 3. Results and Discussion

After going through the developing stages, such as to define, design, and develop, the product produced is a student worksheet based on PhET simulation for parabolic motion using POE model as shown below.

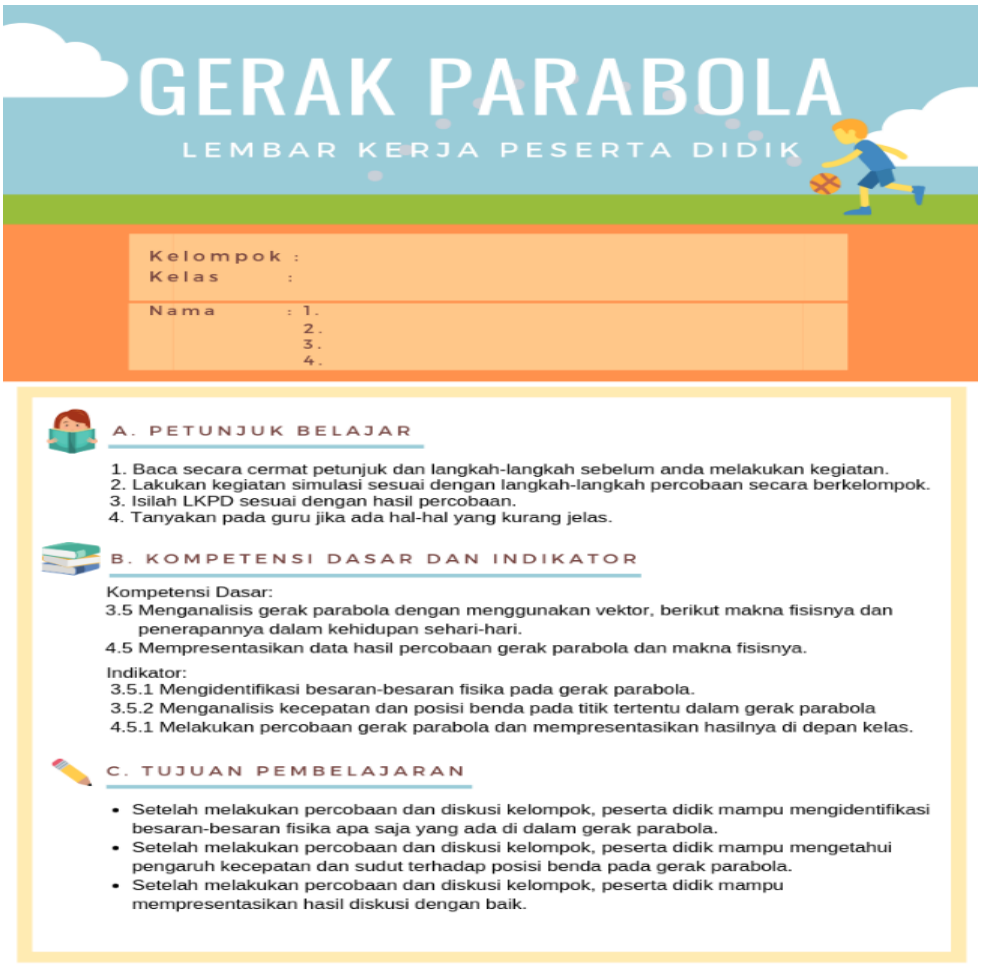



**Figure 1**. The preface part of student worksheet.

This student worksheet was developed by paying attention to the use of POE learning syntax, namely Predict, Observe, and Explain. The following is a description of the the developed student worksheet based on PhET simulation for parabolic motion using POE model:

*3.1. Predict*

In the Predict section, an initial phenomenon or problem related to parabolic motion is given, namely the phenomenon of an automatic tennis ball throwing machine with a throwing angle of the tennis ball and the initial speed of throwing a tennis ball that varies so that the distance of the farthest throw of the ball also varies. In this student worksheet, students must predict how the throwing angle correlates, the initial speed of the throw with the furthest throw distance of the tennis ball.

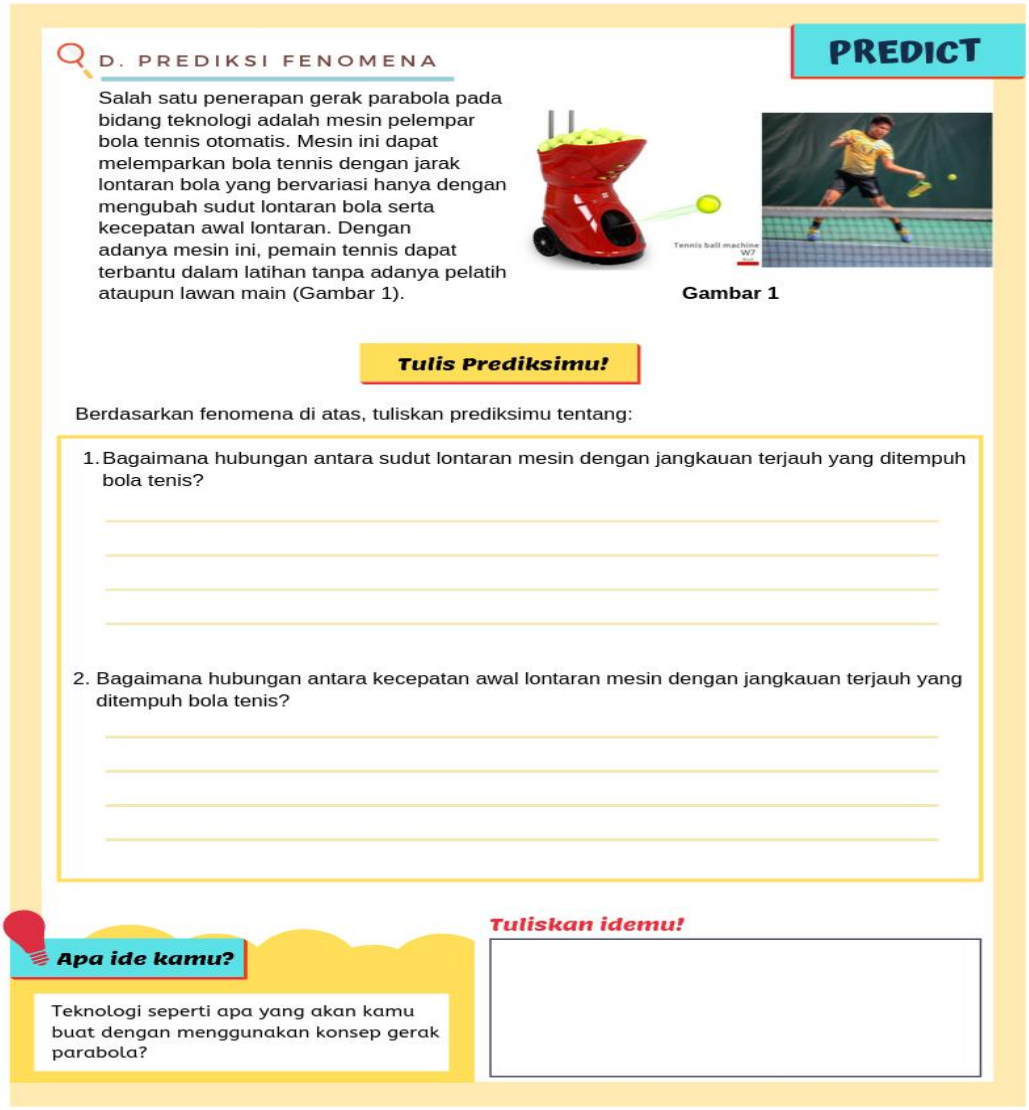
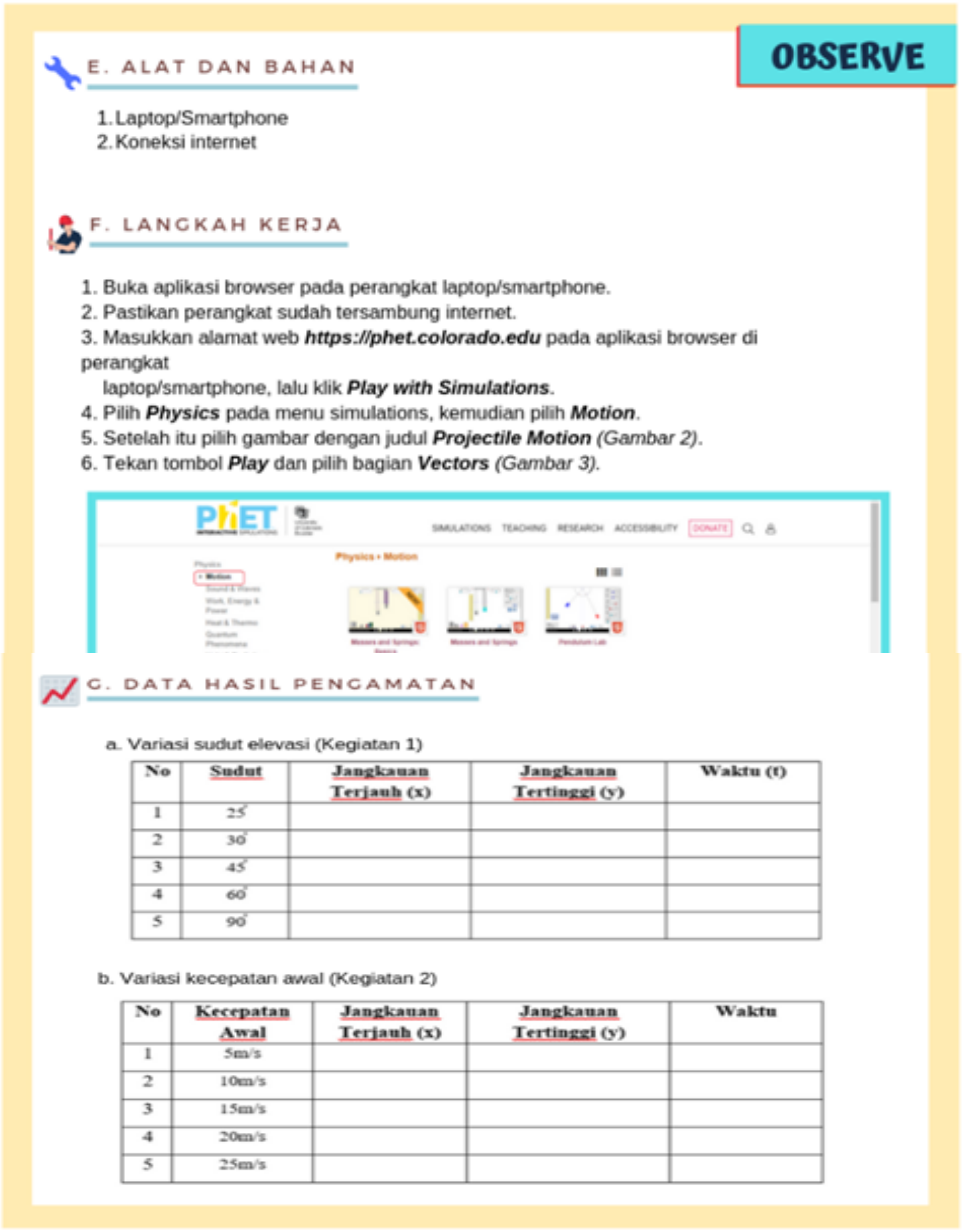



**Figure 2.** *Predict* section in student worksheet.

*3.2. Observe*

In the observe section, students will prove the truth of the predictions they have made by conducting experiments using the PhET simulation media. Students will take the data and then write it in the observation data table in accordance with the instructions contained in the student worksheet. The variables that are manipulated when conducting simulation activities are adjusted to the phenomena or problems that have been presented at the predict section.



OBSERVE

E. ALAT DAN BAHAN

1. Laptop/Smartphone
2. Koneksi internet

F. LANGKAH KERJA

1. Buka aplikasi browser pada perangkat laptop/smartphone.
2. Pastikan perangkat sudah tersambung internet.
3. Masukkan alamat web ***https://phet.colorado.edu*** pada aplikasi browser di perangkat laptop/smartphone, lalu klik ***Play with Simulations***.
4. Pilih ***Physics*** pada menu simulations, kemudian pilih ***Motion***.
5. Setelah itu pilih gambar dengan judul ***Projectile Motion*** *(Gambar 2)*.
6. Tekan tombol ***Play*** dan pilih bagian ***Vectors*** *(Gambar 3)*.

G. DATA HASIL PENGAMATAN

a. Variasi sudut elevasi (Kegiatan 1)

| No | Sudut | Jangkauan Terjauh (x) | Jangkauan Tertinggi (y) | Waktu (t) |
|---|---|---|---|---|
| 1 | 25° | | | |
| 2 | 30° | | | |
| 3 | 45° | | | |
| 4 | 60° | | | |
| 5 | 90° | | | |

b. Variasi kecepatan awal (Kegiatan 2)

| No | Kecepatan Awal | Jangkauan Terjauh (x) | Jangkauan Tertinggi (y) | Waktu |
|---|---|---|---|---|
| 1 | 5m/s | | | |
| 2 | 10m/s | | | |
| 3 | 15m/s | | | |
| 4 | 20m/s | | | |
| 5 | 25m/s | | | |

**Figure 3.** *Observe* section in student worksheet.

*3.3. Explain*

After studets conduct experiments at the observe section, students are asked to explain the results of the experiments at the Explain section by analyzing the results of the experiment guided by several questions then students are asked to compare the results of the experiments with predictions that have been made in the conclusion column.

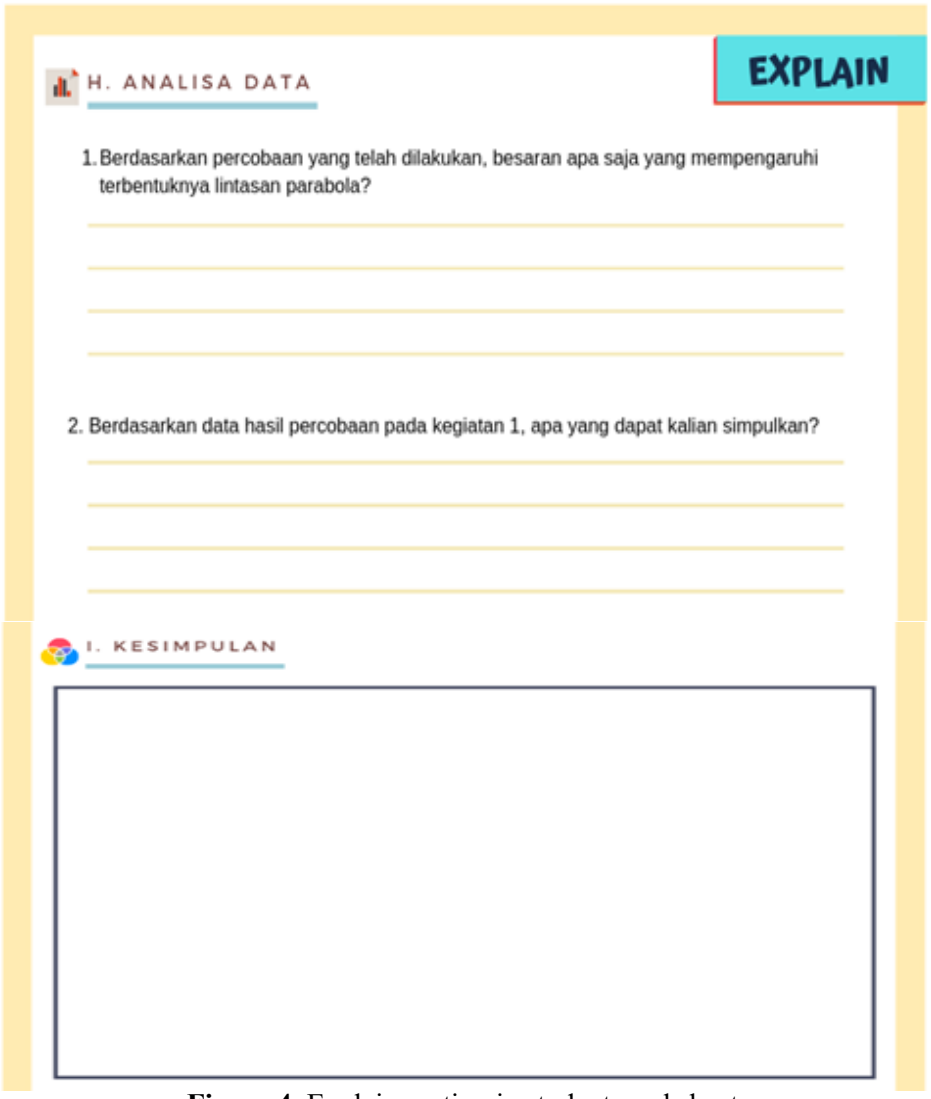



**Figure 4**. Explain section in student worksheet.

Based on the results of the validation carried out by learning media experts, student worksheet based on PhET simulation for parabolic motion using POE model obtained an average value 88.5% in the quality category very good. The summary of student worksheet validation results can be seen in Table 4.

**Table 4.** Results of Validation of student worksheet Parabolic Motion aided by PhET Simulation.

| No | Aspect | Average score | Category |
|---|---|---|---|
| 1. | Contents | 84% | Very Good |
| 2. | Language and Image | 86% | Very Good |
| 3. | Presentation | 94% | Very Good |
| 4. | Grafting | 90% | Very Good |
| Average total | | 88.5% | Very Good |

## 4. Conclusion

Based on the results and discussion that have been presented, this student worksheet can make students active in learning activities using POE models with the syntax Predict, Observe, and Explain.

The results of the validation of this student worksheet show the average value 88.5% by category very good, so that it can be said that this student worksheet is fit to be used as a learning medium in the Parabola Motion assisted PhET simulation. With the use of this student worksheet, it is expected that students can better understand the concept of Parabolic Motion.

**References**


[1] Chang J L, Chen C C, Tsai C H, Chen Y C, Chou M H and Chang L C 2013 Probing and Fostering Students' Reasoning Abilities with a Cyclic Predict-Observe-Explain Strategy *Chemistry Education and Sustainability in the Global Age* (Switzerland: Springer, Dordrecht) eds Chiu M H, Tuan H L, Wu H K, Lin JW and Chou C C p 49

[2] Jayanti R D, Romlah and Saregar A 2016 Efektivitas Pembelajaran Fisika Model Problem Based Learning (PBL) Melalui Metode POE Terhadap Kemampuan Berpikir Tingkat Tinggi Peserta Didik *Pros. Sem. Nas. Pendidikan Program Studi Pendidikan Fisika* (Bandar Lampung: IAIN Raden Intan Lampung) p 208

[3] Susanti S 2017 Efektivitas Model Pembelajaran POE Terhadap Hasil Belajar Siswa Materi Perubahan Wujud Benda Kelas IV MI Akhlaqiyah Bringin Semarang Tahun Ajaran 2015/2016 *Undergraduate thesis* (Semarang: UIN Walisongo)

[4] Efendi R 2017 Pengaruh Model Pembelajaran POE (Predict-Observe-Explain) Terhadap Pemahaman Konsep Fisika Kelas X SMKN 5 Bandar Lampung Pokok Bahasan Kalor *Skripsi* (Bandar Lampung:Universitas Islam Negeri Raden Intan Lampung)

[5] Voogt J and Knezek G 2018 *Technol. Knowl. Learn.* **23** 369

[6] Ceberio M, Almudí J M and Franco Á 2016 *J. Sci. Educ. Technol.* **25** 4

[7] Srisawasdi N and Kroothkeaw S 2014 *J. Computers Educ.* **1** 1

[8] Ülen S, Čagran B, Slavinec M and Gerlič I 2014 *J. Sci. Educ. Technol.* **23** 5

[9] Bakri F, Pratiwi S and Muliyati D 2019 *AIP Conf. Proc.* **2169** 020010

[10] Bakri F, Sumardani D and Muliyati D 2019 *AIP Conf. Proc.* **2169** 020012

[11] Bakri F, Ervina E and Muliyati D 2019 *AIP Conf. Proc.* **2169** 020006

[12] Michaloudis A 2019 *AIP Conf. Proc.* **2075** 180018

[13] Blikstein P, Fuhrmann T and Salehi S 2016 *J. Sci. Educ. Technol.* **25** 4

[14] Lancaster K, Moore E B, Parson R and Perkins K K 2013 Insights from using PhET's design principles for interactive chemistry simulations *Pedagogic Roles of Animations and Simulations in Chemistry Courses (ACS Symposium Series vol 1142)* ed Suits J P and Sanger M J (USA: American Chemical Society) chapter 5 pp 97-126

[15] PhET: Research and Development *How PhET simulations are designed, and the research process of refining the simulations to best promote learning* retrieved from: https://phet.colorado.edu/in/research

[16] PhET: Research and Development *Translated Simulation* retrieved from: https://phet.colorado.edu/in/simulations/translated

[17] Srisawasdi N and Kroothkeaw S 2014 *J. Comput. Educ.* **1 (1)** 49

[18] Salirawati D 2012 *Penyusunan dan Kegunaan LKS dalam Proses Pembelajaran* diambil dari: http://staffnew.uny.ac.id/upload/132001805/pengabdian/19penyusunnan-dan-kegunaan-lks.pdf

[19] Umbaryati U 2016 Pentingnya LKPD pada Pendekatan Scientific Pembelajaran Matematika *Pros. Sem. Nas. Matematika IX 2015 (PRISMA)* (Semarang: Unnes) hal 217

[20] Hanim F, Suyanti R D and Harahap F 2017. IOSR *J. Res. Method Educ. (IOSR-JRME)* **7 (5)** 57

[21] Prastowo A 2014 *Panduan Kreatif Membuat Bahan Ajar Inovatif* (Yogyakarta: Diva Press)

[22] Susilaningrum N 2018 Pengembangan Lembar Kerja Peserta Didik Fisika Berbasis Gasing Untuk Meningkatkan Penguasaan Materi dan Minat Belajar Peserta Didik SMA *Skripsi* (Yogyakarta: FMIPA Universitas Negeri Yogyakarta)

[23] Yulkifli, Ihsan I and Darvina Y 2018 *Risal. Fis.* **2 (1)** 1