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# Validity of Newton's Law of Gravitation Student Worksheet Integrated of PhET Simulation Software

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**Abstract**

Abstract physics material is difficult to visualize, making it difficult to understand. One of the materials in physics, namely Newton's law of gravity, is difficult for conventional experiments to do because it encompasses the universe. Virtual laboratories can make it easy for students to conduct experiments on subject matter that are difficult for conventional experiments to do. The most popular virtual experimental media used in the current learning process is the Physics Education Technology (PhET) application. The PhET Simulation application cannot be given directly to students, we need a teaching material that can guide students in learning using the PhET Simulation application. This is also to the demands of an *kurikulum merdeka*. Namely, educators must always develop teaching materials that suit the needs of students. The purpose of this study was to determine the validity of the development of Newton's law of gravitation in student worksheets integrated with PhET simulation. This research is development research. The data acquisition method is to provide validation questionnaires for student worksheets to three expert validators. Validation includes six aspects, namely relevance, accuracy, completeness of presentation, presentation systematics, presentation method, and language suitability. From the validation data analysis, a final validation value of 4.15 was obtained with the valid category. With these results, the student worksheet is feasible to be used in trials on learning activities.

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## INTRODUCTION

Physics is a subject that emphasizes mastery of concepts, but in practice, students are sometimes unable to understand the physics concepts they are learning (Januaryfin et al., 2018). Physics concepts tend to be abstract, both in the form of knowledge of physics and mathematical logic, so individual talent in mastering these concepts is quite influential. Material physics is abstract and concrete. Abstract physics material is difficult to visualize, making abstract physics concepts difficult to understand (Nursefriani et al., 2016). One of the physics materials that is abstract and difficult to visualize in conventional physics learning is Newton's law of gravity material. This is due

to the material nature of Newton's law of gravity which is difficult to do experiments because it covers the universe (Sitepu & Yakob, 2019). Therefore, virtual experimental media capable of visualizing Newton's law of gravitational material is needed for the experiments to be carried out.

Virtual laboratories can support experimental activities in laboratories that are interactive and dynamic. Virtual laboratories can make it easy for students to be able to do experiments on subject matter that is difficult for conventional experiments to do (Rina Mirdayanti & Murni, 2017). Virtual laboratory technology is also very helpful for educators to be able to provide experimental learning experiences for students without requiring high costs (Budai & Kuczmann, 2018). The use of technology can provide a basis for conceptual understanding and assist in linking theory with practice (Castro-Gutiérrez et al., 2021). The most popular virtual experimental media used in the current learning process is the Physics Education Technology (PhET) application. PhET is a site that provides learning simulations of physics, biology, chemistry and mathematics, which are provided free of charge by the University of Colorado for class or individual learning purposes. Simulations are presented interactively so that users can carry out direct learning (Rizaldi et al., 2020).

The Phet Simulation application cannot be given directly to students, we need teaching material that can guide students through learning using the Phet Simulation virtual practicum media (Imran et al., 2021). This is also the demand for an independent curriculum. Namely, educators must always develop teaching materials that suit the needs of students (Bismawati & Halifah, 2022). Teaching materials can be in the form of student worksheets. Student worksheets are teaching materials that have been packaged in such a way that students get the learning experience independently (Ekantini & Wilujeng, 2018). From the problems that have been described, it is necessary to develop student worksheets on Newton's law material on gravity integrated with the Phet Simulation virtual practicum application which can improve students' mastery of physics concepts on Newton's law material on gravity. The purpose of this study was to examine the validity of Newton's law student worksheets on gravity integrated with the Phet Simulation virtual experiment software.

## METHOD

This research includes the type of Research Development research (development research). This development research was carried out to obtain a valid teaching material product. This development research uses the Tjeerd Plomp development model. The choice of developing the Plomp model in this study is because the development of this model has advantages, including a detailed and systematic description of each phase, easy to understand and this development model is suitable for application in developing learning tools. In this development research, the Plomp model used consisted of 5 phases, namely: 1) initial investigation phase (Preliminary Research), 2) design phase (Design), 3) realization/construction phase (Realization/Construction), 4) test phase, evaluation, and revision and 5) implementation phase

The initial investigative phase is to determine and define the development needs of the integrated Newton Gravity Student Worksheet that will be developed. At this stage, an analysis of the problems and conditions of the students is carried out. The design phase is planning the design of the Newton Gravity Student worksheet integrated with Phet Simulation, the activities at the design stage are the preparation of lesson plans, media selection, format selection, and initial design. The realization phase is to produce a product in the form of a student worksheet integrated with Newton Gravity Phet Simulation. In the test, evaluation, and revision phases, activities were carried out, namely validation and field trials.

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Validation was carried out by three expert validators, namely three physics education lecturers at Jember University. Validation data is obtained through validation sheet instruments. The aspects or criteria that are assessed in the validation activity are 1) relevance, 2) accuracy, 3) completeness of presentation, 4) presentation systematics, 5) method of presentation, and 6) suitability of language. The expert validation sheet is used by the validator to provide grades, criticism, and suggestions for the developed student worksheets. There are five rating scales used for validation, namely, invalid (value 1), less valid (value 2), quite valid (value 3), valid (value 4), and very valid (value 5). Data analysis techniques are described as follows:

a. Recapitulate the assessment data into a table that includes aspects (Ai), indicators (Ii), and values (Vji) for each validator. The results obtained are then written in the column in the appropriate table.
b. Determine the average value of the validation results from all validators for each indicator with the formula:

$$I_i = \frac{\sum_{j=1}^{n} V_{ji}}{n}$$

Where $V_{ji}$ is the value data of the j-th validator against the i-th indicator, n is the number of validators. The results obtained are then written in the column in the appropriate table.
c. Determine the average value for each aspect with the formula:

$$A_i = \frac{\sum_{j=1}^{m} I_{ij}}{m}$$

Where $A_i$ is the average score for the i$^{th}$ aspect, $I_{ij}$ is the average for the ith aspect of the j$^{th}$ indicator, m is the number of indicators in the i$^{th}$ aspect. The results obtained are then written in the column in the appropriate table.
d. Determine the total value or average value of the average value for all aspects with the formula:

$$V_a = \frac{\sum_{i=1}^{n} A_i}{n}$$

Where $v_a$ is the total average score for all aspects, $A_i$ is the average score for the i-th aspect, n is the number of aspects. The results obtained are then written in the column in the appropriate table. Furthermore, the value of $v_a$ or the total average value is referred to as the interval for determining the level of validity of the module as shown in Table 1 below (Hobri, 2010).

**Table 1. Validation category**

| Kategori Validitas | Interval |
|---|---|
| Invalid | $1 \leq V_a < 2$ |
| Less valid | $2 \leq V_a < 3$ |
| Quite valid | $3 \leq V_a < 4$ |
| Valid | $4 \leq V_a < 5$ |
| Very valid | $V_a = 5$ |

Source: Validation category (Hobri,2010)

## RESULTS AND DISCUSSION

At the initial investigation stage, it was found that the problems that had been raised in the background, it is necessary to develop Newton's law of gravity student worksheets

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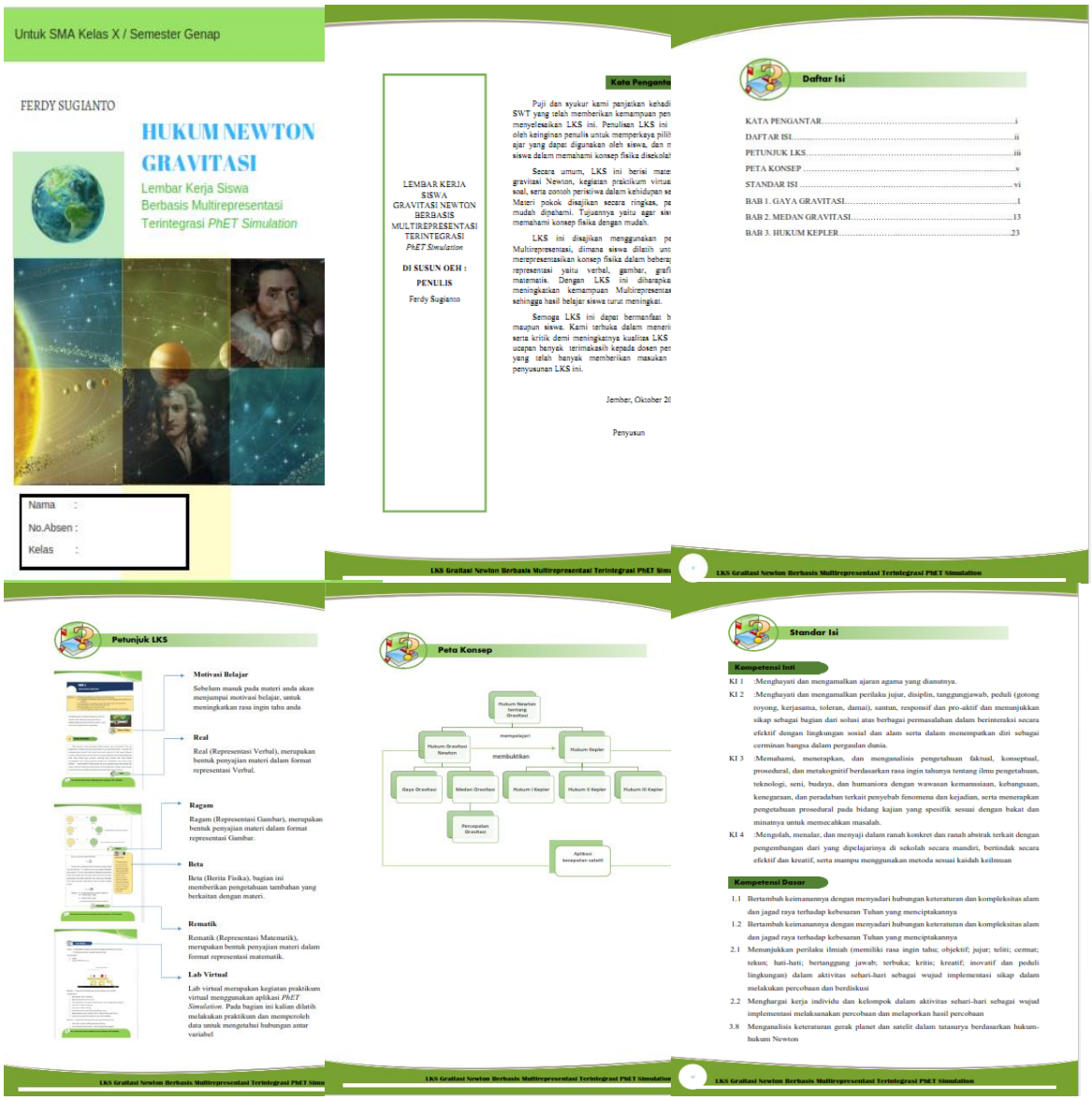
with integrated PhET simulation. Furthermore, at the design stage, the selection of the student worksheet format to be developed is carried out. The format of the student worksheet integrated Newton's law of gravity Phet Simulation that was developed, namely: 1) The cover page contains the main identity of the student worksheet which includes users of educational levels, namely for senior high school class X even semester, the material or subject being taught is Newton's laws gravity, the identity of the developed student worksheet. 2) Supporting pages contain the author's name, contain a foreword and contain an explanation of the characteristics of the worksheet being developed. 3) The table of contents contains a list of sub-materials and their pages. 4) Instructions for using the student worksheet contain steps or ways to use the student worksheet that can assist students in using student worksheet. 5) The concept map contains a material concept mapping diagram of Newton's law of gravity. 6) The front page of the sub-chapter contains the sub-chapter titles, indicators and learning objectives for each sub-chapter. 7) Teaching materials contain a description of the material along with experiments using the PhET Simulation software. At the realization/construction stage, Prototype 1 was produced, namely a student worksheet on Newton's law of integrated gravity PhET Simulation, which is as follows.



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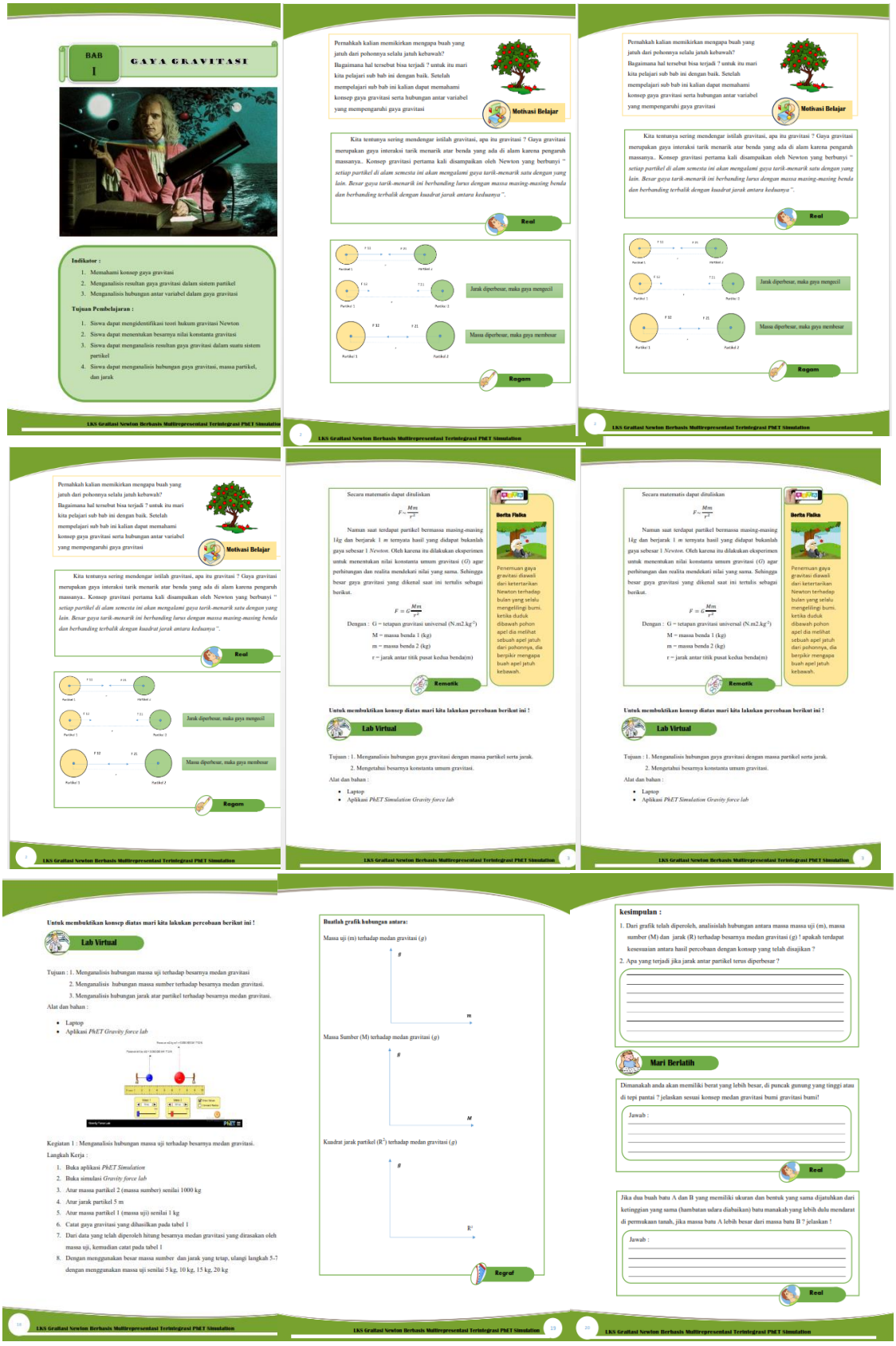

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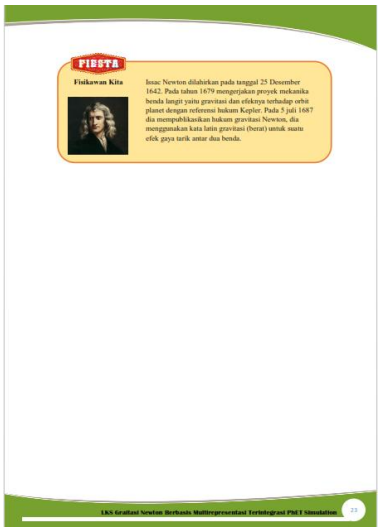


**Figure 1. Design of a student worksheet integrated Newton's law of gravity PhET Simulation**
Source: Researchers, 2023

The draft student worksheets were then validated by three expert validators. Validation data was analyzed using the calculation of the average score obtained for each indicator given by the validator, based on the average value of each indicator then the average value of each aspect was determined, and from the average value of each aspect then the total average value was determined. The values obtained from the two validators are averaged for each indicator and its aspects, then averaged as a whole to determine the expert validation value of the developed student worksheet. This validation value is then referred to as the validity level intervals of the student worksheet developed. The results of the quantitative data assessment from the expert validator are as follows.

**Table 2. Validity of student worksheet**

| Aspect | The average validity of each aspect | Final validity score | Criteria |
|---|---|---|---|
| Relevance | 4,3 | 4,15 | Valid |
| Accuracy | 4,23 | | |
| Completeness of presentation | 4 | | |
| Presentation systematics | 4 | | |
| Method of presentation | 4,37 | | |
| language suitability | 4 | | |

Source: Data analysis by researchers, 2023

Based on Table 2, the final validation value is 4.15 with a valid category. Based on the data obtained, the method of presentation aspect received the highest score from other aspects. encourage students to study in groups. In the aspect of completeness of the presentation, the developed student worksheets can present information about the competencies that students must master, present the important benefits of mastering competencies, present a table of contents, present instructions for using student worksheets, present the title of learning activities, subtitles learning activities, and page numbers. In the systematic aspect of the presentation, the developed student worksheets are capable of presenting material following a simple to complex flow of thoughts, and placing consistent layout elements based on patterns. In the aspect of language suitability,

the developed student worksheets have been able to present sentences according to the level of student understanding. In the aspect of relevance, the developed student worksheets can present material, assignments, and practice questions relevant to the competencies students must master. In terms of accuracy, the developed student worksheets have been able to present material according to scientific truth.

With these results, the student worksheet Newton's law of gravitation integrated Phet Simulation can already be used for experiments in classroom learning. The Phet Simulation virtual laboratory can be a solution to the unavailability of Newton's law of gravity experiment tools. The Phet Simulation virtual laboratory makes it easy for teachers to carry out experiments easily and at a low cost. With the development of student worksheet Newton's law of gravitation integrated Phet Simulation, it is hoped that it can help teachers and students to use Phet Simulation's virtual laboratory software for Newton's law of gravity material. Then in the future it is hoped that student worksheets will also be developed on other materials that can help students to use the Phet Simulation virtual laboratory.

## CONCLUSION

The student worksheet Newton's law of gravitation integrated Phet Simulation that has been developed has gone through the expert validation stage, resulting in a final validation of 4.15 with a valid category. This shows that the integrated Phet Simulation Newton's law of gravitation student worksheets are feasible to be tested in classroom learning. The student worksheet Newton's law of gravitation integrated Phet Simulation are expected to help teachers and students to use Phet Simulation's virtual laboratory software for Newton's law of gravitation materials.

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