

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

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Article Info	Abstract
<p>Received: March 28, 2023</p> <p>Revised: May 11, 2023</p> <p>Online available: July 02, 2023</p> <p>Keywords: Student worksheet, PhET Simulation, Newton's Law of Gravitation</p>	<p>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 <i>kurikulum merdeka</i>. 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.</p>

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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.

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 (A_i), indicators (I_i), and values (V_{ji}) 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 i^{th} 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

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.

Untuk SMA Kelas X / Semester Genap

FERDY SUGIANTO

HUKUM NEWTON GRAVITASI

Lembar Kerja Siswa
Berkas Multirepresentasi
Terintegrasi PhET Simulation

Nama :
No. Absen :
Kelas :

Kata Pengantar

Puji dan syukur kami panjatkan kepada SWT yang telah memberikan kemampuan bagi menyelesaikan LKS ini. Penulisan LKS ini oleh kegiatan penulis untuk memperkaya nilai apa yang dapat digunakan oleh siswa dan siswa dalam memahami konsep fisika disekolanya.

Secara umum, LKS ini berisi materi gravitasi Newton, kegiatan praktikum virtual soal, serta contoh penyelesaian dalam kehidupan sehari-hari yang disajikan secara ringkas, dan mudah dipahami. Tujuannya yaitu agar siswa memahami konsep fisika dengan mudah.

LKS ini disajikan menggunakan per Multirepresentasi dimana siswa dilatih untuk merepresentasikan konsep fisika dalam beberapa representasi yaitu verbal, gambar, grafik matematis. Dengan LKS ini diharapkan meningkatkan kemampuan Multirepresentasi sehingga hasil belajar siswa terus meningkat.

Semoga LKS ini dapat bermanfaat bagi para siswa. Kami berharap dalam materi serta kritik demi meningkatnya kualitas LKS ucapan banyak terimakasih kepada dosen per yang telah banyak memberikan masukan penyusunan LKS ini.

Jember, Oktober 2021
Penyusun

Daftar Isi

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Petunjuk LKS

Motivasi Belajar
Sebelum masuk pada materi anda akan mempelajari motivasi belajar, untuk meningkatkan rasa ingin tahu anda

Real
Real (Representasi Verbal), merupakan bentuk penyajian materi dalam format representasi Verbal.

Ragam
Ragam (Representasi Gambar), merupakan bentuk penyajian materi dalam format representasi Gambar.

Beta
Beta (Berita Fisika), bagian ini memberikan pengetahuan tambahan yang berkaitan dengan materi.

Rematik
Rematik (Representasi Matematis), merupakan bentuk penyajian materi dalam format representasi matematis.

Lab Virtual
Lab virtual merupakan kegiatan praktikum virtual menggunakan aplikasi PhET Simulation. Pada bagian ini kalian dilatih melakukan praktikum dan memperoleh data untuk mengetahui hubungan antar variabel

Peta Konsep

Standar Isi

Kompetensi Inti

KI 1 Menghayati dan mengamalkan ajaran agama yang dianutnya.
KI 2 Menghayati dan mengamalkan perilaku jujur, disiplin, tanggungjawab, peduli (gotong royong, kerjasama, toleran, damai), santun, responsif dan pro-aktif dan menunjukkan sikap sebagai bagian dari solusi atas berbagai permasalahan dalam berinteraksi secara efektif dengan lingkungan sosial dan alam serta dalam menempatkan diri sebagai cerminan bangsa dalam pergaulan dunia.
KI 3 Memahami, menerapkan, dan menganalisis pengetahuan faktual, konseptual, prosedural, dan metakognitif berdasarkan rasa ingin tahunya tentang ilmu pengetahuan, teknologi, seni, budaya, dan humaniora dengan wawasan kemasyarakatan, kebangsaan, kenegaraan, dan peradaban terkait penyebab fenomena dan kejadian, serta menerapkan pengetahuan prosedural pada bidang kajian yang spesifik sesuai dengan bakat dan minatnya untuk memecahkan masalah.
KI 4 Mengolah, menalar, dan menyaji dalam ranah konkret dan ranah abstrak terkait dengan pengembangan dari yang dipelajarinya di sekolah secara mandiri, bertindak secara efektif dan kreatif, serta mampu menggunakan metoda sesuai kaidah keilmuan

Kompetensi Dasar

- Bertambah keimanannya dengan menyadari hubungan keteraturan dan kompleksitas alam dan jagad raya terhadap keberadaan Tuhan yang menciptakannya
- Bertambah keimanannya dengan menyadari hubungan keteraturan dan kompleksitas alam dan jagad raya terhadap keberadaan Tuhan yang menciptakannya
- Menunjukkan perilaku ilmiah (memiliki rasa ingin tahu; objektif; jujur; teliti; cermat; tekun; hati-hati; bertanggung jawab; terbuka; kritis; kreatif; inovatif dan peduli lingkungan) dalam aktivitas sehari-hari sebagai wujud implementasi sikap dalam melakukan percobaan dan berdiskusi
- Menghargai kerja individu dan kelompok dalam aktivitas sehari-hari sebagai wujud implementasi melaksanakan percobaan dan melaporkan hasil percobaan
- Menganalisis keteraturan gerak planet dan satelit dalam tata surya berdasarkan hukum-hukum Newton

BAB I
GAYA GRAVITASI



- Indikator :**
1. Memahami konsep gaya gravitasi
 2. Menganalisis resultan gaya gravitasi dalam sistem partikel
 3. Menganalisis hubungan antar variabel dalam gaya gravitasi

- Tujuan Pembelajaran :**
1. Siswa dapat mengidentifikasi teori hukum gravitasi Newton
 2. Siswa dapat menentukan besarnya nilai konstanta gravitasi
 3. Siswa dapat menganalisis resultan gaya gravitasi dalam suatu sistem partikel
 4. Siswa dapat menganalisis hubungan gaya gravitasi, massa partikel, dan jarak

LKS Grafiasi Newton Berbasis Multirepresentasi Terintegrasi PNET Simulasi

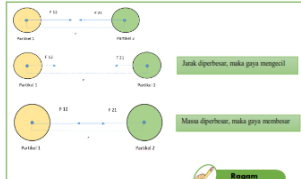
Perubahan kalian memikirkan mengapa buah yang jatuh dari pohonnya selalu jatuh kebawah? Bagaimana hal tersebut bisa terjadi? Untuk itu mari kita pelajari sub bab ini dengan baik. Setelah mempelajari sub bab ini kalian dapat memahami konsep gaya gravitasi serta hubungan antar variabel yang mempengaruhi gaya gravitasi



Metode Belajar

Kita tentunya sering mendengar istilah gravitasi, apa itu gravitasi? Gaya gravitasi merupakan gaya interaksi tarik menarik antar benda yang ada di alam karena pengaruh massanya. Konsep gravitasi pertama kali diungkapkan oleh Newton yang berbunyi " setiap partikel di alam semesta ini akan mengalami gaya tarik-menarik satu dengan yang lain. Besar gaya tarik-menarik ini berbanding lurus dengan massa masing-masing benda dan berbanding terbalik dengan kuadrat jarak antara keduanya".

Real



Ragam

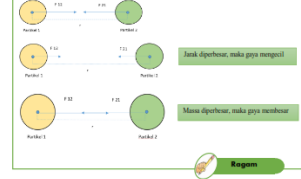
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Real



Ragam

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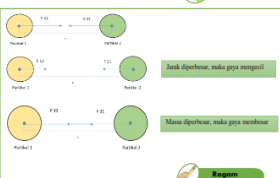
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Real



Ragam

LKS Grafiasi Newton Berbasis Multirepresentasi Terintegrasi PNET Simulasi

Secara matematis dapat dituliskan

$$F = G \frac{Mm}{r^2}$$

Namun saat terdapat partikel bermassa masing-masing M dan m berjarak r m ternyata hasil yang didapat bukanlah gaya sebesar 1 Newton. Oleh karena itu dilakukan eksperimen untuk menentukan nilai konstanta umum gravitasi (G) agar perhitungan dan nilai mendekati nilai yang sama. Sehingga besar gaya gravitasi yang dikenal saat ini tertulis sebagai berikut.

$$F = G \frac{Mm}{r^2}$$

Dengan : G = tetapan gravitasi universal ($N \cdot m^2 \cdot kg^{-2}$)
 M = massa benda 1 (kg)
 m = massa benda 2 (kg)
 r = jarak antar pusat kedua benda(m)



Berita Pribu

Penemuan gaya gravitasi diawali dari keterancikan Newton terhadap bulan yang selalu mengelilingi bumi ketika duduk dibawah pohon apel dia melihat sebuah apel jatuh dari pohonnya, dia berpikir mengapa buah apel jatuh kebawah.

Renotik

Untuk membuktikan konsep diatas mari kita lakukan percobaan berikut ini!

Lab Virtual

- Tujuan : 1. Menganalisis hubungan gaya gravitasi dengan massa partikel serta jarak.
2. Mengetahui besarnya konstanta umum gravitasi.

Alat dan bahan :

- Laptop
- Aplikasi PNET Simulation Gravity force lab

LKS Grafiasi Newton Berbasis Multirepresentasi Terintegrasi PNET Simulasi

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LKS Grafiasi Newton Berbasis Multirepresentasi Terintegrasi PNET Simulasi

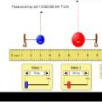
Untuk membuktikan konsep diatas mari kita lakukan percobaan berikut ini!

Lab Virtual

- Tujuan : 1. Menganalisis hubungan massa uji terhadap besarnya medan gravitasi
2. Menganalisis hubungan massa sumber terhadap besarnya medan gravitasi.
3. Menganalisis hubungan jarak antar partikel terhadap besarnya medan gravitasi.

Alat dan bahan :

- Laptop
- Aplikasi PNET Gravity force Lab



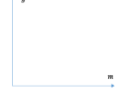
Kegiatan 1 : Menganalisis hubungan massa uji terhadap besarnya medan gravitasi.

Langkah Kerja :

1. Buka aplikasi PNET Simulation
2. Buka simulasi Gravity force lab
3. Atur massa partikel 2 (massa sumber) senilai 1000 kg
4. Atur jarak partikel 5 m
5. Atur massa partikel 1 (massa uji) senilai 1 kg
6. Centang gaya gravitasi yang diaktifkan pada label 1
7. Dari data yang telah diperoleh hitung besarnya medan gravitasi yang dihasilkan oleh massa uji, kemudian centang pada tabel 1
8. Dengan menggunakan besar massa sumber dan jarak yang tetap, ulangi langkah 5-7 dengan menggunakan massa uji senilai 5 kg, 10 kg, 15 kg, 20 kg

Buatlah grafik hubungan antara:

Masa uji (m) terhadap medan gravitasi (g)



Masa Sumber (M) terhadap medan gravitasi (g)



Kuadrat jarak partikel (R²) terhadap medan gravitasi (g)



Ragrat

Kesimpulan :

1. Dari grafik telah diperoleh, analisislah hubungan antara massa masa uji (m), massa sumber (M) dan jarak (R) terhadap besarnya medan gravitasi (g) ! apakah terdapat kesesuaian antara hasil percobaan dengan konsep yang telah disajikan ?
2. Apa yang terjadi jika jarak antar partikel terus diperbesar ?

Mari Berlatih

Ditanya:anda akan memiliki berat yang lebih besar, di puncak gunung yang tinggi atau di tepi pantai ?Jelaskan sesuai konsep medan gravitasi bumi gravitasi bumi!

Jawab :

Real

Jika dua buah batu A dan B yang memiliki ukuran dan bentuk yang sama dijatuhkan dari ketinggian yang sama (hambatan udara diabaikan) mana manakah yang lebih dulu mendarat di permukaan tanah, jika massa batu A lebih besar dari massa batu B ?Jelaskan !

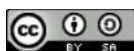
Jawab :

Real

LKS Grafiasi Newton Berbasis Multirepresentasi Terintegrasi PNET Simulasi

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LKS Grafiasi Newton Berbasis Multirepresentasi Terintegrasi PNET Simulasi



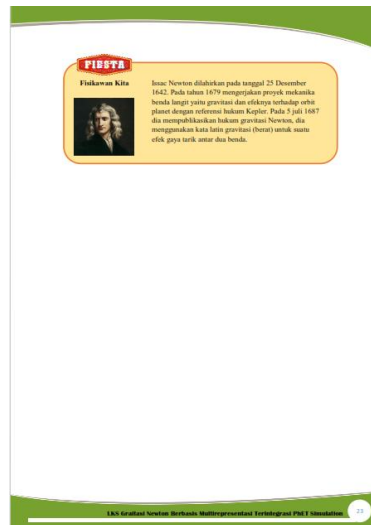


Figure 1. Design of a student worksheet integrated Newton's law of gravity PhET Simulation

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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