Jurnal Inovasi Pendidikan Sains (JIPS)
Volume 2 Nomor 2, November, 2021, pp: 62 - 68
http://jurnal.umpwr.ac.id/index.php/jips
e-ISSN: 2747 - 1551 p-ISSN: 2757 - 1543

Development Free Fall Motion Teaching Aid With Proximity Sensor

Endah Istiqomah ✉, Umi Pratiwi, Ashari

Universitas Muhammadiyah Purworejo
Jl. KH. A. Dahlan 3, Jawa Tengah, Indonesia
| endah.istiqomah99@gmail.com ✉ | DOI : https://doi.org/10.37729/jips.v3i2.1440 |

Article Info

Submitted
05/09/2021

Revised
26/10/2022

Accepted
05/11/2022

Abstract **–** The use of manual teaching aid causes inaccurate results. This study aims to realize a valid and effective free fall motion teaching aid based on proximity sensors for physics learning. This research was conducted at the Laboratory of Physics Education Faculty, University of Muhammadiyah Purworejo with the research subjects of five physics education students. This research is a development research using the ADDIE development model with the Analysis, Design, Development, implementation, and Evaluation stages. Data collection techniques in this study were using validation questionnaires and student responses. The results showed that the developed teaching aid resulted in an error in the acceleration of gravity of 9.59 ± 0.42 m/s^2 when the value of h= 0.90 m, 9.61 ± 0.43 m/s^2 when the value of h= 1.00 m, and 9.74 ± 0.40 m/s^2 when the value of h= 1.10 m, while the results of the validation carried out by media experts obtained a percentage of 93% and material experts 98%. Meanwhile, the results of student responses to teaching aid obtained a percentage of 93.33%. Proximity sensor based free fall motion teaching aid are valid and effective for physics learning.

Keywords: *Free fall, Motion, Teaching aid, Sensor, Proximity*

Abstrak **–** *Penggunaan alat peraga manual menyebabkan hasil yang kurang akurat. Penelitian ini bertujuan untuk mewujudkan alat peraga gerak jatuh bebas berbasis sensor jarak yang valid dan efektif untuk pembelajaran fisika. Penelitian ini dilakukan di Laboratorium Fakultas Pendidikan Fisika Universitas Muhammadiyah Purworejo dengan subjek penelitian lima orang mahasiswa pendidikan fisika. Penelitian ini merupakan penelitian pengembangan dengan menggunakan model pengembangan ADDIE dengan tahapan Analysis, Design, Development, Implementation, dan Evaluation. Teknik pengumpulan data dalam penelitian ini menggunakan angket validasi dan respon siswa. Hasil penelitian menunjukkan bahwa alat peraga yang dikembangkan menghasilkan error percepatan gravitasi sebesar 9,59 ± 0,42 m/s^2 saat nilai h= 0,90 m, 9,61 ± 0,43 m/s^2 saat nilai h= 1,00 m, dan 9,74 ± 0,40 m/s^2 pada saat nilai h= 1,10 m, sedangkan hasil validasi yang dilakukan oleh ahli media diperoleh persentase sebesar 93% dan ahli materi sebesar 98%. Sementara itu, hasil tanggapan siswa terhadap alat peraga diperoleh persentase sebesar 93,33%. Alat peraga gerak jatuh bebas berbasis sensor jarak valid dan efektif untuk pembelajaran fisika.*

Kata Kunci: *Jatuh bebas, Gerak, Alat peraga, Sensor, Proximity*

1. Introduction

Physics is a science that studies natural phenomena through experiments and measurements that are presented systematically based on basic laws to determine the relationship of natural phenomena that occur which in its discussion require imagination and a high understanding of concepts [1], therefore learning media is needed to clarify so that the material to be delivered is not too verbal so that it can generate enthusiasm for student learning by allowing students to learn according to their talents and abilities, both visual, auditory, and kinesthetic abilities [2].

Teaching aid are everything that delivers the characteristics and concepts to be studied so that they can stimulate the thoughts, feelings, and abilities of students to create the learning process [3]. The use of teaching aid allows students to gain knowledge and develop psychomotor skills and foster creativity to solve the problems they face [4]. According to Edgar Dale's experience cone, it is explained that learning carried out with visual aid can provide students with their own learning experiences [5]. Of course, the teaching aid in this case are quite effective and efficient to be used in physics learning, especially in free fall motion material.

Free-fall motion is the motion of falling objects in a vertical direction from a certain height without any initial velocity [6]. An object in free fall will experience the same acceleration if there is no air and other obstacles with an acceleration of Earth's gravity of 9.78 m/s^2 [7].

Advances in science and technology encourage the world of education to be better. In the world of education, technological developments have a positive impact, one of which is being able to produce various electronic devices that support education. Some examples of electronic devices that play an important role in the world of education are microcontrollers that can be used to make teaching aid as a basic physics practicum tool [8]. The other devices that can be used in learning are sensors. A sensor is a hardware device that can receive information (input quantity) in the form of a physical quantity and convert the information signal into information in the form of the same or different physical quantity **[9]**. Sensors can be used to detect changes in physical quantities such as pressure, force, electrical quantities, light, motion, humidity, temperature, and other natural phenomena.

The proximity sensor is a transducer that can detect the presence of an object in the vicinity without any physical touch and can also be used to detect time with a better level of accuracy [10]. The proximity sensor can be used as a measure of time and speed, so that it can be used as a supporting medium that will help students understand the material, especially regular straight motion [11]. With these electronic devices, it is hoped that these devices will be able to produce teaching aid that are more effective, efficient, and have a better level of accuracy in measuring results.

Measurement accuracy is the level of proximity of the measurement results to the actual value, while precision is defined as the extent to which repeated measurements in the same circumstances get the same results regardless of where the average value is to the actual value [12]. Accuracy and precision are very important for a measuring instrument because the level of accuracy and precision will affect the final result of measurement so that if a tool has a low level of accuracy and precision it will cause an error where one error in measurement can affect the results of subsequent measurements and of course it will cause losses [13].

Based on the results of interviews that researchers conducted with students of the Physics Education Study Program and physics laboratory assistants at the Muhammadiyah University of Purworejo conducted at the Muhammadiyah University of Purworejo, that currently the Physics Education Laboratory of the University of Muhammadiyah Purworejo has provided free-fall motion teaching aid, but the available teaching aid are deemed less effective. The teaching aid has a low level of accuracy, especially in a reading time where the time reading is still done manually, namely with a stopwatch. Reading the time manually requires high concentration so that when the hand presses the start and stop buttons, it matches the relatively fast movement of objects. But in reality, the hands are often late when pressing the start or stop button which makes the measurement inaccurate. As a result, the final results of learning activities have not been maximized. Therefore, there is a need for new teaching aid, one of which is an Arduino-based free-fall motion teaching aid using a proximity sensor, where the tool has a higher level of accuracy, especially in reading time so that it can be more effective when used in physics learning, especially in school physics experiment.

2. Methods

This development research uses the ADDIE model. The selection of this model was based on the consideration that this model was developed systematically and based on the theoretical foundation of learning design. This is reinforced by research conducted by Pawana which states that development research with the ADDIE model can produce a final product that is developed according to the procedure so that the final product is suitable to be applied to students [14]. The ADDIE model is a systematic learning design model which can divide the process into several steps in logical sequences, then use the output of each step as input for the next step [15]. This model is structured programmatically with a systematic sequence of activities as an effort to solve learning problems related to learning resources according to the needs and characteristics of students [16]. The steps contained in the ADDIE model consist of (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation [17]. The data collection technique in this study was using observation sheets and questionnaires. This questionnaire method was used to determine the validity of teaching aid by using a 4 scale reference which then to know the validity results.

3. Results and Discussion

This study uses the ADDIE development model, which includes Analysis, Design, Development, Implementation, and Evaluation. The results of the study are described as follows.

3.1 Analysis

At this stage, observations were made, aiming to determine the learning process regarding the learning media used. In general, the learning process, especially in the basic physics practicum course, often runs out of learning time just for a practicum using makeshift tools (manual). From these conditions, a semi-automation-based teaching aid is needed to streamline and accelerate performance rather than using manual teaching aid, besides accelerating the performance of semi-automation teaching aid, it can increase the accuracy and precision of measurement results. The results of observations at the Laboratory of the Faculty of Teacher Training and Physical Education, University of Muhammadiyah Purworejo require a free-fall motion teaching aid based on proximity sensors to determine altitude, time, and acceleration of gravity automatically.

3.2 Design

At this stage, planning for the development of teaching aid is carried out. This planning begins with selecting tools and materials by taking into account the specifications of the apteaching aidriate tools and materials for their function. The design starts from designing the tool frame by designing the shape and size of the tool. Next, make the frame of the teaching aid using stainless and acrylic pipes that are weather-resistant. After making the framework of the teaching aid, then assembling the necessary components such as proximity sensors, ultrasonic sensors, micro servos, LCDs, pushbuttons, Arduino, breadboards, and connecting cables. The next stage is to design a program with Arduino software. The last stage is to design a system between the program and the tool frame so that the teaching aid can work. The display of the teaching aid can be seen in Figure 1.

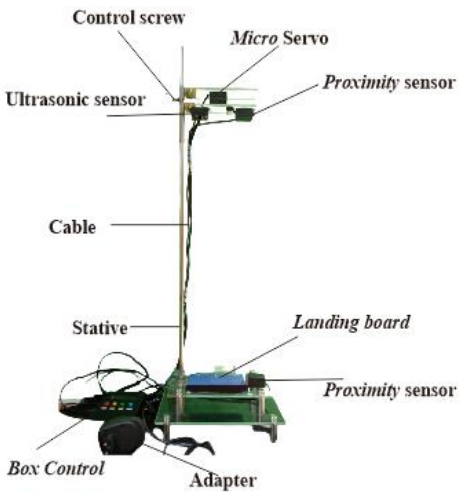

Figure 1. Proximity Sensor-Based Free Fall Teaching Aid Display

3.3 Development

At this stage, the development test of the tool is carried out by the developer, and the validity test is carried out by media and material experts. In the development test of this teaching aid, three reference distances were carried out and five measurements at each reference distance. The test results of the tool are compared with comparison teaching aid or manual teaching aid and with theory through excel calculations. The comparative teaching aid in question are teaching aid with experiments or calculations of distance and time using tools available in the laboratory such as stopwatches and rulers. The measurable quantities of the developed teaching aid include distance (altitude), time, and acceleration due to gravity. The test results are presented in Table 1.

Table 1. Teaching Aid Trial Apparatus Test Result

N	Data Type	Results of Measurement of High (h), Time (t), and Gravity Acceleration (g)											
		h= 0,90 m				h= 1,00 m				h= 1,10 m			
		h (m)	t (s)	g_{exper} (m/s²)	g_{theory} (m/s²)	h (m)	t (s)	g_{expe} (m/s²))	g_{theory} (m/s²)	h (m)	t (s)	g_{expe} (m/s²)	g_{theory} (m/s²)
1	Comparison	0,90	0,41	10,71	10,71	1,00	0,44	10,33	10,33	1,10	0,45	10,86	10,86
	Teaching aid	0,90	0,43	9,86	9,73	1,00	0,45	9,68	9,88	1,10	0,47	10,01	9,96
2	Comparison	0,90	0,43	9,73	9,73	1,00	0,45	9,88	9,88	1,10	0,47	9,96	9,96
	Teaching aid	0,92	0,44	9,47	9,50	1,00	0,46	9,56	9,45	1,09	0,48	9,44	9,46
3	Comparison	0,90	0,43	9,73	9,73	1,00	0,45	9,88	9,88	1,10	0,49	9,16	9,16
	Teaching aid	0,90	0,44	9,36	9,30	0,99	0,45	9,52	9,78	1,10	0,48	9,58	9,55
4	Comparison	0,90	0,42	10,20	10,20	1,00	0,45	9,88	9,88	1,10	0,46	10,40	10,40
	Teaching aid	0,92	0,44	9,91	9,50	1,00	0,46	9,57	9,45	1,10	0,47	10,03	9,96
5	Comparison	0,90	0,43	9,73	9,73	1,00	0,44	10,33	10,33	1,10	0,46	10,40	10,40
	Teaching aid	0,90	0,44	9,34	9,30	1,00	0,46	9,73	9,45	1,10	0,48	9,62	9,55
Comparation mean		0,90	0,42	10,02	10,02	1,00	0,45	10,06	10,06	1,10	0,47	10,16	10,16
Teaching aid mean		0,91	0,44	9,59	9,47	1,00	0,46	9,61	9,60	1,10	0,48	9,74	9,70
$(\overline{g} - g_{Compare})$		-0,44				-0,45				-0,42			
Error g (%)		**4,34%**				**4,44%**				**4,14%**			

Table 2. Error Analysis

Sample *h* (m)	g_{theory}(m/s^2)	g_{exp} (m/s^2)	Error (%)	Error (m/s^2)
0,90	10,02	9,59	4,34%	(9,59 ± 0,42)
1,00	10,06	9,61	4,44%	(9,61 ± 0,43)
1,10	10,16	9,74	4,14%	(9,74 ± 0,40)

From Table 1 and Table 2, the value of gravitational acceleration is close to the theoretical value of 9.78 m/s2. In this test, the error values for the acceleration of gravity in the developed tool were (9.59 ± 0.42), (9.61 ± 0.43), and (9.74 ± 0.40). In addition, there is also a comparison graph between g teaching aid and g theory which will be presented in Figure 2.

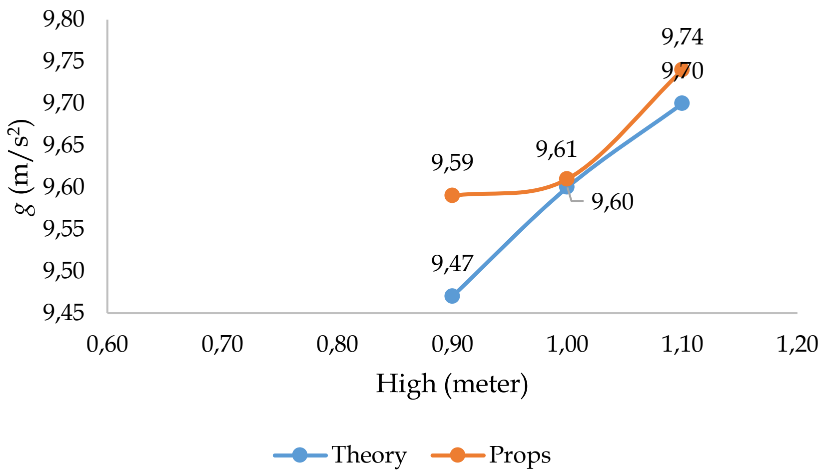

Figure 2. Comparison Graph of g Theory with g Teaching aids

As shown in Figure 2, it can be seen that there is a slight difference between g teaching aid and g theory. This can happen because the ultrasonic sensor readings (for altitude readings h) and proximity sensors (for time readings) are not always constant, causing the final result g to be variable. Furthermore, when using the comparison tool, errors can be obtained due to rushing or even being late when pressing the stopwatch button, this will certainly affect the results.

The validation of teaching aid is carried out by media expert lecturers and material experts. Data validation results by media experts on the aspect of the integrity of the tool 92% in the very good category, the accuracy aspect of the tool 75% in the good category, the effectiveness aspect of the tool 100% in the very good category, the aesthetic aspect of the tool 100% in the very good category, the safety aspect 88% in the very good category, and in the aspect of the kit box 88% which fall into the very good category. While the assessment for the teaching aid manual on the design quality aspect and the communicative aspect got a percentage of 100% in the very good category. The average percentage of media experts is 93% in the very good category.

Meanwhile, the data from the material expert validation on the aspect of linkage with teaching materials got a percentage of 88% in the very good category, the educational value aspect of 100% in the very good category, and the effectiveness aspect of the tool got a percentage of 100% in the very good category. While the assessment for the teaching aid manual on the aspects of content feasibility, presentation feasibility, and language feasibility aspects gets a percentage of 100% which is in the very good category. The average percentage of material experts is 98% in the very good category.

3.4 Implementation

The application of a limited trial was carried out on many student respondents. The results of the responses from respondents will be used to determine student responses to the product before it is used in the actual research. This response was given to five students of the Physics Education University of Muhammadiyah Purworejo by giving a questionnaire to students about the product being developed. Filling this questionnaire using a scale of 1-4. The results of student responses regarding free-fall motion teaching aid based on proximity sensors in a limited trial obtained a percentage of 97% in the aspect of benefit in the very good category, 90% in the aspect of presenting the tool in the very good category, and 93% in the aspect of physical appearance in the very good category. All aspects obtained an average percentage of 93.33% with a very good category so that it is effective to use.

3.5 Evaluation

This stage is carried out using the results of validation, student responses, and input from both validators and students on the proximity sensor-based free-fall motion teaching aid that were developed. Some evaluations from this development research are that the teaching aid have environmental conditions such as a dry environment with a flat base surface, getting enough light, namely light, free from wind, and the allowable mass for the tool is 0.5 grams. The limitations of the research found include limitations on the sensitivity of the teaching aid sensor, the lack of accuracy of falling loads, the load is required to be a magnet with a small mass so that it reduces the effectiveness of the teaching aid.

4. Conclusion

Based on the results of testing tools and validation results as well as the results of student responses, it shows that the Arduino-based free-fall motion prop using a proximity sensor is valid and effective to use in physics learning, especially in basic physics practices. Props developed using this sensor are more accurate in reading time and altitude than using a stopwatch or manual timekeeping device. Of course, this teaching aid still needs to be further developed in terms of tool stability, load motion automation, and the practicality of teaching aids. However, this tool can function properly, and based on the results of validation and student responses, it can be concluded that the Arduino-based free-fall motion prop using a proximity sensor is valid and effective to use in physics learning.

References

[1] M. Masyruhan, U. Pratiwi, dan Y. A. Hakim, "Perancangan Alat Peraga Hukum Hooke Berbasis Mikrokontroler Arduino sebagai Media Pembelajaran Fisika," *SPEKTRA: Jurnal Kajian Pendidikan Sains*, vol. 6, no. 2, hlm. 134, Okt 2020, doi: 10.32699/spektra.v6i2.145.

[2] O. Farhurohman dan S. Sa'adiah, "Penggunaan Media Pembelajaran Sejarah Kebudayaan Islam (SKI) di Madrasah Ibtidaiyah (MI)," vol. 7, no. 1, hlm. 15, 2020.

[3] F. T. Nomleni dan T. S. N. Manu, "Pengembangan Media Audio Visual dan Alat Peraga dalam Meningkatkan Pemahaman Konsep dan Pemecahan Masalah," *Scholaria,* vol. 8, no. 3, hlm. 219–230, Sep 2018, doi: 10.24246/j.js.2018.v8.i3.p219-230.

[4] M. C. Kause, "Rancang Bangun Alat Peraga Fisika Berbasis Arduino (Studi Kasus Gerak Jatuh Bebas)," *CYCLOTRON: Jurnal Teknik Elektro*, vol. 2, no. 1, 2019.

[5] P. Sari, "Analisis Terhadap Kerucut Pengalaman Edgar Dale Dan Keragaman Gaya Belajar Untuk Memilih Media Yang Tepat Dalam Pembelajaran," no. 1, hlm. 21, 2019.

[6] S. Toda, M. Y. M. Tati, Y. C. Bhoga, dan R. B. Astro, "Penentuan Percepatan Gravitasi Menggunakan Konsep Gerak Jatuh Bebas," *OPTIKA: Jurnal Pendidikan Fisika*, vol. 4, no. 1, hlm. 30–37, 2020.

[7] O. A. Atani, L. A. Lapono, dan A. C. Louk, “Rancang Bangun Alat Peraga Praktikum Gerak Jatuh Bebas,” *Jurnal Fisika: Fisika Sains dan Aplikasinya*, vol. 4, no. 1, hlm. 33–39, 2019.

[8] U. Pratiwi, “Kontrol suhu berbasis arduino dengan interface Matlab sebagai alat bantu praktikum fisika dasar,” *Jurnal Pendidikan Surya Edukasi*, vol. 2, no. 2, hlm. 14–26.

[9] S. P. Sakti, Pengantar Teknologi Sensor: Prinsip Dasar Sensor Besaran Mekanik. *Universitas Brawijaya Press*, 2017.

[10] C. Nisa, “Perancangan instrumentasi pengukur waktu dan kecepatan mengunakan dt-sense infrared proximity detector untuk pembelajaran gerak lurus beraturan,” *Jurnal Penelitian Fisika dan Aplikasinya (JPFA)*, vol. 4, no. 1, hlm. 36–41, 2014.

[11] A. Pattiserlihun, “Media Pembelajaran Alat Ukur Koefisien Gesek Kinetis dengan Tetikus Nirkabel,” *Jurnal Fisika*, vol. 7, no. 1, 2017.

[12] T. Kristiantoro, “Ketidakpastian Pengukuran pada Karakteristik Material Magnet Permanen dengan Alat Ukur Permagraph,” *Jurnal Elektronika dan Telekomunikasi*, vol. 16, no. 1, hlm. 1–6, 2016.

[13] N. Fitrya, “Pentingnya Akurasi dan Presisi Alat Ukur dalam Rumah Tangga,” *Jurnal Pengabdian UMRI*, vol. 1, no. 2, hlm. 60–63, Des 2017, doi: 10.37859/jpumri.v1i2.237.

[14] M. G. Pawana, N. Suharsono, dan I. M. Kirna, “Pengembangan multimedia interaktif berbasis proyek dengan model ADDIE pada materi pemrograman web siswa kelas X semester genap di SMK Negeri 3 Singaraja,” *Jurnal Teknologi Pembelajaran Indonesia*, vol. 6, no. 1, 2016.

[15] R. A. H. Cahyadi, “Pengembangan Bahan Ajar Berbasis Addie Model,” HALAQA, vol. 3, no. 1, hlm. 35, Mei 2019, doi: 10.21070/halaqa.v3i1.2124.

[16] I. M. Tegeh, I. N. Jampel, dan K. Pudjawan, “Pengembangan buku ajar model penelitian pengembangan dengan model ADDIE,” dalam *Seminar Nasional Riset Inovatif*, 2015, vol. 3.

[17] B. A. Pribadi, Desain dan Pengembangan Program Pelatihan Berbasis Kompetensi:Implementasi Model ADDIE. *Jakarta: Prenadamedia Group*, 2014.

[18] Y. Wahyuningsih, “Pengembangan aplikasi test online dengan menggunakan framework codeigniter di smk darul ma’wa plumpang pada mata pelajaran jaringan dasar kelas x,” *IT-Edu: Jurnal Information Technology and Education*, vol. 2, no. 02, 2017.