Lumitime: Development of a Simple Straight Uniform Acceleration Laboratory Tool

Asmaul Husna Firamadani [1], Dian Eka Kurniawati [1], Gema Nur Qur'aini Majid [1], Alayya Mar'ani Farikhanifa [1], Ika Kartika [1], Iva Nadiya [1], Muhammad Fuadhil Aufa [1]

[1] *Department of Physics Education, Faculty of Islamic Education Science and Teacher Training, UIN Sunan Kalijaga Yogyakarta, Yogyakarta, Indonesia*

***Abstract* – The problem that is the focus of this research is the lack of practical tools that can explicitly demonstrate the concept of Straight Motion Regularly Changing (GLBB) on an inclined plane. Therefore, this research aims to create a simple practicum tool named "Lumitime" to study GLBB, with the aim of evaluating the effectiveness and suitability of the tool as a means of learning physics. The research method applied is the research and development (R&D) approach, which is integrated with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). Data analysis was conducted using Aiken's V method with the acquisition of assessment scores by material and media experts of 0.75 and 0.69, respectively. The results of user assessment through questionnaires also indicate that this tool is considered "Very Valid" with a value of 0.78. Thus, Lumitime is declared feasible as a practicum tool for illustrating simple GLBB material, with the results showing a high level of validity in various aspects, especially in terms of educational value, relevance to teaching materials, tool durability, and aesthetic aspects. This validity is supported by validation results from material experts and media experts.**

DOI: 10.18421/SAR71-07
https://doi.org/10.18421/SAR71-07

Corresponding author: Asmaul Husna Firamadani,
Department of Physics Education, Faculty of Islamic Education Science and Teacher Training, UIN Sunan Kalijaga Yogyakarta, Yogyakarta, Indonesia
Email: 21104050010@student.uin-suka.ac.id

Received: 04 January 2024.
Revised: 06 March 2024.
Accepted: 15 March 2024.
Published: 27 March 2024.

***Keywords* – experimental apparatus, learning media, physics, uniformly accelerated linear motion.**

1. Introduction

The existence of physics learning in studying natural phenomena and phenomena can train and foster the ability of students to solve a problem [1]. These problems can be solved by reviewing activities through the experimental process (experiment) [2]. Indeed, physics cannot be separated from the implementation of laboratory activities [3]. These activities can be in the form of simple experiments to experiments that require specialized equipment to collect data. Experiments have a function to test a theory or even find a new theory. Experiment design can be adapted to various levels of education and can create a fun learning experience [4]. Experimental process activities involve delivering teaching by carrying out activities, enabling students to discover concepts individually and in groups. This approach allows students to verify hypotheses or demonstrate their understanding of what they have learned [5]. This makes students not only limited to remembering science but more on understanding the science [6].

Practical tools serve as a tool to explain concepts with a direct experimental stage. In the learning process, not all learners can easily understand science just by reading books and listening to explanations from educators. Some learners may comprehend concepts in this way, while others may have difficulty. Therefore, practicum tools are important in helping students understand physics lessons (Ahmad Solihun et al., 2015: 101). According to (Darwis & Hardiansyah, 2021), the implementation of laboratory practicum in science subjects provides opportunities for students to conduct experiments and analyze data according to the purpose of the experiment being carried out [8]. Through this practicum activity, students can observe natural phenomena directly through the investigation process.

Science practicum has an important significance in science learning because it acts as a support for discovering and explaining certain principles.

In the context of kinematics, it discusses straight motion which is divided into Regular Straight Motion (Uniform Rectilinear Motion) and Regularly Changing Straight Motion (Uniformly Accelerated Motion) [9]. Although the concept often appears in everyday life, students often face difficulties in understanding Straight Motion material. This is due to learning methods that tend to be abstract and only rely on the lecture approach [10]. Therefore, learning physics in this modern era requires an innovative approach that can trigger students' interest and understanding of important concepts, such as Straight Motion Regularly Changing (Uniformly Accelerated Motion). One aspect that can support interactive and contextualized learning is the use of specially developed teaching aids to help students' understanding of the material. In this context, the development of an inclined plane practicum tool on Uniformly Accelerated Motion material is important to be explored and developed. Based on the results of research Azka, Sudarmanto, & N.Yusufiyah (2020), with the title "The Effect of Experimentation Method on Motivation and Learning Outcomes of Grade X Students on Straight Motion Material", shows the results that the learning motivation of experimental class students is higher than the control class and the learning outcomes of experimental class students are better than the control class [10]. Another study conducted by Darwis & Hardiansyah (2021) with the title "The Effect of the Application of PhET Virtual Laboratory on Students' Science Learning Motivation on Straight Motion Material", showed the results that the application of the PhET virtual laboratory had a better effect on students' science learning motivation on straight motion material

Uniformly Accelerated Motion as one of the basic materials in physics has movement characteristics that are not only linear, but can also involve inclined planes. Inclined planes provide a new dimension to students' understanding of the forces acting on objects in motion, and add complexity to motion analysis. Therefore, there is a need for practicum tools that can present this concept in a real way with direct experiments and facilitate comprehensive learning.

Based on the above problems, researchers aim to create simple practical tools that can visualize motion on an inclined plane clearly, and can integrate well in the broader context of physics learning.

Through the approach of developing inclined plane props on Uniformly Accelerated Motion material, it is expected to make a real contribution to improving students' understanding of physics concepts related to motion, especially in conditions involving inclined planes. Thus, this approach not only supports the achievement of learners' competence in physics, but also stimulates their interest to explore science more thoroughly.

2. Research Methods

The type of research conducted is research and development (R&D). Research & Development is a research method applied to create new products [11]. In this study, the resulting product is learning media in the form of simple practicum tools. The focus of this learning media development lies in media design, which involves planning and making media according to student needs. The purpose of this development is to improve the existing media to make it more effective.

This research procedure follows the development design of the ADDIE model by Robert Maribe Brach, which consists of Analysis, Design, Development, Implementation, and Evaluation (Latip & Permanasari, 2017). Product trials were conducted to evaluate the effectiveness of the learning media that had been made. Respondents involved in this study included physics education lecturers as material experts and media experts, as well as high school students in grades X, XI, and XII as users.

Respondents will use the learning media that has been developed, after which they are asked to fill out an assessment questionnaire and provide comments, criticisms, and suggestions for program improvement. The questionnaire is used as a data collection tool to assess the feasibility of practicum tools that have been made and will be answered by respondents. The data collection technique used is important to ensure the data obtained is complete and valid.

The questionnaire method is used to measure program indicators related to the content of the learning tool program, the appearance of the tool, the feasibility of the tool, and the technical quality of the tool. The product assessment score uses a Likert scale with alternative responses of less (1), poor (2), fair (3), good and excellent (4), as described in Table 1. These criteria are used to evaluate the durability of the tool, the accuracy of the tool, the efficiency of the tool, safety for students, aesthetics (appearance of the tool), and the tool storage box.

Table 1. Linkert Scale Product Assessment Score Criteria

Score	Criteria	Description
4	Excellent	If the tool is rated as excellent in the context of its use, it is highly accurate, reliable and fulfills all the desired needs or criteria.
3	Good	Indicates that the tool is rated as good, although there is little room for improvement or some weaknesses that could be addressed. In general, the tool is still considered adequate.
2	Fair	The tool is considered adequate, but may have some shortcomings or areas where improvements can be made. The tool meets most needs, but there are some things that need to be improved.
1	Poor	The tool does not meet expectations, is inaccurate or unreliable in the context of its use.

The type of data collected in this study is quantitative and obtained through the use of a questionnaire as a research instrument. Product trial data is categorized into three groups, namely data used for analysis by experts (media experts and material experts), and data obtained from user trials. Data related to product testing includes scores from questionnaires regarding validation and feedback from respondents.

With reference to the classification of these types of data, the data collection instruments in this assessment are divided into three main instruments: (1) Instruments for media experts; (2) Instruments for material experts; and (3) Instruments for users. The research data were obtained from one material expert, one media expert, and five practicum assistants. Furthermore, the learning was tested on students in grades X, XI, and XII in Senior High School.

The validity analysis used uses Aiken's V analysis by involving the calculation of the correlation between the item score and the total score of the instrument as a whole. The following are general steps in conducting validity analysis using Aiken's V [7]:

1. Collect data from respondents who have filled out the measurement instrument.
2. Calculating the Total Score by calculating the total score for each respondent by adding up the scores on each instrument item.
3. Calculating the correlation between the score on each item and the total score. This can be done using the formula:

$$V = \frac{\sum S}{n\ (c-1)}$$

V = Rater agreement index
S = The score assigned to each rater minus the lowest score in the category
n = Number of raters
c = The number of categories a rater can choose from

4. Analyze the results by evaluating the level of correlation between the item score and the total score for each item. The higher the correlation, the better the validity of the item.
5. Interpret the data by reviewing the results and determining whether each item has adequate validity or needs revision. Good validity is characterized by a significant correlation between the item score and the total score.
6. Make improvements to the Instrument if there are items that have low or insignificant correlations, and consider revising or removing the item from the instrument.

Based on the V data that has been obtained, it is then transformed into a table so that reading the research results becomes easy. To determine qualitative criteria, it is done by:

1. Reading Aiken's V table so that the validity value is obtained from the table.
2. Comparing the average V Aiken with the validity of the table.
3. Determining the range of values for each validity.

Table 2. Aiken's V Assessment Score Criteria

Range	Description
0.71 – 1.00	Very Valid
0.31 – 0.70	Quite Valid
0.00 – 0.30	Not Valid

According to Table 2, it can be classified that the Aiken validity index obtained from expert judgment is declared low if it produces a value below 0.3. Validity is declared moderate between 0.31 - 0.7 and high validity results in a value above 0.71 (Aiken, 1985). Validity is declared moderate between 0.31 - 0.7 and high validity results in a value above 0.71 (Aiken, 1985).

This research is said to be successful if the questionnaire results are in the range of 0.31-0.7 and 0.7-1.0 or at high and medium.

3. Results and Discussion

This study is a research in the form of developing a physics learning media and testing its feasibility. The subjects of this research are 3 material experts and 3 media experts.

This research was conducted from October to November 2023 at the Integrated Laboratory of State Islamic University Sunan Kalijaga Yogyakarta.

• Learning material

The term motion refers to a process in which an object moves from one point to another. To be categorized as motion, the main requirement is that there is a change in the position of the object with respect to a reference point, known as displacement. One type of movement that is commonly known is straight motion. In straight motion, the trajectory of the object is in the form of a straight line or relatively straight trajectory in a certain time interval, as explained by Efrizon Umar (2008). As for position, it is explained as a vector that connects the location of the object with the coordinate center, referring to the point where all coordinate axes cross each other [12].

There are two types of straight motion in physics, namely regular straight motion (Uniform Rectilinear Motion) and regular changing straight motion (Uniformly Accelerated Motion). Uniformly Accelerated Motion describes the movement of an object on a straight line trajectory with a fixed direction of motion, and the object travels a distance that changes regularly in each unit of time. Uniformly accelerated motion is also often known as One-Dimensional Motion with Fixed Acceleration. In Uniformly accelerated motion, the acceleration of an object is fixed or does not change over time. So, it can be concluded that its current acceleration and average acceleration will be the same if the acceleration of the object remains from the beginning of the movement [13].

In situations where a body is moving on an inclined plane, there are certain differences. The angle of inclination (θ) of the inclined plane has an impact on the velocity component of the body along its trajectory. In the case of accelerated movement, the force acting on the object causes a change in its velocity. In the context of an inclined plane, gravity is the main force responsible for the acceleration of the body, and the magnitude of the gravitational force depends on the angle of inclination of the inclined plane with respect to the horizontal. Thus, in a movement accelerating on an inclined plane, the total acceleration a of the object can be decomposed into two components: acceleration along the inclined plane ($a\ parallel$) and acceleration perpendicular to the inclined plane (a perpendicular). So there will be a modification of the uniformly accelerated motion equation, in accordance with real conditions.

This concept is the same as the concept put forward by Ruspitasari, Yushardi, & Supeno (2022) in his research entitled "Study of Motion Kinematics in Motor Vehicle Motion on Ngawi Regency Road as a Physics Learning Resource" that in theory [14], the kinematics of motion on a downhill road is described in Figure 1:

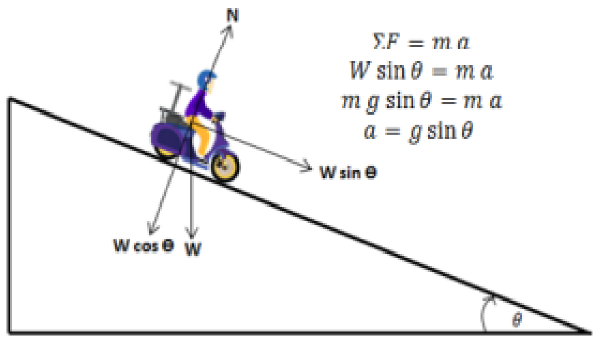

Figure 1. Schematic of the direction of the force acting on the Inclined plane Uniformly Accelerated Motion

So if it is derived mathematically using the kinematics equation of straight motion, the velocity and acceleration quantities are obtained:

$$a = g\ sin\,\theta$$

$$v = t\ g\ sin\,\theta$$

The development of this simple practical tool uses one flexible track board with test objects of varying mass and shape. On the track board, a meter is attached with the aim of allowing variations in the distance that can be set. In addition, this track board has the ability to change its tilt angle, thus providing flexibility in adjusting the tilt angle as needed. The slope variation is varied using nails mounted on a support rod, and then the angle can be measured using an arc.

• Design Stage

The preparation of this simple practicum tool begins with preparing the tools and materials to be used. The main materials used in this simple practicum tool are wood blocks and plywood by considering the durability of the practicum tool. In addition, we used 1 iron rod, 2 bolts, 1 bow, some nails, and paint to add aesthetic value to the tool. The practicum tool scheme is illustrated in Figure 2.

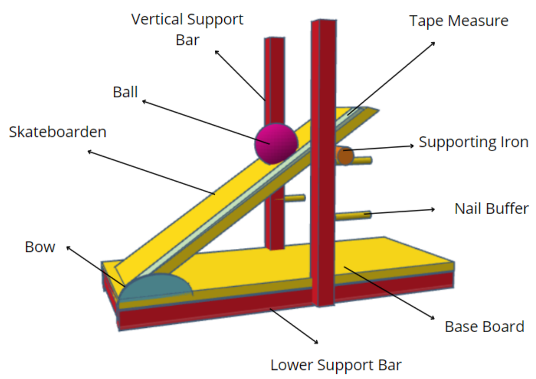

Figure 2. Tool Schematic

• Expert Validation Results

The validity of learning media can be improved through the validation process by material experts and media experts as shown in Table 3 and Table 4, respectively. Thus, learning media that have been validated by material experts and media experts can be used as effective and efficient learning media.

Table 3. Content Expert Assessment

Aspects Assessed	V Aiken Score	Description
Educational Value	0,74	Very Valid
Relevance to Teaching Materials	0,81	Very Valid
Tool durability	0,75	Very Valid
Aesthetics	0,72	Very Valid
Average Score	**0,75**	**Very Valid**

Table 4. Tool Expert Assessment

Aspects Assessed	V Aiken Score	Description
Tool durability	0,78	Very Valid
Tool accuracy	0,61	Quite Valid
Tool Efficiency	0,74	Very Valid
Safety for learners	0,67	Quite Valid
Aesthetics	0,67	Quite Valid
Average Score	**0,69**	**Quite Valid**

Based on the validation results from material experts and media experts related to simple physics practicum tools, it can be concluded that the practicum tools have a high level of validation, especially in the aspects of educational value, linkage to teaching materials, tool resistance, and Aesthetics according to material experts, as well as tool resistance, tool efficiency, and safety for learners according to media experts. The input from experts related to tools and concepts has been improved as follows:

1. Adding a meter, colored to match the skateboard on the right and left which is permanently attached.
2. Adding a barcode that leads to the drive manual book, which is attached to the support rod. Thus, it can facilitate access to how to use the tool.
3. Adding the name of the tool as a characteristic which is adjusted to the existing concept. The tool name used is LUMITIME, which stands for Straight-Miring-Time (time). This naming is in accordance with the basic concept used in the practical tool, namely straight motion on an inclined plane, which involves the element of time as an independent variable in the experiment. Time can be an example of an independent variable, especially if the experiment aims to test how changes in time affect the speed of objects. Meanwhile, the dependent variable in this context might be the distance traveled by the object, while the control variables could be other factors that could affect the motion of the object, such as friction, initial velocity or the angle of inclination of the track.
4. Clarify the physics concepts that will be used in the tool. Clarifying in this context means adding explanations related to other factors that can affect the independent variable (travel time).

There are several inputs, related to the use of the Phypox application, to get precise track slope measurement results. The adaptation of the phypox application was then implemented when revising the manual book.

Based on input from media experts and material experts, the developer made improvements to the props, namely by adding meters, barcodes, and tool names. Here we include a photo of a simple practicum tool that has been improved in Figure 3.

Figure 3. Simple practicum tool for straight uniformly accelerated motion

After making revisions based on input from media experts and material experts, the practical tool was tested on students in grades X, XI, and XII, and was declared "Very Valid" based on the results of user assessment with a v aiken score of 0.78. Therefore, the simple practicum tool can be used as an effective and efficient learning media in physics learning.

4. Conclusion

Based on the results of the assessment and analysis carried out, a simple practicum tool for Uniformly Accelerated Motion is declared as an effective and efficient learning media in physics learning.

This tool has a high level of validity, with most aspects rated "Very Valid" by material experts and media experts. This practicum tool helps students understand the concept of regular straight motion directly through the process of investigation and integrates in the broader context of physics learning. The use of this tool in teaching physics concepts related to motion, especially in conditions involving inclined planes, can make a real contribution to improving students' understanding of physics concepts.

References:

[1]. Maiyena, S., Imamora, M., & Ningsih, F. (2018). Pengembangan Alat Praktikum Gerak Jatuh Bebas Menggunakan Sensor Phototransistor Untuk Pembelajaran Fisika Pada Materi Gerak Jatuh Bebas. *Sainstek: Jurnal Sains dan Teknologi*, *9*(1), 54-67.

[2]. Gkioka, O. (2019). Learning How to Teach Experiments in the School Physics Laboratory. *Journal of Physics: Conference Series, 1286*(1). Doi: 10.1088/1742-6596/1286/1/012016

[3]. Stern, C., Echeverria, C., & Porta, D. (2017). Teaching Physics through Experimental Projects. *Procedia IUTAM, 20,* 189-194. Doi: 10.1016/j.piutam.2017.03.026

[4]. Nurqomariah, N., Gunawan, G., & Sutrio, S. (2017). Pengaruh Model Problem Based Learning dengan Metode Eksperimen Terhadap Hasil Belajar IPA Fisika Siswa Kelas VII SMP Negeri 19 Mataram Tahun Pelajaran 2014/2015. *Jurnal Pendidikan Fisika Dan Teknologi, 1*(3), 173–179. Doi:10.29303/jpft.v1i3.255

[5]. Waris, A., & Nurjannah, D. (2015). Pengembangan Alat Praktikum Sederhana Konsep Listrik Magnet untuk Siswa SMP Daerah Terpencil. *Jurnal Pendidikan Fisika Tadulako Online, 3*(2).

[6]. Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods (6th ed.).* Thousand Oaks, CA: SAGE Publications.

[7]. Darwis, R., & Hardiansyah, M. R. (2021). Pengaruh Penerapan Laboratorium Virtual Phet Terhadap Motivasi Belajar Ipa Siswa Pada Materi Gerak Lurus. *ORBITA, 7*(2), 271-277. Doi: 10.31764/orbita.v7i2.5514

[8]. Handayani, I. D., Bektiarso, S., & Astutik, S. (2019). Kajian kinematika jalur wisata gunung bromo melalui senduro-lumajang sebagai e-suplemen bahan ajar fisika SMA. *FKIP e-PROCEEDING, 4*(1), 146-151.

[9]. Azka, M., Sudarmanto, A., & N.Yusufiyah, H. K. (2020). Pengaruh Metode Eksperimen Terhadap Motivasi dan Hasil Belajar Siswa Kelas X pada Materi Gerak Lurus. *Physics Education Research Journal, 2*(1), 9-18.

[10]. Sudikan, S. Y., Indrianti, T., & Faizin. (2023). *Metode Penelitian dan Pengembangan dalam Pendidikan dan pembelajaran.* Malang: Penerbit Universitas Muhammadiyah Malang.

[11]. Abdullah, M. (2016). *Fisika Dasar I*. Bandung: ITB.

[12]. Rochim, W. J. K., Wulandari, R. D., Afida, N. A., Andini, A. D., & Alwiyah, A. U. (2023). Rancang Bangun Alat Praktikum GLBB Pada Bidang Miring dengan Pengendali Kemiringan Berbasis Arduino. *Jurnal JE-UNISLA: Electronic Control, Telecomunication, Computer Information and Power System, 8*(2), 97-100.

[13]. Ruspitasari, H., Supeno, S., & Yushardi, Y. (2022). Kajian Kinematika Gerak pada Gerak Kendaraan Bermotor di Jalan Kabupaten Ngawi sebagai Sumber Belajar Fisika. *ORBITA: Jurnal Kajian, Inovasi dan Aplikasi Pendidikan Fisika, 8*(2), 282-292.

[14]. Bueche, F. J., & Hecht, E. (2006). *Fisika Universitas Edisi Sepuluh.* Jakarta: Erlangga.