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Fundamental physics practicum e-module to determine the value of the Earth's gravitational acceleration based on recorded experiments

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Abstract. The research aims to improve the effectiveness of fundamental physics practicum to determine the value of the Earth's gravitational acceleration, whether online or offline. This type of research is development research. The research was conducted using the 4D Model: define, design, development, and disseminate. The product developed as a module contains a guidebook into an electronic module by integrating a practicum video (recorded experiment) that contains how to use the tools and practicum work steps. Interviews and questionnaires carry out data collection techniques. Questionnaires are given to material, language, and media experts to find out the validity of the e-module. Questionnaires are also given to lecturers who teach fundamental physics courses and students participating in introductory physics courses to find out the feasibility of e-modules. From the study, the average score of material, language, and media experts was 89.08%, stating that the e-module was very valid. At the same time, the average score for the feasibility test is 89.38% which states that the e-module is very feasible. Thus, developing a fundamental physics practicum e-module can increase the effectiveness of the fundamental physics practicum in determining the value of the Earth's gravitational acceleration.

Keywords: The electronic module, Earth's gravitational acceleration, recorded the experiment

I. Introduction

The COVID-19 (Coronavirus Disease-19) pandemic is still ongoing. The impact of this pandemic is being felt by the community, one of which is in education. Educational activities in tertiary institutions have changed by using the hybrid learning method, namely the combination of face-to-face and computer-based learning methods [1]. At Semarang State University, the Hybrid Learning method has also been implemented. However, applying to practicum courses in laboratories that require the availability of practicum tools and materials will be difficult.

A laboratory is an academic support unit in an educational institution, in the form of a closed or open room, permanent or mobile in nature, managed systematically for testing, calibration, and or production activities on a limited scale, using equipment and materials based on specific scientific methods in the context of implementing education, research, and community service [2].

While practicum is an activity that aims to help students to understand theory and practice [3], interpreting data (2) developing the ability to solve problems with a scientific approach so that students gain the ability to identify real problems that are felt, formulate operationally, design the best way to solve problems and

implement them in the laboratory as well as analyze and evaluate the results (3) increase understanding and expansion of knowledge (facts, concepts, principles, theories) students [4].

The Fundamental Physics Practicum is one of the compulsory subjects in the Physics Department of FMIPA UNNES, intended for Physics students in semesters 1 and 2. The objectives of the Fundamental Physics practicum are (1) to acquire skills and skills in using and understanding the use of laboratory equipment, (2) to appreciate better the material taught given in lectures and understand the relationship between theory and observation, (3) able to analyze, make hypotheses or conclusions from data obtained from experimental results (4) able to communicate orally and in writing regarding research methodology [5]. One of the Fundamental Physics practicum materials is determining the value of the acceleration due to gravity. The type of practicum used to determine the value of the acceleration due to gravity is a mathematical pendulum swing [6]. The physical pendulum oscillation experiment is also a type of Fundamental Physics practicum which aims to determine the value of the acceleration due to gravity [7]. In addition to these two types of practicum, the Atwood plane is also a practicum material that aims to determine the value of the acceleration due to gravity [8].

The implementation of the Fundamental Physics practicum requires a practicum module. So far, the Fundamental Physics practicum module still uses printed books distributed to students. The weakness of modules is that they need more flexibility in providing practical instructions for students. The Fundamental Physics practicum activities during the pandemic have been adapted to home-based and virtual experiment modules. Home-based experiment-based practicum requires students to be able to make their practicum tools and materials used, and this raises problems where not all tools and materials are easily found in the market. While practicum is based on virtual experiments, students can obtain relatively more accurate data using physics experiment software following the theory being taught. However, the weakness is that students need to learn the tools and materials used for practicum and how the tools work and function. Thus, the right solution is needed in carrying out Fundamental Physics practicums online and offline.

As with the previous research, developing digital modules for fundamental physics practicum on electricity magnets has met the validity and feasibility criteria with a validity value of 89% and a feasibility value of 86% [9]. Because the Fundamental Physics practicum material is not only Magnet Electricity, it needs to be developed for other materials, including determining the value of the acceleration of Earth's gravity.

According to research by Erniwati et al. [10], there are differences in student learning outcomes in the control and experimental classes. The control class is a class with the application of learning methods, as is usually done. In contrast, the experimental class is a class that applies video-based practicum media in the learning process. In the normalized gain test, the average student learning outcome in the experimental class was 0.4, while in the control class, it was 0.24. because video-based practicum media can increase students' understanding of learning material, they can observe learning material using practicum videos to provide a clearer picture.

The research of Utomo [11] states that the results of learning development using video tutorials based on validation from media experts get an average assessment percentage of 89%. In contrast, from material experts, the average percentage is 86%, to increase student learning outcomes classically by 31%.

Thus, the right solution in conducting Fundamental Physics practicums, whether done boldly or enticingly, is to do experimental-based or video-based Fundamental Physics practicums that utilize computer technology in learning through practicum activities [12]. By viewing the video shown, students can get an overview of the tools and practicum materials used and find out how these tools function and work [13].

The series of Fundamental Physics practicums to determine the value of the acceleration due to gravity will be packaged in a video or recorded experiment. Video is a live image on a screen capable of presenting information and explaining complex concepts that cannot even be captured by the human senses when viewed directly or with the naked eye [14]. These videos will be integrated into electronic modules (e-modules). E-modules can be operated via smartphones, PCs, tablets, or laptops so that they can be opened anytime and anywhere. The advantages of e-modules include displaying text, animation, images, and videos [15]. So the purpose of this research is to increase the effectiveness of fundamental physics practicum to determine the value of the acceleration of gravity of the Earth, whether done online or offline.

II. Method

This research uses the type of R&D research (Research and Development) with a 4D development model, Define, Design, Development, and Disseminate [16]. The description is as follows (1) Define the researcher

and describe the background and analysis of objectives to find out how much it is necessary to use a product to overcome existing problems. Then the researchers analyzed the needs needed in making a practicum video as a basis for making the Fundamental Physics practicum e-module to determine the value of the Earth's gravitational acceleration. (2) Design, namely preparing the material to be displayed in the product, compiling the video concept to determine the value of the acceleration of gravity of the Earth, then taking video pictures according to the scenario, editing and mixing to combine the video pieces into all components of the learning media (prototype). (3) Development, namely the development of the Fundamental Physics practicum module data with the material for determining the value of the acceleration of gravity being converted into a portable document format (PDF) file, integrating practicum videos or recorded experiments into the module so that it becomes an e-module and then conducts a validity test material, language, and media experts as well as due diligence. The practicum video for determining the value of the Earth's gravitational acceleration consists of 3 practicum titles: mathematical swing, physical swing, and Atwood machine. (4) Disseminate, which is the distribution of the Fundamental Physics practicum e-module to determine the value of the acceleration of gravity based on recorded experiments to students in semester 1 of the 2022-2023 academic year who are taking the Fundamental Physics 1 practicum course [17].

Researchers collected data using interviews and questionnaires [18]. The purpose of the interviews was to gather information from students taking the Fundamental Physics practicum course regarding the modules used so far. At the same time, the questionnaire contains written questions addressed to material experts, language experts, media experts, and students using the Fundamental Physics practicum e-module to determine the value of the acceleration of gravity.

The data analysis technique used in this research is percentage descriptive statistical data analysis [19] with the formula $P = f / N \times 100\%$ where P is the rater's percentage, f is the frequency (total score obtained), and N is the number of cases (maximum total score). This data analysis technique tests the validity of material, language, media, and due diligence [20].

III. Results and Discussion

Based on the results of the researcher's interview with students who have taken the fundamental physics practicum course in determining the value of the acceleration of gravity of the Earth which is carried out offline, it is known that students do not understand and have not yet obtained an overview of the methods or work steps of carrying out practicum activities, because they only read the sentences in the practicum module. Whereas during the practicum period, which was carried out online, students increasingly needed help understanding the practicum work steps and the functions of the practicum equipment because they did not see and carry out practicum activities directly.

The e-module is a development of the practicum module by integrating videos into the e-module (Figures 1, 2, 3). Researchers made three videos uploaded on the official UNNES physics youtube channel. The video integration process is done by inserting a practicum video link for each title uploaded on YouTube. The following is a practicum video image that has been integrated into the Fundamental Physics practicum e-module to determine the value of the acceleration of gravity of the Earth:

Figure 1. Mathematical pendulum practicum video

Figure 2. Video of physical pendulum practicum

Figure 3. Atwood machine lab video

The e-module that has been developed consists of 17 pages covering the cover of the e-module, preface, table of contents, practicum material, and bibliography. The practicum materials in the e-module are a mathematical pendulum, a physical pendulum, and Atwood machines. Each material consists of objectives, tools and materials, theory, and methods which contain video integration, observation tables, and preliminary and final assignments. The e-module cover can be seen in Figure 4.

Figure 4. Cover of the fundamental physics practicum e-module to determine the value of the acceleration due to gravity

The E-module is validated by competent material experts, linguists, and media experts. The e-module validation and eligibility criteria [15] can be seen in Table 1.

Table 1. Criteria for validity and eligibility

Score percentage intervals	Criteria
$25\% \leq P \leq 44\%$	Invalid / Not Feasible
$45\% \leq P \leq 63\%$	Valid Enough / Decent Enough
$64\% \leq P \leq 81\%$	Valid / Feasible
$82\% \leq P \leq 100\%$	Very Valid / Very Feasible

The results of e-module validation by material experts are shown in Table 2.

Table 2. Results of e-module material assessment by material experts

No	Assessment Aspects	Total score	%
1.	Aspects of material coverage	15	94
2.	Aspects of material accuracy	14	88
3.	Aspects of material up-to-date	15	94
4.	The aspect of delving into the curiosity of users	14	88
	Mean		**91**

Each aspect of the material assessment found that the average percentage score was 91%, which stated that the e-module was very valid.

The results of e-module validation by linguists are shown in Table 3.

Table 3. E-module language assessment results by linguists

No	Assessment Aspects	Total Score	%
1.	Aspects of language suitability with student development	15	94
2.	Aspects of communicative language use	14	88
3.	An aspect of using precise language	14	88
4.	Aspects of conformity with the rules of the Indonesian language	13	81
	Mean		**87**

The aspects stated in the language assessment in Table 3 show an average percentage score of 87%, which states that the e-module is very valid.

The results by media experts can also be seen in Table 4.

Table 4. The results of the e-module media assessment by media experts

No	Assessment Aspect	Total Score	%
1.	Aspects of presentation techniques	14	88
2.	Aspects of completeness supporting the presentation material	15	94
3.	Graphic aspect	13	81
4.	Media aspect	15	94
	Mean		**89.25**

Validation on the media assessment aspect shows an average score of 89.25%, which states that the e-module is very valid.

The evaluation aspect of e-module validation by material experts, linguists, and media experts stated that the Fundamental Physics practicum e-module to determine the value of the acceleration of gravity of the Earth is very valid. The next step is to conduct e-module feasibility tests. The e-module due diligence questionnaire was given to 40 students, and different results for each aspect were obtained. The following results of the e-module due diligence assessment can be seen in Table 5.

Table 5. Results of e-module feasibility assessments by students

No	Assessment Aspect	Total Score	%
1.	Audio-visual compatibility	143	89.38
2.	Image and video design	148	92.50
3.	Content eligibility	139	86.88
4.	Presentation of material	142	88.75
	Mean		**89.38**

These data show that the average score for each aspect of the due diligence is 89.38%. This states that the Fundamental Physics practicum e-module to determine the value of the acceleration of gravity of the Earth is very feasible to use. The research by Utomo [11] states that video tutorial learning media can improve student learning outcomes.

IV. Conclusion

Based on data analysis and discussion of the development of the fundamental physics practicum e-module to determine the value of the Earth's gravitational acceleration based on recorded experiments, it can be concluded that the e-module can increase the effectiveness of the Fundamental physics practicum to determine the value of the Earth's gravitational acceleration whether done online or offline. The e-module has an average validity of the material, language, and media validation tests of 89.08%. In contrast, the feasibility test of the e-module is 89.38%. This research was only conducted at the level of students in tertiary institutions. In future research, a similar product could be developed for students in high schools.

References

[1] Verawati and Desprayoga, "Solusi Pembelajaran 4.0: Hybrid Learning," *Semin. Nas. Pendidik. Progr. Pascasarj. Univ. PGRI Palembang*, pp. 1183–1192, 2019.

[2] S. Sungkono, A. A. Nugroho, and E. Miyarso, "Tingkat kepuasan pengguna dan analisis kebutuhan pengembangan Laboratorium Jurusan," *Epistema*, vol. 1, no. 2, pp. 94–102, Oct. 2020, doi: 10.21831/ep.v1i2.34985j.

[3] U. M. Nisa, "Metode praktikum untuk meningkatkan pemahaman dan hasil belajar siswa kelas V MI YPPI 1945 Babat pada materi zat tunggal dan campuran," *Proceeding Biol. Educ. Conf. Biol. Sci. Enviromental, Learn.*, vol. 15, no. 1, pp. 62–68, 2017.

[4] R. Susanti, "Pengaruh Penerapan Pembelajaran berbasis Masalah pada Praktikum Fotosintesis dan Respirasi untuk Meningkatkan Kemampuan Generik Sains Mahasiswa Pendidikan Biologi FKIP Unsri," *Pendidik. Biol. FKIP Unsri*, pp. 1–14, 2013, [Online]. Available: https://repository.unsri.ac.id/18497/1/Makalah_Seminar_Kenaikan_Jabatan.pdf.

[5] Nasrodin, N. Hindarto, and S. S. E., "Analisis Kebiasaan Bekerja Ilmiah Mahasiswa Fisika Pada Pembelajaran Mata Kuliah Praktikum Fisika Dasar," *Unnes Phys. Educ. J.*, vol. 2, no. 1, pp. 84–91, 2013.

[6] Nurhayati, R. D. A. A, and S. Aslamiyah, "Penentuan Nilai Percepatan Gravitasi Bumi dengan Model Gerak Jatuh Bebas di Laboratorium Fisika UIN Ar-Raniry Banda Aceh," *J. Phi J. Pendidik. Fis. dan Fis. Terap.*, vol. 2, no. 1, pp. 15–18, 2021.

[7] F. Dwiatmoko, "Rancang Bangun Percobaan Bandul Fisis Berbasis Mikrokontroler Untuk Menentukan Periode Minimum," *Inov. Fis. Indones.*, vol. 8, no. 1, pp. 1–4, 2018.

[8] M. Ariska, "Penyelesaian Dinamika Pesawat Atwood dengan Persamaan Eular-Lagrange Sebagai Alternatif Persamaan Newton Pada Fisika SMA," *J. Inov. dan Pembelajaran Fis.*, vol. 6, no. 1, pp. 62–69, May 2019, doi: 10.36706/jipf.v6i1.7816.

[9] N. Wijayanti, D. Wahyuningsih, and D. T. Rahardjo, "Pengembangan E-Modul Praktikum Listrik Magnet pada LMS Moodle di Laman Spada UNS dengan Model Inkuiri Terbimbing untuk Mahasiswa Pendidikan Fisika," *J. Mater. dan Pembelajaran Fis.*, vol. 10, no. 2, p. 110, Oct. 2020, doi: 10.20961/jmpf.v10i2.54347.

[10] Erniwati, R. Eso, and S. Rahmia, "Penggunaan Media Praktikum Berbasis Video Dalam Pembelajaran Ipa-Fisika Untuk Meningkatkan Hasil Belajar Siswa Pada Materi Pokok Suhu Dan Perubahannya," *J. Sains dan Pendidik. Fis.*, vol. 10, no. 3, pp. 269–273, 2014.

[11] A. Y. Utomo and D. Ratnawati, "Pengembangan Video Tutorial dalam Pembelajaran Sistem Pengapian di SMK," *Taman Vokasi*, vol. 6, no. 1, p. 68, Jun. 2018, doi: 10.30738/jtvok.v6i1.2839.

[12] G. E. Averina, S. Sumpeno, and A. Zaini, "Pengembangan Media Penunjang Praktikum Daring Fisika Dasar Berbasis Multimedia Interaktif," *J. Tek. ITS*, vol. 10, no. 2, Dec. 2021, doi: 10.12962/j23373539.v10i2.70702.

[13] K. A. Rakhman, A. R. Saraha, and N. Sugrah, "Pengembangan video penggunaan alat gelas laboratorium kimia di universitas," *J. Inov. Pendidik. IPA*, vol. 3, no. 2, p. 161, Oct. 2017, doi: 10.21831/jipi.v3i2.15667.

[14] N. Nurwati and H. Purwanti, "Pemanfaatan Video Tutorial (Demonstrasi) pada Pembelajaran Pcki di Masa Pandemi Covid-19," *J. Ilm. WUNY*, vol. 3, no. 2, Jan. 2022, doi: 10.21831/jwuny.v3i2.42426.

[15] M. S. A. Dewi and N. A. P. Lestari, "E-Modul Interaktif Berbasis Proyek terhadap Hasil Belajar Siswa," *J. Imiah Pendidik. dan Pembelajaran*, vol. 4, no. 3, pp. 433–441, 2020.

[16] S. Ramadhan, Y. Asri, E. Sukma, and V. Indriyani, "Design of learning modules writing factual text based on discovery learning by using mobile devices," 2020, doi: 10.4108/eai.11-12-2019.2290894.

[17] G. Sossou, F. Demoly, H. Belkebir, H. J. Qi, S. Gomes, and G. Montavon, "Design for 4D printing: Modeling and computation of smart materials distributions," *Mater. Des.*, vol. 181, p. 108074, Nov. 2019, doi:

10.1016/j.matdes.2019.108074.

[18] M. M. Malik, Adam and Chusni, *Pengantar Statistika Pendidikan: Teori dan Aplikasinya*. 2018.

[19] A. Sudijono, *Pengantar Statistik Pendidikan*. 2021.

[20] R. T. Sari, "Uji Validitas Modul Pembelajaran Biologi pada Materi Sistem Reproduksi Manusia melalui Pendekatan Konstruktivisme untuk Kelas IX SMP," *Sci. Educ.*, vol. 6, no. 1, p. 22, Jun. 2017, doi: 10.24235/sc.educatia.v6i1.1296.