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Development of a Practicum Guide on Static Electricity Using a Van de Graaff Generator for Students

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Abstract: This research aims to develop practical guidelines for the Van de Graaff Generator on Static Electricity for Students that are valid and practical. This research uses research and development research methods with the Rowntree development model. The Rowntree development model is product-focused, consisting of three stages: planning, development, and evaluation. At the evaluation stage using, Tessmer's formative evaluation, namely self-evaluation, expert review, one-to-one evaluation, and small group evaluation. This research collected data in two ways: walkthrough and student response questionnaires. The results of the two methods are then analyzed by finding the average percentage value and converted according to the predetermined category. Based on the results of the expert review, it was found that the average overall aspect was 90.80% which was categorized as very valid. At the one-to-one evaluation stage, an assessment of student responsiveness was obtained of 81.67%, categorized as practical. Furthermore, in the small group evaluation stage, the results of student responses were obtained by 87% in the very practical category. Thus, based on the results of the research, the Van de Graaff Generator (GVG) practicum guide on Static Electricity for Physics Education Students is very valid and practical.

Keywords: Practicum guide; Rowntree development; Van de Graaff Generator.

Introduction

The 21st century is marked by technological developments, including in the world of education. The development of technology in the world of education requires students to have the ability to think critically to make it easier to understand observations of natural phenomena (Ariyati, 2012; Azzahra, 2019). Through practicum with direct observation of a scientific process, it is helpful to train scientific thinking skills, develop and instill a scientific attitude, and be able to solve and discover new problems through the scientific method (Tahnia et al., 2022; Harefa, 2018; Fajarianingtyas & Hidayat, 2018; Helmita et al., 2022). Besides that, the advantages of carrying out practicums are being able to develop attitudes to conduct exploratory studies on science and technology, being able to foster scientific attitudes of students or students such as being honest, cooperative, critical, open, and tolerant, providing learning experiences by experiencing or observing a process yourself. Alternatively, phenomena able to enrich experiences with things that are objective and realistic and experimental results will be understood longer, and the process of internalization will occur (Rahayu & Eliyarti, 2019).

One supporting component that is very important to carry out the practicum is the practicum guide. The practicum guide functions as a guide or basics in conducting a practicum so that it can work continuously and be directed (Suprianto et al., 2017). The practicum guide is also used per the stages of practicum work to be carried out. The laboratory is a supporting facility for carrying out experiments or practicums so that the laboratory can run adequately; room facilities, laboratory equipment storage, laboratory administration, and management, as well as practical maintenance activities, are needed (Won et al., 2020; Elorrieta & Pylkkänen, 2017). One tool that can be used in the laboratory is the Van de Graaff Generator (GVG).

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The Van de Graff Generator (GVG) is a device that can generate a considerable amount of static electricity through a friction process. Robert Jemison Van de Graff made this generator from 1901-1967 (Lim et al., 2016). The Van de Graff generator can demonstrate the phenomenon of electric charges in the form of the properties of electric charges and Coulomb's law (Sholehuddin, 2020; Lim, et al., 2016). The Van de Graff generator in the Physics Education laboratory has never been used, let alone for practicum activities; in fact, many Physics Education students need to learn about this tool. In addition to needing to carry out practicum in related subjects, there is also no practicum guide on using the Van de Graff Generator. So that there is no practical guide to using this tool also makes this tool still new for physics education students. As a laboratory tool that is quite dangerous, it has its standardization of use. Electromagnetic exposure generated by the Van de Graff Generator (GVG) with electric field strength with units of V/m and magnetic field strength with units of A/m emits a large enough electromagnet exposure at close range, namely at the demonstration distance between the discharge distance and touching it. The greatest danger can occur from burns and stings (Lee et al., 2017; Khalid et al., 2018).

In addition, the researchers also conducted a needs analysis for Physics Education students. The results of the student need analysis stated that 88% of students needed help understanding Static Electricity material. For several reasons students, 55% stated that Static Electricity material was abstract, so it required practicum activities; 39% stated that Static Electricity material was challenging to understand if learning was only done using the lecture method, and 6% stated that learning activities did not vary. For these reasons, students need other learning methods besides the lecture method. Moreover, it was found that 100% of students stated the importance of practicum activities on Static Electricity material. However, 73% of students need to learn about the Van de Graaff Generator (GVG) experimental tool. Namely a tool designed for practical activities of Static Electricity. From this, 100% of students agreed that the Generator Van de Graaff practicum guide was developed for Static Electricity material in the School Physics Teaching and Introduction to Core Physics courses.

The development of a Static Electricity practicum guide using the Van de Graaff Generator is very important for students because it can increase students' understanding of the concept of Static Electricity, introduce students to technology and tools used in industry and research, and help students to develop social skills and teamwork. This practicum guide will help students to prepare themselves to become a reliable workforce in the future.

Based on these things, the researcher will develop practical guidelines for using the Van de Graff Generator (GVG) which are appropriate and valid so that they can be used in conducting practicum on static electricity, which can be used in introductory core physics courses and teaching school physics in the Education study program. Physics FKIP Sriwijaya University. Therefore the title of this research is "Development of the Practical Guide to the Van de Graff Generator (GVG) Static Electricity Material for Physics Education Students."

Method

This research uses development research methods by utilizing the Rowntree model. The Rowntree model is a research model that focuses on producing products, and this study focuses on product practical Van de Graaff generator practicum guides for Physics Education students that are valid and practical. The stages of the Rowntree research model can be seen in Figure 1.

Figure 1. Stages of the Rowntree Research Model

In the last stage, namely the evaluation stage, the researcher used Tessmer's formative evaluation. Tessmer's evaluation is an evaluation phase that has five steps, including (1) self-evaluation, (2) expert review, (3) one-to-one evaluation, (4) small group evaluation, and (5) field test. However, this research was only carried out up to stage 4 because it was adapted to the purpose of this research, namely to produce valid and practical products. The description of each research step is as follows:

Planning Stage

The first stage of this research is conducting a literature study, looking for related references, and conducting a needs analysis. A needs analysis was carried out to find out student problems on the subject matter of Static Electricity. Then proceed with identifying the material and the formulation of practicum objectives.

Development Stage

The development stage is the stage of designing and designing the initial product. This stage consists of (1) instrument preparation, (2) draft preparation, and (3) prototype production.

Evaluation Stage

The evaluation stage consists of the self-evaluation stage; the evaluation carried out by the researchers themselves aims to avoid basic mistakes in product development. Next, an expert review is an evaluation of product validity carried out by experts. She was followed by a one-to-one evaluation step, namely an evaluation of the product's practicality, which three students carried out with different abilities. Then the final step, namely the small group, carried out a product trial small group consisting of 9 physics education students.

Data collection in this research used two methods: walkthrough interviews and student questionnaires. The walkthrough is used at the expert review stage to see the level of product validity. The expert validation instrument grid can be seen in table 1.

Table 1. Grid of expert validation instruments

Aspect	Assessment Indicator	Number of Questions
Content Aspect	Appropriate practicum title	1
	Appropriateness of practicum objectives	1
	Material suitability	3
	Compatibility of work steps	1
	Appropriateness of observational data	1
	Appropriateness of data analysis	1
	Appropriateness of conclusions	1
	Feasibility as a complete learning device	1
Design Aspect	Clarity of practicum guide format	4
	Compatibility of illustrations and photos	2
	Correspondence of letters and numbering	2
	Display design compatibility	3
Language Aspect	Clarity of sentences and information	5
	language suitability	3
	Word suitability	1

Furthermore, student questionnaires were used to see student assessments and responses to practicum guidelines in the one-to-one and small-group evaluation stages. The questionnaire contains questions in the form of a checklist covering practicum guidelines that have been developed and a column for criticism and suggestions. Student question indicators can be seen in table 2.

Table 2. Questionnaire grid for students

Question Indicator	Number of Questions
Ease of use guide	7
The attractiveness of the dish	6
Material linkage1	6

The data that has been obtained from the collection of walkthroughs and student questionnaire results are analyzed by finding the average value with the following equation 1.

$$P = \frac{f}{N} x100\% \quad (1)$$

Information
P: Final score
F: Score acquisition
N: Maximum score

The final value obtained at the walkthrough stage is then confirmed with the category of expert validity results, which can be seen in table 3.

Table 3. Category of expert validation results (HVA) (Wiyono, 2015)

Percentage (%)	Category
$86 \leq HVA \leq 100$	Very valid
$70 \leq HVA \leq 86$	Valid
$56 \leq HVA \leq 70$	Less valid
$0 \leq HVA \leq 56$	Invalid

Furthermore, the final value of the student questionnaire stage is confirmed by the product practicality level category, which can be seen in table 4.

Table 4. One-to-one and small group (HOES) result categories (Wiyono, 2015)

Percentage (%)	Category
$86 \leq HOES \leq 100$	Very practical
$70 \leq HOES \leq 86$	Practical
$56 \leq HOES \leq 70$	Less practical
$0 \leq HOES \leq 56$	Not practical

Result and Discussion

Planning Stage

The result of the planning stage of this research is an analysis of the needs of physical education students and is followed by the formulation of learning objectives.

Needs Analysis

A needs analysis was conducted by distributing online questionnaires to Physics Education students in

semester 8. This analysis was carried out to know students' problems in learning static electricity material. The needs analysis showed that 88% of students needed help understanding Static Electricity material. This difficulty is due to static electricity material, which is abstract and requires practicum activities, static electricity material, which is difficult to understand with lecture learning, and monotonous learning activities. From these problems, students need different learning methods, such as practicum.

Formulation of Practicum Objectives

The formulation of practicum objectives is expected so that practicum activities stay consistent with the specified material and students can achieve the expected competencies. The formulation of practicum objectives can be seen in table 5.

Table 5. Formulation of practicum objectives

Subject matter	Experiment Objective Indicator
Coulomb force	1. Students can observe the occurrence of electric jumps. 2. Students can understand objects that are electrically charged. 3. Students can understand the effect of distance on the magnitude of the force. 4. Students can determine the magnitude of the coulomb force.
Electrical charge	1. Students can observe the events of electrically charged objects. 2. Students can detect electrically charged objects.
Electric Potential	1. Students can observe the event of an electric discharge to a fluorescent lamp. 2. Students can understand the effect of distance on the intensity of electric discharge. 3. Students can determine the magnitude of the electric potential in a Leon lamp.
The direction of the Electric Field	Students can observe the direction of the DC electric field.
Electrical Induction	Students can observe the events of electric induction

Development Stage

In the product development stage, the researcher carried out three steps: preparation of the instrument, development of the draft, and development of the prototype. The results of the development stage are products in the form of prototype 1.

Preparation of Instruments

The instrument's preparation is carried out by compiling instrument questions that will be used as a reference in developing data analysis in practicum activities. The preparation of questions in the instrument analysis can be seen in table 6.

Table 6. Preparation of instrument analysis indicators for each practicum

Instrument Analysis Indicator
Accuracy in compiling a series of practicum tools
Observation skills on practicum variables
Skills in calculating the distance between electric charges
Skills in calculating coulomb force and electric potential

Drafting

The draft is prepared by sorting practicum activities and the components presented in the practicum guide, namely as follows: 1) Practical guide cover, 2) Foreword, 3) Table of contents, 3) List of Tables, 4) Introduction consisting of Motorized Van de Graaff Generator and how to clean the Van de Graaff Generator, 5) Practicum activities consist of sub-chapters: practicum objectives, basic theory, work safety, tools and materials, practicum procedures, observation tables, results, and analysis of observations and conclusions, 6) An appendix consisting of practicum rules, 7) Bibliography.

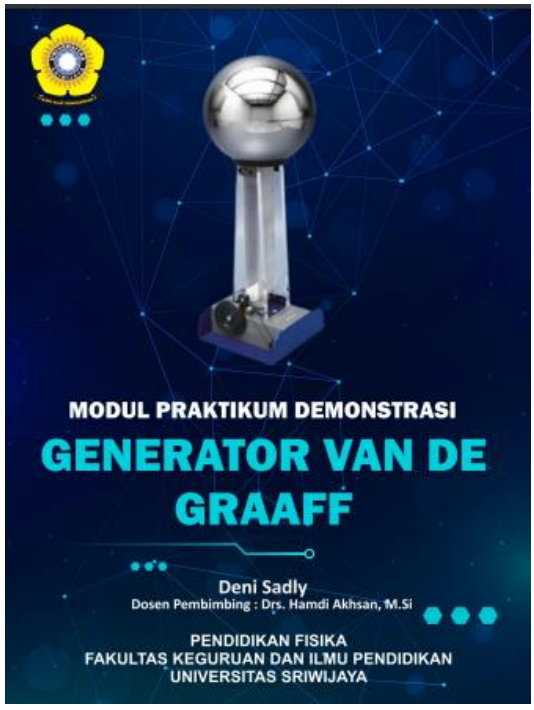

Figure 2. Practicum Module Cover

Prototype Production

The researcher made a practicum guide prototype by planning and designing at the previous stage. Researchers used the Microsoft Word application with portrait paper format and A4 paper size. In addition, researchers develop products by producing prototypes according to the rules for writing practicum guidelines. It is intended that the practicum guide developed follows applicable rules or norms.

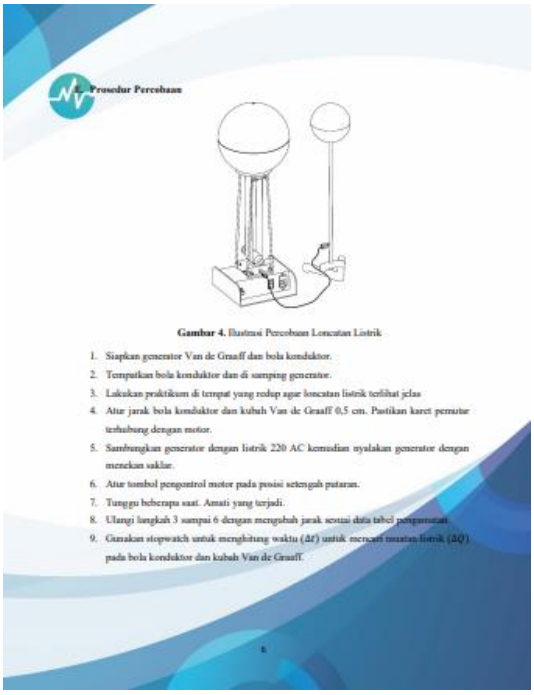

Figure 3. Practical Esperiment Procedure 1

Evaluation Stage

Researchers used Tessmer's formative evaluation, which aims to determine the validity and practicality of the developed practicum guide. Based on Tessmer's formative evaluation procedure, the prototype I will be self-evaluated, followed by an expert review stage and a one-to-one evaluation stage. After the product is declared valid in the expert review stage and practically in the one-to-one evaluation stage, the prototype I will change to prototype II. In prototype II, it will proceed to the small group evaluation stage. The results of these stages can be seen in the following description.

Self-evaluation is an assessment carried out independently by researchers. This stage is carried out by reviewing the products that have been made so that the product of the Van de Graaff Generator practicum guide is correct.

Expert review is the stage to determine the product's validity for developing the van de Graaff generator practicum guide researchers have developed. The expert review stage involves three validators from several aspects, namely content, media, and language aspects. The validator fills out online and offline validation sheets using a Likert scale.

Table 7. Results of the validator's assessment at the expert review stage

Aspect Validity	HVA score	Percentage (%)	Criteria
Content Aspect	4.29	85.80	Valid
Design Aspect	5.00	100	Very valid
Language Aspect	4.33	86.67	Very valid
All aspects of the expert review stage	4.54	90.80	Very Valid

The results of the practicum guide validation assessment of all validators amounted to 90.80%, so it can be concluded that it is included in the outstanding category and is feasible to try out. In this study, the validator provides ratings in the form of numbers and comments and suggestions regarding the products that have been developed. These comments and suggestions became the basis for making improvements to the van de Graaff generator practicum guide that was developed. The comments and suggestions of the validators can be seen in table 8.

Next, the one-to-one evaluation involved three physics education students at the Sriwijaya University FKIP. At this stage, it was carried out in the Physics Education laboratory, FKIP, Sriwijaya University. The three students have different academic levels, namely high, medium, and low levels. In this stage, students are given practicum products that have been developed and asked to conduct experiments according to these guidelines. Based on student assessments at this stage, the percentage data obtained was 81.67% and was included in the practical category. The results of the student questionnaire at the one-to-one evaluation stage can be seen in table 9.

Table 8. Expert review comments and suggestions

Validation Aspect	Comments and Suggestions	Revision Decision
Content Aspect	A tool type is used to determine the amount of electrometer charge, but it has yet to explain how to use it. It is better if each tool component is explained in how it works.	No revisions were made because they did not use the tool
Language Aspect	Cover: do not double identity Preface: one paragraph, not just one sentence, and tidy up the signature section. Table of contents: tidy up the writing (paragraph spacing). Paragraph spacing uses 1.5 spacing. When writing foreign words, use italics. In the table, use one space. Do not use a number if it is only 1 point. Trim caption spacing on images. Use a large font at the beginning of the caption for the image and a small font for the following letters.	Revise as suggested
Design Aspect	Find the relationship between Q and I	Revise as suggested

Table 9. Results of the student response questionnaire assessment in the one-to-one evaluation stage

Indicator	Students		
	AK	JMS	ZQ
Ease of use of the module	4.00	3.57	3.86
The attractiveness of the dish	4.83	4.17	4.00
Material linkage	4.50	3.67	4.17
Average			4.08
Percentage			81.67%
Category			Practical

The last step in this evaluation stage is the small group evaluation. The small group evaluation stage is the trial stage in small groups. The revision results in the previous stage, namely the one-to-one evaluation stage, resulted in product prototype 2. Furthermore, in the small group evaluation stage, students were given practical guidance from prototype 2. Then students were asked to conduct experiments according to the guidelines that had been developed. After that, students will be given a response questionnaire regarding the use of practicum guidelines. The student response questionnaire is in the form of a Likert scale with a maximum score of 5. Based on the questionnaire filled in by students, the percentage of student Validation Questionnaire Results (HVA) is 87%, concluding that the practicum guide is included in the practical criteria.

Learning activities should be carried out in an exciting and varied way to motivate students to participate. Learning activities can be carried out by conducting experiments or practicum so that students take an active role in learning. Especially learning physics is highly recommended with a learning process focusing on students. By doing practicum, students will participate in the learning process to easily understand learning and add to student skills. Practicum activities are proven to improve student abilities, such as critical thinking skills, increase student creativity and improve students' science process skills (Kadir, 2018; Dewi & Setyaningsih, 2016; Lestari & Diana, 2018). One of the practicum activities in physics learning is the Van de Graaff Generator practicum which is related to Static Electricity material. The Van de Graaff Generator practicum guide developed in this research is equipped with observation table activities and observation analysis data to increase students' analytical skills.

Table 10. Results of student use response questionnaire in the small group evaluation stage

Question Indicator	Students								
	A A	DJW	JW	MK	MFF	N	RK	RP	TA
Ease of use of the module	4.14	4.00	4.29	4.71	4.71	4.43	4.86	4.71	4.86
The attractiveness of the dish	4.17	4.33	4.17	4.67	4.50	4.50	4.83	4.83	4.50
Material linkage	4.17	4.00	4.33	4.17	4.83	4.67	5.00	4.50	4.67
Average									4.30
Percentage									87%
Category									Very Practical

Conclusion

Based on this research, a Van de Graaff Generator practicum guide has been successfully developed regarding Static Electricity material for students in valid and practical categories. At the expert review stage, 90.80% was obtained with a valid category. Then at the one-to-one evaluation stage, 81.67% was obtained in the practical category. After the small group evaluation stage, 87% was obtained in the practical category. So the Van de Graaff Generator practicum guide for students is feasible. This practicum guide product is expected to be an additional learning activity related to learning Static Electricity for students. Further research is needed to test the effectiveness of the practicum guidelines that have been developed.

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Author Contribution
Deni Sadly, the principal author, took involved in the planning, execution, and writing of the study. Hamdi Akhsan, the author of both publications, took part in overseeing the study and offering advice.

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Conflicts of Interest
There are no competing interests, according to the authors.

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