JSER

Journal of Science Education Research

Journal homepage: https://journal.uny.ac.id/index.php/jser/index

ISSN: 2597-9701

Development of Student Worksheets on Static Electricity Material to Identify Higher Order Thinking Skills (HOTS)

M. Rasyid[1], H. Unayah[2], N. Iqdami[2], S. Nurohman[3]

[1,2,3]*Science Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta State University*

[*]*Corresponding Author. Email: muhammadrasyid.2023@student.uny.ac.id*

Keywords

4D model
Static electricity,
Higher-Order Thinking Skills (HOTS),
Student worksheets

Phone*: +6282137668788

Abstract

This study examined the design of learning materials based on Android, using both static and dynamic electricity. It created educational materials that include electrical components, both static and dynamic but are invisible to the human eye. The study aimed to determine the viability of producing Student Worksheets Based on Higher-Order Thinking Skills (HOTS) on Static Electricity Material and making a product based on HOTSs on static electricity. The 4D (Four D Model) development model from Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel that is, defining, planning, developing, and disseminating is used in this work in conjunction with the Research and Development (R&D) technique. The experts in materials and media conducted validation through an evaluation form to measure the product's viability. Two phases of the experiment were conducted: field trials and restricted trials. Based on Higher Order Thinking Skills (HOTS) information on static electricity, student worksheets for physics instruction have been created using a 4D stage model: define, design, develop, and disseminate. After going through several phases of validation with media experts, material experts, and trials, the instructional materials were deemed acceptable and fit for students. The student worksheets produced teachers' feedbacks received an average score of 88% in the "very good" standard. The average score for students' feedback on the student worksheets was 87% in the "very good" standard. Thus, the student Worksheets for physics in class IX Static Electricity based on Higher Order Thinking Skills (HOTS) are prepared to be used as teaching material.

History

Received:

July 29, 2024

Revised:

October 8, 2024

Accepted:

February 11, 2025

How to cite:

Rasyid. M., Unayah. H., Iqdami. N., Nurohman. S. (2025). Development of Student Worksheets on Static Electricity Material to Identify Higher Order Thinking Skills (HOTS). *Journal of Science Education Research*, 9(1), .doi:https://doi.org/10.21831/jser.v9.i1.74886.

INTRODUCTION

In the 21st century, education plays a crucial role in preparing students to face complex challenges by developing their skills. The rapid advancement of science and technology demands an education system that not only provides knowledge but also fosters students' ability to analyze, evaluate, and create solutions to real-world problems. One of the key components in achieving this goal is the implementation of Higher Order Thinking Skills (HOTS) in the learning process. Especially for higher students, they must not only have a lower order thinking (LOT) but also have to reach a higher order thinking (HOT). However, based on PISA, reported by the Organization for Economic Co-Operation and Development (OECD), Indonesia is at 64 ranks of 65 countries OECD 2017. This result shows that most Indonesian students still have low ability if it is seen from a cognitive aspect (knowing, applying, reasoning).

Students with advanced thinking abilities will be intelligent in reading, informing, and environment analysis (Unayah et al., 2023). To use HOTS, it needs to employ operational verbs as a guide when generating activity sheets. These verbs include analysing, evaluating, and creating. Additionally, HOTS questions are evaluations that are grounded in real-world scenarios (Sari et al., 2020; Pratiwi et al., 2020). To overcome obstacles to students' self-confidence in their ability to comprehend the academic world, Higher-Order Thinking Skills (HOTS) are crucial (Awaliyah & Widiyawati, 2022; Carroll, 2020).

As part of the process of producing new knowledge, HOTS engages in critical and creative thinking as well as problem-solving and strategic

planning (Hava Ester Vidergor, 2017). One of the relevant learning tools employed during the COVID-19 epidemic is Student worksheets with science learning, as it can help students' critical thinking skills grow through the learning process and resources (Umbaryati, 2018; D Sobari & Ramalis, 2022; Syukrul Hamdi, 2018).

Student worksheet learning tools are a very beneficial way to enhance learning activities, boost student learning activities, and improve the effectiveness of the learning process between teachers and students. There is abstract material in the course Static and Dynamic Electricity. Teachers can help students to understand abstract concepts better by making the tangible content. As a result, the researchers created an Android-based learning tool to help teachers support students' comprehension of the subject. Additionally, even if students find traditional classroom education uncomfortable, mobile learning may let them study at any time and from any location. Static and Dynamic Electricity contains abstract material (Sanjiwani, 2022).

Additionally, mobile learning can assist students in learning anywhere and at any time, even when they are not comfortable with traditional classroom instruction. The success of education aimed at improving human capital is influenced by several factors. One factor that significantly affects this success is the teacher's ability to conduct and utilize research, process evaluations, and learning outcomes (Hendriani & Gusteti, 2021). This ability is very important to understand and meet the learning objectives set in the curriculum (Budiman, 2014).

A critical thinking skill for every student is Higher Order Thinking Skills (Anggereni et al., 2022). The thinking process is a method for an individual to check the knowledge stored in memory for a particular situation. It aims to retrieve, organize, and extract information. The ability to conclude using higher order thinking skills is the capacity to connect, manage, and change knowledge as well as experience critically and creatively in understand and solve problems in new situations (Dini Widyastuti, 2020). A person's ability to think at a high level might allow them to analyze, discern, or manipulate information. Analysis, evaluation, and creating using high levels of thinking can be identified by students' abilities. In addition, the ability to write at a high level requires not only the ability to write clearly but also the ability to write critically and creatively in practice (Antomi Saregar, 2018; Adawiyah et al., 2022).

With the advent of globalization, technology has changed around the world, which made human activities more efficient. One of the most notable examples is the smartphone (Habsyi et al., 2022). According to data from kemenperin.go.id, 62% of smartphones in Indonesia are running Android, and the remaining 50%–60% are running with other operating systems. Within the learning community and teaching staff, most phones are only used for accessing social media platforms, such as Facebook and Twitter. They are not used to discuss important material related to education. One of the mobile learning applications in education is the use of mobile learning as a teaching medium (Mahesi Agni Zaus, 2018).

Besides the repetitive text, the accompanying media includes multimedia components that are both auditory and visual and even animation, which helps pupils to have a better comprehension of the subject matter (Ilmy et al., 2022). Learning media can support students in comprehending and applying topics so they can meet learning objectives (Ernia Wulansari, 2018). Student worksheets contain activities that can foster curiosity in students, high-level thinking skills, and skills (Suryaningsih & Nurlita, 2021). This Student worksheet functions as a guide in completing a task based on the steps in learning activities and facilitates educator activities. Then, efficient interaction is achieved between educators and students (Zahrah & Mitarlis, 2023).

Student worksheets that are compiled, designed, and developed must also follow the conditions in educational activities. Online Student worksheets are a form of presentation of teaching materials that are systematically arranged by a program to make a more interactive Student worksheets (Nur Nadifatinisa, 2021). When employing Student worksheets in accordance with recent advancements and in circumstances where doing tasks entirely online is necessary, the Liveworksheets program serves as the online source for the Student worksheets that are required. According to (Wahono et al., 2022), Liveworksheet is a web-based platform that use modern technology to display engaging features like sound, images, and videos. By reinforcing this learning, it is hoped that the quality of learning outcomes and the capacity to improve the quality of learning will be more effective, efficient, pleasurable, and meaningful. It emphasizes high-level thinking among students. With the today's circumstances, many educators are aware of HOTS (Widodo 2021; (Ahmad Fanani, 2018).

Based on research, conducted at SMPIT Ibnu Abbas Godean, the school has provided learning resources in the form of textbooks and Liveworksheets. The Liveworksheets and books of students worksheets are derived from the reader; they only include text, examples, and biased statements that do not facilitate the process of

writing in an active and creative manner. They have also already created an instrument to improve the learning outcomes of students who are often drawn from a variety of sources, such as books, bundles of papers, Liveworksheets, or collections of exam test questions. Textbooks and Liveworksheets are examples of the learning materials offered by SMPIT Ibnu Abbas Godean. Moreover, the Liveworksheets and books of students' worksheets are reader-generated; they don't help with the process of writing in an active and creative way; instead, they merely include text, examples, and opinionated statements. Additionally, They have previously produced a tool to enhance the students learning outcomes who are frequently selected from a range of sources, such as books, collections of papers, liveworksheets, or collections of of exam test questions. There is a lack of test questions specifically designed to train the use of higher-level thinking in solving contextual problems, requiring reasoning, argumentation, and creativity in solving them, so far students have only worked on ordinary questions. Thus, to achieve the goals of scientific education, high-quality materials are needed, not only to understand and apply indicators but also to analyze, evaluate, and create. Thus, specifically designed topics are needed to learn HOTS or students' high-level thinking skills. The final result of this study highlights the importance of developing the High Order Thinking Skill (HOTS) liveworksheets to train students in developing their critical and creative thinking skills as well as to become critical and creative thinkers who can analyze, evaluate, and formulate ideas (Khovivah et al., 2022; Mardhatilah et al., 2022).

According to Bloom, Kratwhwol, and Anderson, there are two main thresholds for a person to reach in a high level thinking situation: realizing (C1), understanding (C2), issue of By using (C3), analyzing (C4), evaluating (C5), and drafting (C6), Chintia Tri Noprinda and Sofyan M. Levels of reasoning at C1, C2, and C3 represent levels of reasoning at a low level (Low Order Thinking), meanwhile levels of reasoning at C4, C5, and C6 represent levels of reasoning at a higher thinking skill (HOTS) (Imam Gunawan, 2018).

The rapid development of science and technology in the 21st century has significantly influenced education, necessitating innovative learning models that foster students' Higher Order Thinking Skills (HOTS). One of the fundamental topics in science education is static electricity, which is often abstract and challenging for students to grasp without proper instructional support (Umiliya et al., 2023). To address this, student worksheets (Lembar Kerja Peserta Didik or LKPD) have been developed as essential learning tools that facilitate student engagement and conceptual understanding (Rahmayumita et al, 2024). These worksheets are designed not only to guide students through inquiry-based learning but also to develop their analytical, evaluative, and creative thinking abilities (Mitasari & Hidayah, 2022). Research has shown that integrating PhET simulations and inquiry-based approaches in science education can improve students' comprehension of static electricity concepts while fostering independent learning (Umiliya et al., 2023). Therefore, this study aims to develop and evaluate student worksheets on static electricity material using PhET to identify and enhance HOTS, ensuring that students can apply their knowledge to real-world problems effectively.

It is not difficult to determine that students can face the challenges of a worldwide peer-to-peer exchange process to facilitate addressing and resolving any issue. For this reason, it is necessary to continuously carry out the exam questions exercises that can inspire students to increase their ability to the highest level. Therefore, the article conducted an investigation on the topic of "Development of Student worksheets Based on Higher Order Thinking Skills (HOTS) in Static Electricity Material of Class IX, Semester 1 at junior high school."

RESEARCH METHOD

The study employed a research and development (R&D) approach design, using 4D research and development methodology developed by S. Thigharajan. The steps were Define, Design, Develop, and Disseminate. The study was conducted at SMPIT Ibnu Abbas Godean. The study period began with the preliminarily planned phase and ended with the final phase of the academic year 2023–2024. This research used research and development (R&D) methods for analysis as influenced by the study's period.

The participants for worksheet are participated in the creation of 4D, with the steps of Identify, Create, Expand, and Distribute. The dissemination stage was completed by distributing teaching materials under investigation by SMPIT Ibnu Abbas. It employed the 4D method due to an exclusive focus on the product's viability, which was determined by evaluations from media specialists, physics instructors, material experts, and students. Expert validation sheets, instructor response sheets, student response sheets, and Likert scale data analysis were used in data collection. Two categories of data were employed.

1. Quantitative data is in the form of an assessment score. Student assessments and the results of the validator assessment questionnaire provided quantitative data.
2. Qualitative data or information presented as sentence-by-sentence descriptions. This qualitative data takes the form of product development ideas and criticisms from validators, as well as an account of how product testing were carried out. Expert validation sheets, instructor response sheets, student response sheets, and Likert scale data analysis were used to collect the data. Data analysis approaches use the following steps:
1. Methods of Qualitative Data Analysis. Qualitative information in the form of critiques and recommendations for the physics curriculum Higher Order Thinking Skill (HOTS) from the validator includes evaluation by media specialists and instructors at SMPIT Ibnu Abbas.
2. Methods of Quantitative Data Analysis Expert and student assessments and tests demonstrate the applicability of physics teaching materials in tabular form. Then, the information is used to inform the revision of each prepared component of the physics teaching materials, and the viability of the Higher Order Thinking Skill (HOTS). Student worksheet is assessed through analysis. According to (Sugiyono, 2019), the percentageis calculated using the following formula:

$$P = \frac{Equation\ of\ scores\ resulting\ from\ data\ collection}{total\ criteria\ scores\ x\ 100\%}$$

Information:

P = Percentage of eligibility.

Answers to a questionnaire using four alternative answer choices were chosen based on the questions' substance. A Rating Scale, as shown in table 1, is used to convert the evaluation findings from letters to scores for material experts, media experts, and physics professors (Hendriani & Gusteti, 2021).

Table 1. Scores for answer choices

Ratings	Score
Very good	4
good	3
Not good	2
Very not good	1

Respondents were given a questionnaire to complete and assess the applicability of the Student Worksheet (Saraswati, 2023).
The average analysis of the relevant questionnaire questions provides the final score by dividing the total number of responses by the total number of scores.
The percentage score obtained from the research are interpreted in the criteria in Table 2.

Table 2. Percentage of Eligibility

No	Percentage	Eligibility
1	0% ≤p ≤25%	Very good
2	25% <p ≤ 50%	Good
3	50% <p ≤75%	Not good
4	75% <p ≤ 100%	Very not good

The product will come to an end when the percentage of teaching materials in the form of material and teaching materials eligibility, and technical quality of Student worksheet Higher Order Thinking Skill (HOTS) on static electricity material for class IX semester 1 in junior high school has achieved the eligibility requirements, namely by being classified as quite good or very good, according to the data in the percentage analysis feasibility table.

RESULT AND DISCUSSION

A team of five expert lecturers, comprising two material expert validators and three media expert validators, validated the High Order Thinking Skill (HOTS) based on static electrical material. Three aspects were examined. They were the suitability of the language, the presentation, the content, and the HOST assessment. All were based on the material expert's validation assessment of the High Order Thinking Skill (HOTS) based Student worksheet on static electricity. Three components of static electricity were examined in the material expert validation evaluation of Student worksheets based on higher-order thinking skills (HOTS): the appropriateness of the content, the appropriateness of the presentation, the language's appropriateness, and the HOTS evaluation. Three aspects—the Student worksheet size aspect, the Student worksheet cover design aspect, and the Student worksheet content design aspect—were examined in the media expert validation evaluation of the Student worksheet based on High Order Thinking Skills (HOTS) on static electricity.

The research in question underwent design change after expert approval. Next, use the Student worksheet to test the product with students in class IX using their High Order Thinking skills on Static Electricity.
The outcomes of each stage of the research and development processes were:
1. Stage of Define. In a research project, the define stage is the definition stage. This phase is frequently referred to as needs analysis in other frameworks. There are four primary phases involved at this point: front-end analysis, idea analysis, task analysis, and learning objective formulation (which

specifies instructional objectives).
2. Stage of Design. After the completion of the requirements analysis, it continues to participant worksheet development, planning, and design. During the product development design stage, several tasks are completed, including format selection, instructional material selection, and preliminary design.
3. Stage of Development (Develop). It created training materials in the form of a Student worksheet on static electricity based on Higher Order Thinking Skills (HOTS) after completing the definition and preparation stages.
Subsequently, the it completed the following stage in the development stage:

a. Confirmation from material experts

Table 3 presents the findings of the material expert validation evaluation for the product (Alfi Mubarok et al., 2024).

Table 3. Material Experts Validation Result

No	Aspects	Validator	Analysis $\sum p$	Analysis $\bar{p}$	Criteria
1	Content Eligibility	1 2 3	80% 86% 91%	86 %	Very Good
2	Feasibility of Presentation	1 2 3	75% 88% 92%	85 %	Very Good
3	Language Eligibility	1 2 3	78% 86% 83%	82 %	Very Good
4	HOTS assessment	1 2 3	75% 94% 88%	86 %	Very Good
	Total Aspects		**85%**		Very Good

Table 3 presents the findings of validation by material specialists. It is evident that the content feasibility aspect met the criteria for "very good" with an average percentage of 86%. The presenting feasibility element met the "very good" criterion with an average percentage of 85%. With "very good" criteria, the linguistic feasibility element received an average percentage of 82%, while the HOTS evaluation part received an average percentage of 86%. The material experts' evaluation of each validator with regard to four aspects—content suitability, presentation suitability, language suitability, and HOTS assessment—is shown graphically in addition to being displayed as a data table of validation results from Stage 2. Besides displayed in tabular form, the findings of the material experts' evaluation are also shown in the following graph, which allows users to compare the results of each assessment aspect (Diella et al., 2019).

b. Verification from media experts

Table 4 presents the findings of the second validation stage by media experts. It is evident that the Student worksheet size aspect met the criterion for "very good" with an average percentage of 88%. About the "very good" criterion, the Student worksheet cover design component received an average percentage of 90%, while the Student worksheet content design aspect received an average percentage of 93%. The findings of the stage 2 validation by media experts are not only provided in tabular form but also in graph.

Three elements may be shown in visual form to determine the average % of each validator: the Student worksheet's size, cover design, and content design. In addition to being displayed in table format, the evaluation outcomes from material experts are also shown in the following graph.

Table 4. Media Experts Validation Result

No	Aspek	Validator	Analisis $\sum p$	Analisis $\bar{p}$	Kriteria
1	Student worksheet size	1 2 3	100% 88% 75%	88%	Very good
2	Cover of student worksheet	1 2 3	89% 92% 89%	90%	Very good
3	Student Worksheet Content Design	1 2 3	91% 91% 97%	93%	Very good
Total Aspects				**90 %**	**Very good**

C. Testing a product

This student worksheet is designed to improve the critical thinking skills of class IX, SMP students through an in-depth understanding of static electricity material. This worksheet includes a variety of experimental and analytical activities that challenge students to not only understand basic concepts but also apply, analyze, and evaluate information critically.

Experiments and Observations:

Students carry out simple experiments with plastic straws and rulers that are rubbed with a wool cloth to produce an electric charge. In this experiment, they will observe how small pieces of paper are pulled by objects that have been rubbed. Students are then asked to explain why this happens, explore the basic concepts of static electricity, and question the relationship between friction and charge transfer.

Data analysis:

After conducting the experiment, students are asked to record the results of their observations in detail. They must analyze the data to find existing patterns and relationships and develop hypotheses to explain the observed phenomena. Students are challenged to think critically about how electric charges work and how they can validate their hypotheses with further experiments.

Application of Coulomb's Law:

Students will also solve problems involving Coulomb's law, analyzing how the forces repulsion between static electricity can be calculated and predicted. They must apply these concepts in real contexts, such as explaining how the principles of static electricity affect everyday life, starting from the use of electronic devices to natural phenomena such as lightning.

Discussion and Reflection:

This Student worksheet also includes a discussion session where students are invited to share their findings and debate various explanations and solutions. Teachers will facilitate these discussions to ensure that students are not only passively receiving information but are also active in exploring and questioning their knowledge. Through reflection, students will reassess their understanding, identify areas that require further understanding, and plan the steps to overcome the difficulties.

Thesis:

As a final assignment, students are given a complex case study in which they must apply all the knowledge they have learned. For example, they may be asked to design a new experiment that tests a particular hypothesis about static electricity or explain how it can be manipulated to benefit a particular technology.

With an approach that emphasizes critical thinking and problem-solving, this static electricity worksheet not only helps students understand scientific concepts but also develops higher-order thinking skills that are essential for academic success and everyday life (Minarni & Barus, 2023).

There was an increase in the average percentage in each component of the trials pertaining to attractiveness, which were conducted in limited trials. The results of limited trials at Ibnu Abbas IT junior high school obtained an average percentage of 89% with "very good" criteria (Syahrul Gunadi et al., 2023).

Figure 1. Product Development

The Student Worksheet for static electricity material in class IX is designed with an interactive and practical approach to help students understand the concept of static electricity in depth. This worksheet includes various activities that encourage active student involvement, starting from simple experiments with easy-to-find materials such as plastic, wool, and pieces of paper to using an electroscope to detect a static electricity.

Moreover, this Student worksheet uses digital technology through the Liveworksheet platform, which allows students to do exercises and quizzes online in a fun and interactive way. Students are invited to rub plastic with a wool cloth, observe how pieces of paper are pulled by charged plastic, and use an electroscope to understand the working principle of the tool. Through this experiment, students can see firsthand how static electricity work and interact.

Assessment in this Student worksheet includes written tests to evaluate students' theoretical understanding and observations during experimental activities to assess their practical skills. Thus, this Student worksheet not only helps students understand the concept of static electricity theoretically but also applies it in a real context. So, learning becomes more comprehensive and meaningful. This guide to using Liveworksheets in Student Worksheets also makes it easier for students to study independently and teachers to monitor student learning progress efficiently (Syachruroji et al., 2023).

Figure 2. students performing practice

This static electricity practicum in class IX is designed to provide students with direct experience in understanding the phenomenon through simple experiments using straws and rulers. At the start of the practicum, students are given a plastic straw, a plastic ruler, and a piece of wool cloth. In the first step, students rub the straw with a woolen cloth for a few seconds. After rubbing, the straw is then brought closer to a small piece of paper that has been prepared on the table. Students observed that the small pieces of paper were pulled and stuck to the straw, indicating the existence of an electric charge resulting from friction between the straw and the wool cloth. Next, students conducted a similar experiment with a plastic ruler. The ruler is rubbed with a wool cloth to create an electric charge. Then, they held close to a small piece of paper or another light object. Students observed that the ruler was able to pull the objects, confirming the transfer of electric charge. In both experiments, students were invited to record and analyze the results of their observations.

They discussed why the light objects were stuck to the rubbing straws and rulers. They understand that the process was caused by the accumulation of electric charge due to friction. Through this practicum, students not only see the concept of static electricity in theory but also see its practical application, providing a deeper and more concrete understanding of this phenomenon. Apart from that, this practicum is also equipped with reflections where students write down the difficulties they face and new things they learn. In this way, static electricity practicum using straws and rulers helps students understand the basic concepts of static electricity in a comprehensive and applicable way.

CONCLUSION

Based on Higher Order Thinking Skill (HOTS) on static electricity, student worksheets for physics instruction have been created using a 4D stage model: define or definition stage, design stage, development stage, and disseminate stage. After several stages of validation with media experts, subject material experts, and trials, the instructional materials were deemed acceptable and feasible. The Student worksheet produced teachers' feedback and received an average score of 88%, in the "very good" standard. The average score for students' feedback on the Student worksheet was 87%, in the "very good" standard. Thus, the Student worksheet for physics in class IX on Static Electricity material based on Higher Order Thinking Skill (HOTS) is prepared to be used as teaching material. After treated using the student worksheet, students show a deeper understanding of the concept of static electricity.

They were able to identify and explain the phenomenon of static electricity using real examples from experiments, such as how small pieces of paper can be pulled by straws and rulers that have been rubbed with wool. Through analysis of experimental data, students can formulate hypotheses and test their validity using a scientific

approach. They applied Coulomb's law to solve more complex problems and explain the relationship between the forces of repulsion between static electricity in various situations.

Discussion and reflection help students develop the ability to debate and critic explanations, as well as find alternative solutions to the problems. The final assignment in the form of a case study challenges students to integrate all the knowledge they have acquired and apply it in a broader context.

Overall, the use of Student worksheets has succeeded in improving students' critical thinking abilities, equipping them with strong analytical skills, as well as the ability to overcome and solve scientific problems independently and collaboratively.

ACKNOWLEDGMENTS

We would like to express our deepest gratitude to all parties who have contributed to the preparation and implementation of this Student Worksheets. We express our gratitude to theteachers who have patiently guided and provided valuable guidance and all the students who enthusiastically participated in every step of the practicum and discussion, we appreciate your dedication and hard work.

We would like to express our thanks to the school for providing the facilities and support this activity of research smoothly. Also, we would like to thank the students' parents who have provided moral and material support, so that students can participate in this learning optimally.

With collaboration and support from various parties, this static electricity Student worksheet has successfully improved Higher Order Thinking Skills (HOTS), enriching their understanding of static electricity concepts, and developing analytical skills that are important for future learning. We hope this spirit of learning and scientific exploration continues to develop among students and guiding them toward higher academic achievements.

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