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The Development of e-Worksheet based on High Order Thinking Skills (HOTS) for Critical Thinking Student

Jessica Kristanti Hartono[1,a)], Rida Siti Nur'aini M[1], Izza Fauzia[1], Rita Juliani[2]

[1]*Departement of Physics Education, Universitas Negeri Yogyakarta, Jl. Colombo No.1, Yogyakarta, 55281, Indonesia*
[2]*Departement of Physics Education, Universitas Negeri Medan, Jl.W. Iskandar Pasar V, Medan 20221, Indonesia*

✉: [a)] jessicakristanti.2023@student.uny.ac.id

Abstract

This research aims to know the level validation and level practicality of development e-worksheet based on HOTS on doppler effect material from a material expert, media expert, teacher and student. The research type is a 4D model but this research is limited to 3D steps are define, design, and develop due to time and another constraints. The research population was students in SMA Negeri 3 Pematangsiantar Class XI Science. The research population includes trial large group in class XI IPA 1 with 37 students and trial small group with 6 students. The research population has a total of 43 students. The sample research is taken by cluster sampling. In this research, the validators have an instrument with a questionnaire of development e-worksheet to know the level of validation. The instrument of this study was a questionnaire from material expert, media expert, and teacher. The analysis result that development gets level validation and practicality are very worthy with 92,5% from material expert, very worthy with 97,5% from media expert, and very worthy with 95,2% from teacher. Based on the data, the conclusion is that the development of e-worksheet based on HOTS with a 4D model on doppler effect is very worthy of validation and practicality.

Keywords: development, critical thinking, e-worksheet, HOTS, physics

INTRODUCTION

Physics is a subject that integrates technological advancements and the study of natural phenomena within the Indonesian curriculum. The Indonesian education curriculum has undergone significant renewal to align with 21st-century demands (Astra et al., 2021). The inclusion of physics in the curriculum aims to enhance the quality of education and meet the evolving needs of students (Santoso et al., 2022). The renewing of curriculum in Indonesia aims to omprove the quality of education and needs of 21st century, including in physics subjects (Lestari et al., 2019). The cuririculum in Indonesia has undergone changes to be more relevant to social, technological and economics development with diffrences in cognitive learning (Ayu et al., 2023). Although, curriculum reform and educational decentralization have not shown significant improvements in students learning, the curriculum has had a positive impact by improving critical thinking skills, scientific literacy and numeracy (Mohd Abeden & Siew, 2022). The learning approach more inclusive and the used of technology can help teachers adapt learning according to the diverse needs of students (Jannah, 2023). A more inclusive learning approach, combined with the use of technology, can help teachers adapt instruction to meet the diverse needs of students. These technologies not only enhance accessibility for students with disabilities but

also support varied learning preferences through multimodal content delivery, including visual aids, auditory prompts, and interactive resources (Abrori et al 2021).

The curriculum in Indonesia is designed to oincrease the ability of students to think creatively and critically (Dewi, 2021). The innovation of curriculum aims to improve the good quality education and can be need of students (Nurdin et al., 2023). Indirectly, the ability of students to think critically and creatively is part of the high order thinking skills (HOTS). HOTS can be improved and trained by instructional design where teachers can use appropriate raters to assess students in HOTS learning (Chandra & Hayati, 2021). The HOTS of question is an instrument for measuring the HOTS ability of students in seeking to solve a problem by applying learning concepts or principles that do not only use memory, restate or refer without processing. Students must be able to solve a problems in the scientific learning (Li et al., 2022). Physics learning is one of process that requires high order thinking skills (HOTS). Physics as a science that is closely related to various events and nature events in makes it very important for students to have critical level thinking skills because learning physics requires students to be able to recognize, solve problems, interfere, analyze, summarize and evaluate in physics (Astutik et al., 2017). Critical thinking skills are very important in 21st century of physics learning, and can be improved through various learning models and teaching material (Trusikova & Velmovska., 2022). Knowledge in physics will overcome and solve problems from problems that arise and teachers have a role in efforts to build knowledge and students' thinking skills (Chandra & Hayati, 2021). The different physics learning methods also significantly influence students' conceptual knowledge. The proper physics learning can improve students' for scientific process skills and critical thingking (Batlolona & Diantoro., 2023).

The physics learning with process in high scholl must be properly formed and managed to realize concept so that teacher have to need providing quality learning experiensces to increase knowledge of congnitive, competitiveness, and quality of human resources to students (Haqi & Astutik, 2020). The quality physics learning in school can be achieved through the application of appropriate learning models (Maryumi & Putra, 2022). The development of integrated learning tools and the use of innovative methods such as visual-based student worksheets can improve high order thinking skills (Putranta, 2023). The physics learning process in high school requires learning that can build high order thinking skills so that a solution is found in the form of a student worksheet equipped with technology as a student media based on HOTS with 4D model (Trúsiková & Velmovská, 2022). Innovation 4D model in the develop research is a solution for teachers and students as interactive that can improve critical thinking skills (Bakri et al., 2020). The development used 4D but steps are limited to 3D step as define, design, develop than validated by experts. The validation in this research contains aspects according to the implementation of National Professional Certification Agency (BNSP). The results of validation with the development e-worksheet based on HOTS with 4D model, that converge these requirements have gone through a feasibility test of media expert and material expert with very effective and good categories (Daryanto & Suryanto, 2022).

The research conducted to solve problems in SMA Negeri 3 Pematangsiantar important to designed with strategies and technology according to the times in education. Based on observations and interviews with physics teachers at SMA Negeri 3 Pematangsiantar, it was found that only 20% of students had HOTS in physics learning. The physics learning process at SMA Negeri 3 Pematangsiantar need to improvment high-level critical thingking skills of student. Based on observations, student worksheet is a teaching material can help students build concepts with indenpendent and encourage student to participate learning activies. The implication of research is alternative in overcoming the problems of 21st century education in the era of the industrial revolution 4.0 which refers to problem physics learning of low critical thinking skills, creative skills, and scientific creativity skills. By conducting e-worksheet based on HOTS, students can understanding that build students' HOTS and able students interesting physics learning process. Therefore, it is very important to develop appropriate physics learning design in overcoming low critical thinking and able to improve students' thinking skills (Astutik et al., 2020). Students are expected to have easier access to the e-worksheet anytime and anywhere. Researcher feel important with the development of e-worksheet berbasis HOTS with the existence of validation and practicality in accordance National Professional Certification Agency (Tambunan, 2021). Researcher are making it easier for students to learn with help of technology and making teaching material as an e-worksheet.

The teaching material can use for facilitate students' understanding of the material in a more enjoyable and efficient (Amerstorfer et al., 2021). Research shows that instructional materials play an important roel in improving students' academic performance by increasing engagement, understanding of complex concepts, retention, motivation and good value (Ahmed et al., 2024). Student worksheet is a teaching material that can help students build their knowledge independently and encourage students to participate in classroom learning activities (Taslidere in Misbah et al., 2018: 20). The use of teaching materials according to Julian et al., (2020) makes it easier for students to understand the material more pleasantly and does not require a long time. The solution to improve educational skills in the 21st century is to develop teaching materials that can facilitate student learning activities and have an impact on forming active interactions between students and teachers. A teacher must make efforts to develop students' knowledge in varying media with models any learning that can improve students' higher order thinking skills (Ramadhan et al., in Chandra & Hayati, 2021). This student worksheet is one of the facilities that can facilitate learning activities and form effective interactions between students and teachers so that they can increase student activities that affect the improvement of students' thinking skills. The ability to solve and solve problems contained in the student worksheets will affect the students' HOTS. Therefore, the development of HOTS-based questions in student worksheets can be used as an instrument for teachers in measuring students' HOTS abilities (Dooly & Sadler, 2023). The physics learning process in high school requires learning that can build higher order thinking skills so that a solution is found in the form of a student worksheet equipped with technology as a HOTS-based student media. Innovation in the development of HOTS-based student worksheets is a solution for teachers and students as interactive learning that can improve critical thinking skills. Based on the research of Bakri et al., the HOTS-based student worksheet has been validated to be applied as teaching material in physics learning that can build students' HOTS abilities. The results of the validation with the development of a HOTS-based student worksheet that meet these requirements have gone through a feasibility test of media experts and material experts with very effective and good categories (Bakri et al., 2020).

The implications of research on HOTS-based student worksheets are an alternative in overcoming the problems of 21st century education in the era of the industrial revolution 4.0 which refers to the problem of low critical thinking skills, creative thinking skills and scientific creativity skills in physics learning (Susiana & Rendra, 2021). The application of student worksheet in various forms and approaches has proven effective in increasing student involvement and activity during the learning process (Ellianawati et al., 2024). The student worksheet can improve learning outcomes through a more interactive and critical tingking. Therefore, it is very important to develop appropriate physics learning designs in overcoming low critical thinking and being able to improve students' thinking skills (Astutik et al., 2020). The results of the development of physics learning design in this study resulted in a product in the form of a HOTS-based worksheet that was able to overcome the low level of higher-order thinking skills and improve students' higher-order thinking skills (Nurfitriani et al, 2024).

Based on the problems in the physics learning process at SMA Negeri 3 Pematangsiantar, researchers important to conduct research to provide solutions in the form of developing an electronic student worksheet containing for understanding that can build students' HOTS (Li et al., 2022). By conducting HOTS-based e-worksheet research on the Doppler effect material, students will be able to improve critical thinking skills and be able to overcome low critical thinking skills with a more interesting physics learning process. Students are expected to have easier access to the student worksheet anytime and anywhere, making it easier for students to learn with the help of technology and making this teaching material in the form of an electronic student's worksheet.

METHODS

Teaching materials are all things that are shaped as materials in helping teachers carry out teaching and learning activities in the classroom (Heong, 2011). Teaching materials are a set of learning facilities or tools that contain learning materials, learning methods, and methods of objectives designed in a systematic and attractive manner so as to increase competencies or sub-competencies with all their complexity (Slade, 2020). According to the Ministry of National Education (2008) teaching materials are information, tools and texts used by teachers as instructors in planning and studying the

implementation of learning. The design of teaching materials must be in accordance with the background in the form of a curriculum, target characteristics and learning problem solving guidelines.

There are three objectives (Depdiknas, 2008: 10) of preparing teaching materials, namely:

1. Based on the needs of students, teaching materials are provided in accordance with the demands of the curriculum such as teaching materials that are in accordance with the characteristics and social characteristics of students.
2. Teaching materials as an alternative tool for students to obtain information after text books which are sometimes difficult to obtain.
3. Teaching materials are used to facilitate teachers in carrying out learning.

The research have been held in SMA Negeri 3 Pematangsictar with development e-worksheet based HOTS. The research population of class XI IPA needs to improve student of HOTS skills so that researcher made teaching materials as e-worksheet. The development E-worksheet was carried out with process to product validation which the will be used as teaching materials for the physics learning process (Julian et al, 2020). That was concluded that the student worksheet functions as a teaching material that guides students to be more active and learn independently so that they can improve their critical thinking skills. Utilizing student worksheets means helping students to understand the subject matter and be able to answer questions about the subjects that have been studied (Arshavskiy, 2018). With the student worksheet, students can understand the subject matter more easily. According to Reiser & Carr-Chellman (2024) the composition of the student worksheet consists of six elements and formats, as follows:

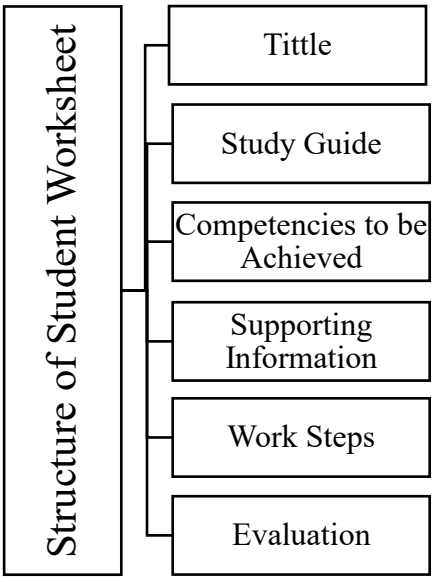


FIGURE 1. Structure of e-worksheet

Development research is research that will be carried out and in accordance with the development of researchers in the form of HOTS-based e-student worksheets (Reiser & Carr-Chellman, 2024). The author chose this development research because it is in accordance with the purpose of conducting experiments and improving objects. The development of the HOTS-based e-student worksheet refers to one of the 4-D development models developed by Thiagarajan in 1974 so that there are several procedures that must be passed (Azizah, 2017). The problem that often occurs in almost all schools that implement the curriculum is that the use of questions in the assessment of cognitive instruments tends to test the memory aspect more so that HOTS-based questions are still not available (Kusuma et al., 2017). According to Supriono in (Chandra & Hayati, 2021) the HOTS question is an instrument of measuring HOTS-based questions that is not just recall, restate or recite. HOTS questions are real-world-based assessments so that students are expected to be able to solve problems by applying school learning concepts or principles. HOTS questions with the context of this assessment measure abilities, such as: 1) changing one concept to another; 2) processing and applying information; 3) looking for links from different kinds of information; 4) use information in solving problems; and 5) critically

understanding ideas and information (Widana, 2017). Thus development of HOTS questions in the student worksheet can be used as a teacher's instrument in measuring students' HOTS abilities. The development of the HOTS assessment instrument can be measured with indicators as follows:

TABLE 1. Indicators of HOTS includes critical, creative and problem-solving thinking skills

Dimension of Knowledge	**Dimension of Cognitive Process**		
	C4 (Analysis)	**C5 (Evaluate)**	**C6 (Create)**
The Knowledge of Factual	Making structure and classifying	Comparing and correlating	Joining
The Knowledge of Conceptual	Explain and analysis	Examine and interpret	Planning
The Knowledge of Procedural	Distinguish	Conclude and resume	Arrange and formulate
The Knowledge of Metacognitive	Create and find	Make and assessment	Realization

(Anderson & Krathwohl in Kusuma et al., 2017)

So that the type of research carried out is qualitative and quantitative research with questionnaires. Meanwhile, research is also carried out based on aspects analysis learning needs of physics and referring to the curriculum so that the research design of e-worksheet based on HOTS with a 4D model on effect doppler was designed with the implementation of 4-D be 3D model, in FIGURE 2.

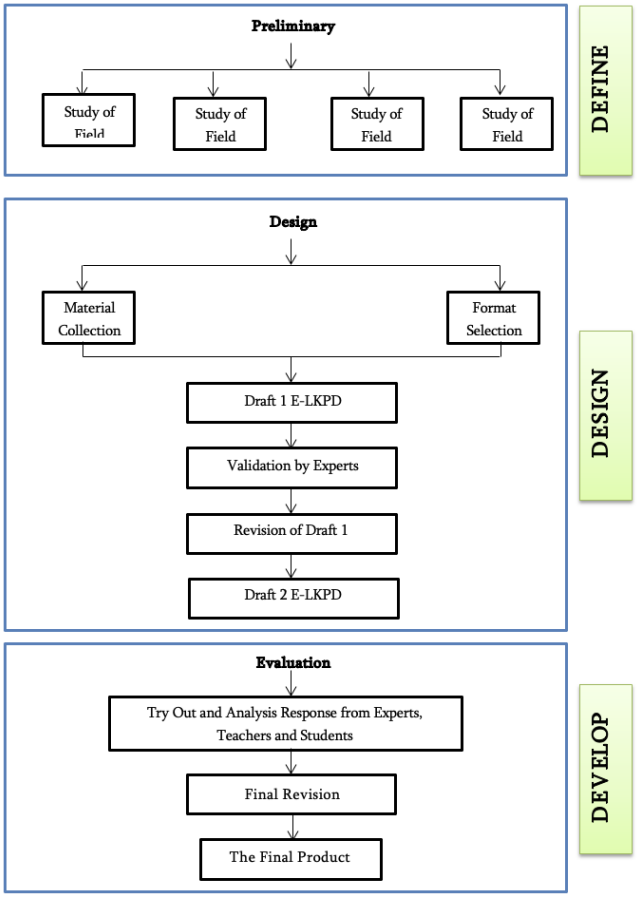


FIGURE 2. Procedure of Research & Development e-worksheet based HOTS Modified

In FIGURE 2. there are three steps: (1) Define for the researcher conducts a needs analysis before developing teaching materials based on the background problems found in learning as a supporter of the researcher in developing e-worksheet based on HOTS. The define stage aims to determine learning requirements; (2) The design aims to make products based on the response rate method of scientific

material (components of the e-worksheet), which includes the presentation of the contents of the chapters to train students' HOTS. The design stage should have student discussion questions to enable them to discover important concepts related to response rates; (3) Develop aims to produce an e-worksheet that is suitable for use. This development stage is a continuation of the design product from development (Saragih et al., 2022). This research was conducted only 3D model due to limited time in the research.

Relevant research is research that has been carried out and research similar to the research that will be carried out by the author. The research that is relevant to the HOTS-based e-student worksheet research is as follows TABLE 2.

TABLE 2. Research relevant to the development of HOTS based e-student worksheets that will be developed by researchers

No.	Researcher	Title	Results
1.	S Astutik, K Mahardika, Indrawati, Sudarti and Supeno, (2020)	HOTS student worksheet to identification of scientific creativity skill, critical thinking skill and creative thinking skill in physics learning.	The results of the development of the HOTS student worksheet showed that there was an increase in scientific creativity skills, critical thinking skills and creative thinking skills in physics learning. So, the implication of research can be used as an alternative in overcoming low HOTS in 21st century education in the era of the industrial revolution 4.0.
2.	F Bakri, S Pratiwi and D Muliyati, (2019)	Student worksheet with augmented reality technology: media to construct higher order thinking skills of high school students in elasticity topic.	The results of this student worksheet research were developed to meet the requirements and are suitable for use as teaching materials in learning that are able to build students' HOTS abilities.
3.	AN Chandra dan M Hayati, (2021)	Pengembangan LKPD Fisika kelas X berbasis DBL (Discovery Based Learning) Dilengkapi soal HOTS.	In the development of DBL-based LKPD and equipped with HOTS questions which were realized with the R&D stage, it was valid and very practical to use.
4.	A Purwanto, I Sakti dan D Sindita (2021)	The Development of Students Worksheets is oriented to The Higher Other Thinking Skill with Problem Solving Models on Electromagnetic Introduction Materials.	The development of Student Worksheets on physics material is carried out with the aim of obtaining validation so that it can be concluded that Student Worksheets on physics material are declared valid and HOTS-oriented with student worksheet development classified as very good in meeting the presentation, content and language aspects.

After the development stage, e-worksheet is validated by a material expert, media expert, and teacher to get a level of validation. The validation has been collecting data with a questionnaire. The Feasibility of teaching materials that the researcher will develop refers to the National Professional

Certification Agency (BNSP) eligibility criteria. The questionnaire aims to assess the validation with category level Linkert scale (Sugiyono, 2019).

The instrument used in the development of teaching materials in the form of an electronic student worksheet is a validation sheet using a questionnaire will be assessed and filled out by tje validator. The assessment instrument aims to determine the assessment of the feasibility, practicality and effectiveness of the validator on the product developed in this study based on assessment data from media experts, material experts and learning practitioners (teachers). In the define stage, the researcher conducts a needs analysis before developing teaching materials based on the background problems found in learning as a supporter of researchers in developing HOTS-based e-student worksheets. Then, at the design stage aims to design products based on the response rate method of scientific material, namely the components of the e-student worksheet which includes the presentation of the contents of the chapters to train students' HOTS. At the develop stage, it aims to produce an e-student worksheet that is suitable for use. This development stage is a continuation of the design stage. The development of the HOTS assessment instrument based on Bloom's taxonomy revised refers to several dimensions of knowledge and cognitive processes, as follows:

TABLE 3. Instrument Validation HOTS of Development E-student Worksheet for Critical Thinking

Aspect	Indicator	Indicator Number
Content Eligibility	The suitability of the material with SK and KD	1, 2
	Material accuracy	3, 4, 5, 6, 7, 8,
	Update	9, 10, 11
Language	Straightforward	12, 13
	Communicative	14, 15
	Dialogic and interactive	16, 17
	Conformity to the level of development of students	18, 19
	Use of terms, symbols and symbols	20, 21
Serving Eligibility	Presentation technique	22, 23
	Serving support	24, 25, 26
	Presentation of learning	27
Graphics	Use of Fronts (Type & Size)	28, 29
	Layout	30,31
TOTAL		31

The data from instrument validation has received an assessment for E-student worksheet to improve critical thinking. Assessment is carried out to determine suitability, weaknesses and strengths in development (Esteve-Mon & Pérez-Sánchez, 2021). The procedure is declared to be validated if it obtains a percentage interval with a very feasible and appropriate category according to the Linkert scale. In obtaining the value on the Linkert scale, calculations are carried out using the percentage formula (Iskandar, 2019). Percentage The formula is used for validation validation with aspects according to the field that will be assessed by experts, of course this aspect has a correlation with student respondents.

RESULTS AND DISCUSSION

The research results of e-worksheet development based on High Order Thinking Skill (HOTS) on Doppler material using a 4D development model are limited to the 3D development stage. The 3D development stages carried out are: define, design and development. The design stage is the stage of designing the E-Student Worksheet being developed. In the initial stage of creating a material collection, the researcher determined the suitability of the material with the syllabus used at SMA N 3 Pematangsiantar. The material selected and developed in the HOTS-based E-student Worksheet is Doppler effect material. The Doppler effect is physics material in class XI. The research population in development e-student worksheet based HOTS had implemented at SMA Negeri 3 Pematangsiantar of class XI IPA. The research population includes trial large group in class XI IPA 1 with 37 students and trial small group with 6 students. The research population has a total of 43 students.

The Doppler effect material is collected throughout the material content from many appropriate literacies to obtain information as a complement to the development of E-student worksheets. Researchers use a website media called liveworksheet in developing e-student worksheets. This media can access the learning images and videos that have been provided. Researchers chose this media because it is easier for students to learn independently by accessing it for free, can be used anywhere and anytime with the internet, can be used repeatedly, is practical and lasts a long time. The e-worksheet can be accessed by students via the link in liveworksheet. Student have been given the following link https://www.liveworksheets.com/node/2451004; https://www.liveworksheets.com/node/2451019; https://www.liveworksheets.com/node/2451031 to be able to access the e-worksheet based HOTS as in FIGURE 3.

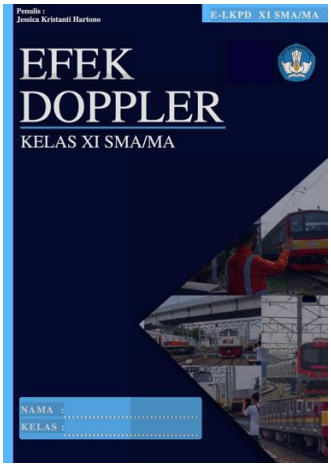
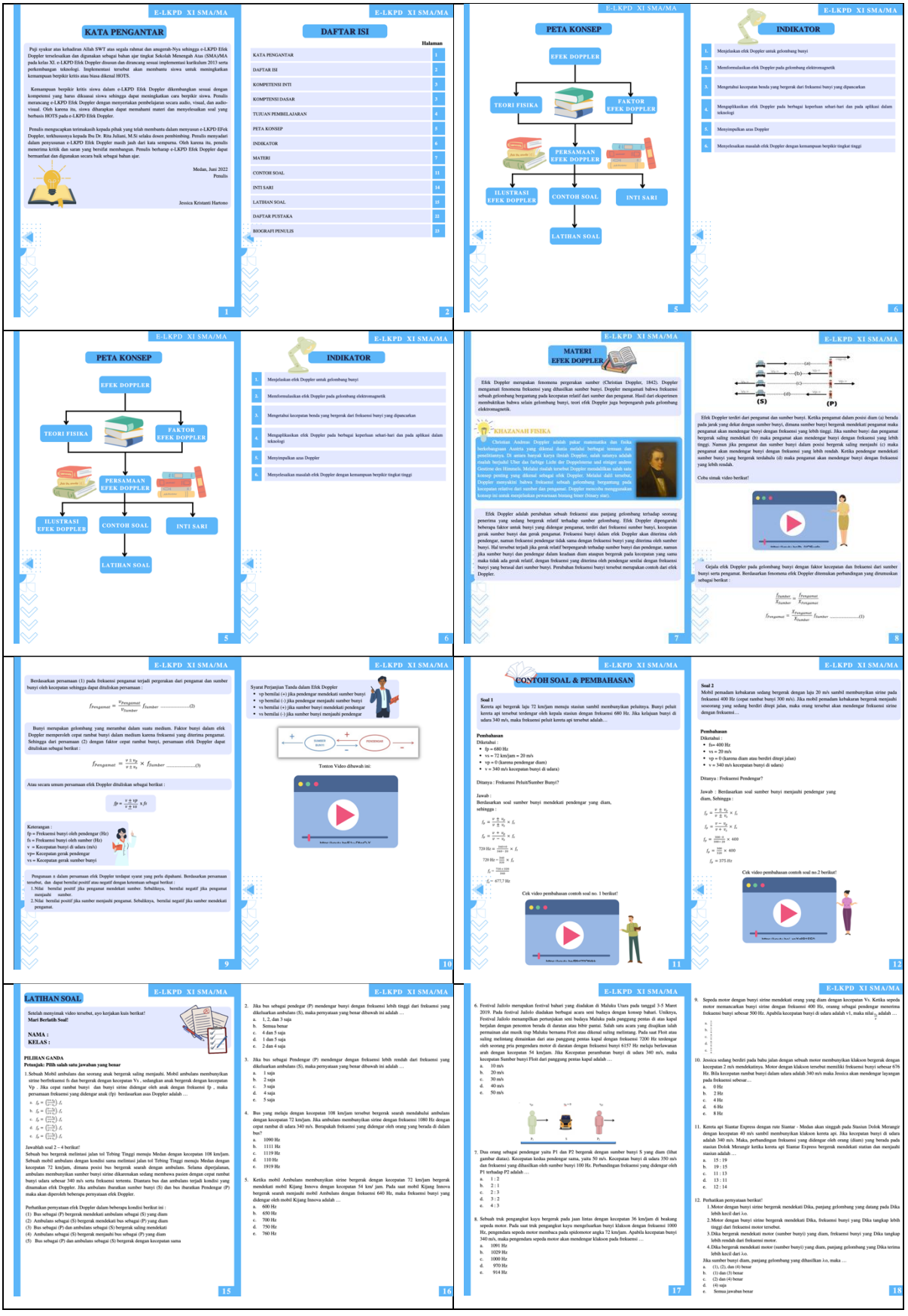


FIGURE 3. Cover E-worksheet

FIGURE 3. The cover in the E-student worksheet was developed using a picture of a station guard who is controlling a train to stop. The activities in the pictures are daily activities that the researcher directly saw and were photographed by the researcher. The cover has a navy and orange background with white writing to make it clearer with the education logo, namely 'Tut Wuri Handayani'. As an E-student worksheet, name and class columns are available for students which can be filled in directly by typing letters and numbers in the student identity box. The e-student worksheet is equipped with material content starting from the introduction, table of contents, core competencies (KI), basic competencies (KD), learning objectives, concept maps, Doppler effect material, sample questions, essence, and practice questions based HOTS for improve critical thinking students.



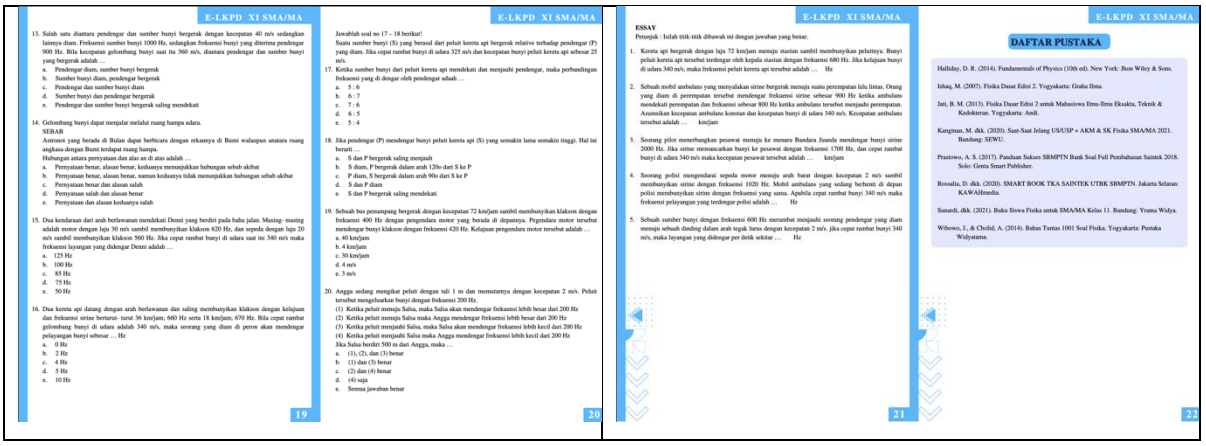


FIGURE 4. The Content of Development E-Worksheet based HOTS

FIGURE 4. The e-student worksheet is equipped with material content starting from the foreword, table of contents, core competencies (KI), basic competencies (KD), learning objectives, concept map, Doppler effect material, example questions, essence, and practice questions (Maharani & Ahmad, 2024). The display of material content is accompanied by colorful pictures, illustrations and learning videos in accordance with the material, especially in everyday life. In practice questions, HOTS questions are used as parameters in measuring students' thinking skills in solving HOTS question levels, so that teachers can see improvements in HOTS question thinking skills in e-workstudeent based on students' achievement scores (Kusno & Setyaningsih, 2021).

FIGURE 5. The Cover Section of Development E-Worksheet based HOTS

FIGURE 5. The E-student worksheet is equipped with a bibliography and author biography as a conclusion to the E-student worksheet. A bibliography is created to provide further information to students and is added with a biography as a form of introduction and brief interaction with students in the E-studeng worksheet. Author biographies can also be used as a source of motivation for students (Arianto & Fauziah, 2020). The development stage produces products that are developed and validated by media experts, material experts and teachers.

Then the product receives responses from students through questionnaires. Based on the validator's criticism and suggestions concluded, the product will be revised according to these conclusions. This revision process will become the final product development stage. The data analysis technique have been collected with the following steps:

1) The data that has been collected will be sumarized in the from of a Likert scale, TABLE 4.

TABLE 4. The Criteria Answer for Instrument's Item Validation with Likert Scale

No	Answer	Score
1	Very Worthy	4
2	Worthy	3
3	Not Feasible	2
4	Very Inappropriate	1

2) Calculate the feasibility level with the following formula:

$$P = \frac{\sum X}{N} \quad (1)$$

Description: P = Category Presentation (average score)
$\sum X$ = Total scores obtained
N = Total score

3) The score classification is the converted into classification for practicality in the form percentages to be interpreted in qualitative, as following:

$$\text{Percentage of eligibility (\%)} = \frac{\text{Aspect score average}}{\text{Total score}} \text{ x } 100\% \quad (2)$$

TABLE 5. The Criteria of Percentage for Questionnaire Instrument

Scale Range	Percentage Interval	Criteria	Qualification
76 ≤ 100	76 ≤ x ≤ 100%	Very Worthy	The product is very valid and can be used in the field for learning activities without revision.
50 ≤ 75	50 ≤ x ≤ 75%	Worthy	The product is valid and can be used in the field for learning activities but needs minor revisions.
26 ≤ 50	26 ≤ x ≤ 50%	Not feasible	The product is invalid and it is necessary to revise the product by re-examining it carefully and looking for product weaknesses to be improved.
0 ≤ 26	0 ≤ x ≤ 26%	Very Inappropriate	The product fails and is invalid so it cannot be used and needs maximum revision.

The results of the validation questionnaire can be seen in FIGURE 6. that the average validation by media experts, material experts, and teachers. Validation is carried out to see exactly what is in development and then obtain the results of the validation developed by the researcher (Tanti et al., 2020). The questionnaire validation of the media expert, material expert, and teacher referred to the scoring description adapted by National Professional Certification Agency (BNSP). The FIGURE 6. shows the average validation by experts. There is average material expert got 92.5% in very worthy

category, media expert got 97.5% in very worthy category, and teacher got 95.2% in very worthy category.

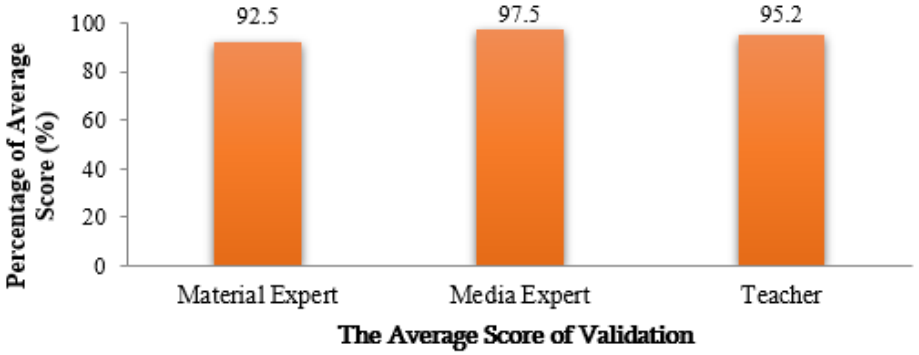


FIGURE 6. The Average Result Score of Validation

The result of the data in Figure 7. material expert average score cover four aspects, namely (1) the Feasibility of content aspect is 93% with a very worthy category; (2) the Language aspect is 95% with a very worthy category; (3) Presentation aspect is 96% with a very worthy category; and (4) Graphical aspect is 81% with a very worthy category. The results of the assessment by material expert obtained an average score of 92.5%. The material expert's average score covers five aspects, namely (1) the feasibility aspect of 93.1% with a very worthy category; (2) The linguistic aspect is 95% with a very worthy category; (3) The presentation aspect is 95.8% in the very category that deserves the highest score. Presentation techniques on the assessment of material expert include learning activities that contain motivation, procedural content and positive things (Susiana & Rendra, 2021: 294). The sequence of concepts has a meaningful and non-repeating flow of inductive or deductive thinking. Supporters are presented including examples and practice questions of HOTS with relevant material as well as examples of various questions that strengthen understanding of the concept of the material. The table of contents in the presentation of development is systematic, neat, updated and not repetitive. The presentation of learning materials is interactive, participatory and active; (4) The graphic aspect is 81.2% in the very category that deserves the lowest score. The graphic aspect of assessing the use of fonts has different sizes in the selection of titles, subtitles and content (Harahap et al., 2017). Consistency in delivering material has a font that is a combination of two types of letters and uses Italic and Bold features. The layout in this development has a proportional form and colors that match the placement of layout elements at the beginning of each activity consistently, follow the pattern. Aspects by material expert can be interpreted that the components in the e-student worksheet are in accordance with the basic orientation of content and development indicators so that students are able to improve understanding through electronics (Pratama & Saregar, 2019: 91).

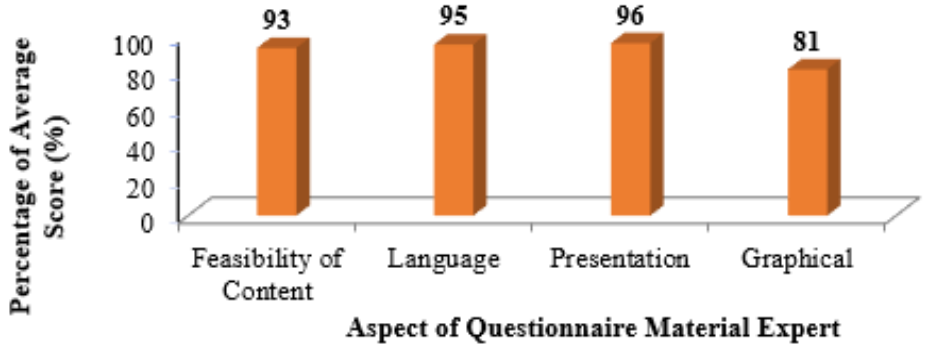


FIGURE 7. The Average Result Score by Material Expert

The result of the data in Figure 8. media expert average score cover four aspects, namely (1) the Language aspect is 100% with a very worthy category; (2) the Software Engineering aspect is 96% with a very worthy category; and (3) Visual display aspect is 97.5% with a very worthy category. The results of the assessment by media expert obtained an average score of 97.5%. The media expert's average score covers three aspects, namely (1) the linguistic aspect of 100% with the category worthy

of the highest score. Media expert assess the development of the language aspect of having the initial words of the language used in writing and conveying correctly according to Indonesian grammar with Subject- Predicate- Object, sentences without subject have doubles and connecting links (Kristianingsih et al., 2016). Media expert considered that the development carried out by the researcher had the correct use of accuracy in accordance with EYD, diction, synonyms and correlations. Researcher is able to adapt to the improvement of students' thinking skills so that students can understand the information in development (Changwong et al, 2018). The language aspect by media expert can be interpreted that clear writing is an important thing that will make it easier for students to understand the part of the material that is being studied by students (Pratama & Saregar, 2019: 91); (2) The aspect of electronic engineering is 96.4% in the very category that deserves the lowest score. Media expert assessments on aspects of software engineering, namely innovation and innovation in development are different from others, flexible, interesting and fun. The buttons on the media work well and are easy to use, including easy access to and from media. Media is also well managed and can be reused in the long term with the failure of technological developments and; (3) The aspect of visual appearance is 97.2% with a very worthy category.

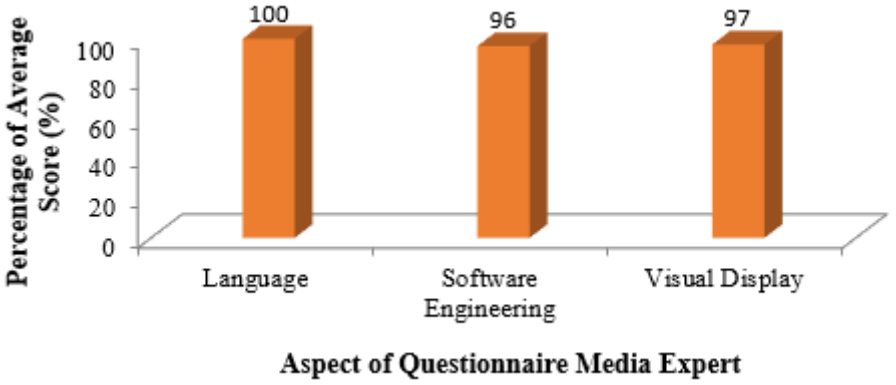


FIGURE 8. The Average Result Score by Media Expert

The result of data in FIGURE 9. teacher get average scores cover six aspects, namely (1) the Feasibility of Content aspect is 95.4% with a very worthy category; (2) the Language aspect is 92.5% with a very worthy category; (3) Presentation aspect is 91.6% with a very worthy category; (4) Graphical aspect 100% with a very worthy category; (5) Software engineering aspect is 93.7% with a very worthy category and (6) Visual display aspect is 100% with a very worthy category. The results of the assessment by the teacher obtained an average score of 95.2%. The average teacher questionnaire score covers six aspects, namely (1) the feasibility aspect of 95.4% with a very worthy category; (2) the linguistic aspect of 92.5% with a very worthy category; (3) The presentation aspect of 91.6% is the lowest value in the very feasible category. The teacher's assessment in the presentation aspect has differences in the bibliography which according to the teacher has a systematic, neat, non-repetitive and the same title; (4) The graphic aspect of 100% is the highest score in the very feasible category. The teacher's assessment of the graphic aspect is on the suitability of the font according to the teacher having different fonts in important sentences and the proportional appearance having the appropriate shape, color and size of the object; (5) The software engineering aspect is 93.7% with a very worthy category and; (6) The visual aspect of 100% is the highest score in the very feasible category. The teacher's assessment of the visual appearance aspect has the ease of operating media that is easily accessible, does not look complicated and is easily accessible at the secondary school level. The development of e-student worksheet is validated in terms of attractive features, icons and designs so that the delivery of learning materials looks more attractive (Inan & Erkus, 2017). Aspects by the teacher's questionnaire can be interpreted that the appearance component of development with graphics looks synchronous so that the delivery of material in improving critical thinking skills is conveyed communicatively and easily accessible to users (Prastika & Masniladevi, 2023). The conclusion of the validation results of media expert, material expert and teacher expert on the development of e-student worksheet based on HOTS with Doppler effect material shows that the development carried out by researcher is very valid. The conclusion is that media expert, material expert and teacher expert based

on proportions meet the quality requirements very feasible as electronic learning, as stated in the study (Pratama & Saregar, 2019).

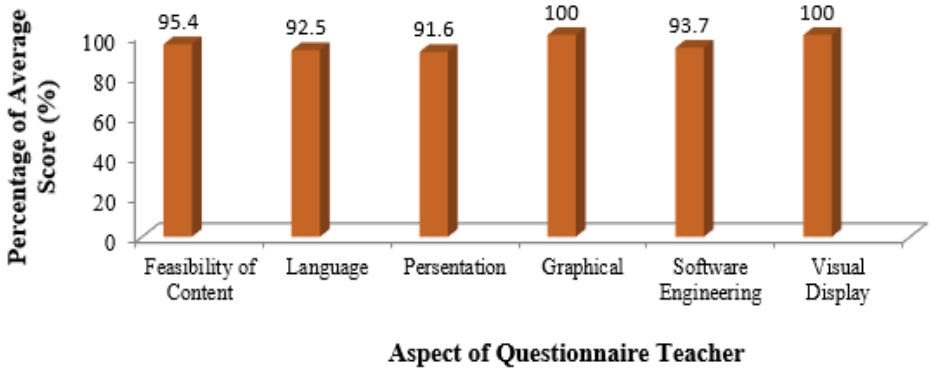


FIGURE 9. The Average Result Score by Teacher

The practicality of the development is determined based on the results of user assessments (Irawan & Hakim, 2021). The practicality of developing e-worksheet based on HOTS with Doppler effect material taken by the development of teacher and student questionnaires. The results of the teacher's questionnaire are shown in FIGURE 5. get an average percentage of 95.2%, a worthy category with six aspects. The practicality based on the percentage of teacher's questionnaire results, the development of e-worksheet based on HOTS with Doppler effect material with a 4D model is included in the very valid and practicality category.

Practicality students as users get the result with large group tests and small group tests. The results of student questionnaires on large and small group tests indicate that development meets the criteria of practicality (Irawan & Hakim, 2021). The practicality questionnaire data are large group test with 37 students is presented with 85.5% in the very feasible category, and small group test with 6 students is given 88.5% in the very feasible category. The percentage can see in FIGURE 7.

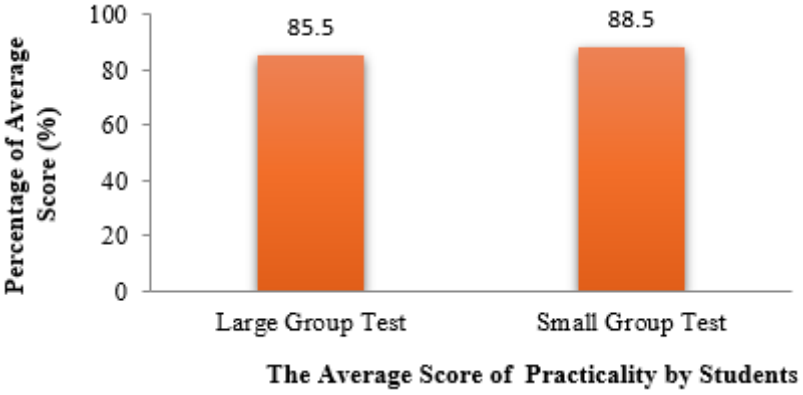


FIGURE 10. The Average Result Score by of Practicality by Students

The results data in FIGURE 10. that the practicality by students is practicality in a large group because got an average score of 85.5% in the benefit aspect with very helpful category. The small group test got an average score of 88.5% in the benefit aspect with very helpful category. The development of e-worksheet as teaching materials get the practicality criteria if 50% of students give a positive response with a minimum option of 70% answer by students (Pramita & Agustini, 2016). The conclusion is that developing e-worksheet based on HOTS with Doppler effect material with 4D model is a very practical category. So that teacher and students have no difficulty using the development of e-worksheet as alternative teaching material to realize higher-quality learning (Syafitri & Annas, 2023). The results of student respondents are divided into two, namely: (1) Large group test in terms of 37 students. The average score obtained is 3.42 if it is presented as 85.5% in the very feasible category.

In addition to the overall average score, practicality can be seen specifically in the benefit aspect of the large group test, which is 3.43 in the very helpful category and; (2) The small group test in terms of 6 students got an average score of 3.54 if the percentage was 88.5% with very worthy category. The practicality of the benefit aspect of the small group test is 3.43 with a very helpful category. The results of student questionnaires on large and small group tests indicate that this development meets the criteria of practicality. This is supported by the research of Irawan & Hakim (2021: 91) which states that teaching materials meet the practicality criteria if 50% of students give a positive response to aspects of the questionnaire with a minimum proportion of 70% which students answer. In addition, this development is categorized as practicality because it obtains the results of an assessment with the "worthy" atau "very worthy"category in appendix 8 (Pramita & Agustini, 2016). The conclusion obtained is that the development carried out by researcher is included in the "very practicality" category in the learning process. Researcher ensure that teachers and students do not have difficulty using e-student worksheet as an alternative teaching material to realize higher quality learning (Misbah et al., 2018).

The HOTS-based e-student worksheet on the Doppler effect material at SMA N 3 Pematangsiantar has received assessments from media experts, material experts, teachers and class XI IPA students' responses received a valid and practical category to use. The data results also show that student responses are at the very good category level. The HOTS-based e-student worksheet on Doppler effect material is expected to support teachers' teaching and learning activities as well as independent learning for students. According to (Laba Laksana et al., 2024) the development of teaching materials is designed to accommodate students' needs in developing problem solving and critical thinking skills. This development can make students become student centered, where the teacher only acts as a facilitator and students become more active in the teaching and learning process, analyzing, evaluating and being creative with everyday life. Students are also expected to be able to solve HOTS questions according to their needs and curiosity so that students can improve their critical thinking skills through material, example questions and practice questions as contained in the curriculum criteria in this development. The HOTS-based e-student worksheet on Doppler effect material is something new for teachers and students, the material displayed is new knowledge for students, and the functional content is easy for students to understand, proven by simple and communicative writing (Rosari, 2023).

After the e-student worksheet received validation scores from the experts, the researcher distributed the e-student worksheet to students and required student respondents. Student respondents aimed at student responses to the product developed by the researcher. Student respondents include 30 indicators with aspects of appearance, material aspects, and skills aspects. Student respondents were divided into 2 parts, namely small group trials and large group trials. The e-student worksheet that has been validated can be tested by researchers through small group trials and large group trials so that researchers know the level of practicality, effectiveness and attractiveness of the products developed by researchers. The development of e-student worksheet based on HOTS with Doppler effect material at SMA N 3 Pematangsiantar has received an assessment from media expert, material expert, teachers and the responses of class XI science students get valid and practicality categories for use. The results of the data also show that the student's response is at the very good category level. The development of e-student worksheet based on HOTS with Doppler effect material are expected to support teacher teaching and learning activities as well as independent learning for students. According to (Tanti, et al., 2020) the development of teaching materials is designed to accommodate the needs of students in developing problem solving and critical thinking skills. This development can make students as student centered, where the teacher is only a facilitator and students become more active in the teaching and learning process, analyze applications, and create with life (Susiana & Rendra, 2021: 296). Students are also expected to be able to solve HOTS questions with the need and curiosity so that students can improve their abilities through critical material, examples to practice questions as they are in the criteria in this development. HOTS-based e-student worksheet on the Doppler effect material are something new for students, the material appearanceed becomes students' new knowledge, as well as functional content that is easily accessible to students as evidenced by simple and communicative writing (Pratama & Saregar, 2019: 95). This conclusion proves that the e-student worksheet based HOTS on the doppler effect material meets the requirements with quality in the very feasible and very practicality category.

The research on development e-student worksheet based HOTS on the doppler effect need to be improved for next research. This research only implemented 3D stages (Define, Design and Develop) due to time and cost constraints. The model 4D used for this reseacher because was still used as a conceptual basis from the beginning but the disseminate stage was not applied. However, there are aspects that are less than optimal and need to be improved to address these shortcomings. First, the Disseminate stage needs to be included in further research so that e-LKPD products can be tested widely, integrated into classroom practices, and their effectiveness in improving students' HOTS evaluated. Second, it is necessary to add practical feasibility tests and user responses (teachers and students) on a larger scale to measure the effectiveness and acceptance of the product. Third, a review of long-term impacts, such as the influence of e-LKPD use on students' learning outcomes and critical thinking, would be very valuable in enriching research contributions.

CONCLUSION

The conclusion from research are :

1. The development of e-worksheet based HOTS on the Doppler effect material with a 4D model has obtained a very decent level validity. This is based on assessments from media experts, material experts and education experts who provide positive evaluations of the quality of the e-worksheet. Apart from that, this e-worksheet has also received a copyright certificate, which shows that the development of this material has met intellectual property protection standards.
2. The level practicality development of e-worksheet based HOTS on the Doppler effect material with a 4D model also shows very decent results, based on assessments form teacher and students' as users. This shows that e-worksheet is easy to apply in the learning process and can be used effectively by teacher and students'.
3. The development of e-worksheet has been proven to be able to helps students at SMA Negeri 3 Pematangsiantar in independent learning, This e-worksheet supports improving students' high order thinking skills (HOTS), which allows them to be more active in the learning process, understand physics concepts in depth, develop analytical and problem solving abilities independently
4. The research of e-worksheet based HOTS on the Doppler effect material only implemented 3D stage because time and cost constraints. Therefore, further research can improve by implementing all 4D stages to make it more effective and sustainable in the long term.

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Attachment

The worksheet can be accessed at the following link:

https://www.liveworksheets.com/node/2451004

https://www.liveworksheets.com/node/2451019

https://www.liveworksheets.com/node/2451031