



Analysis of Validation Results of Electronic Student Worksheet Based on Multi Representation of Linear Motion Kinematics Materials

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Abstract

Multi-representation-based electronic student worksheets are learning media with teaching materials that include verbal components, pictures, graphics, and mathematics. This study aimed to analyze the electronic student worksheet based on multi-representing valid linear motion kinematics material in high school physics class X. The research was conducted using Define-Design-Develop-Disseminate) model. Produce a valid product. There are two main aspects that we will analyze, namely: material and media. The results of the validation of the material aspects with indicators (1) content/breadth of material include material breadth, material depth, material truth, material completeness, material presentation, learning evaluation, and student activities with a percentage of 79% (valid), (2) Presentation of material that are covering techniques for presenting material, systematics, and generating motivation to learn with a percentage of 80% (valid), and (3) Language which includes sentence clarity, conformity with Indonesian language rules, and very valid status sentence structure with a percentage of 80% (valid). Meanwhile, the results of the analysis for the validation of media aspects with indicators (1) Didactic, which includes the learning process and ability development with a percentage of 80% (valid), (2) Construction which includes the accuracy of using language and sentences, paying attention to students' abilities, and has benefits, objectives, and identity with a percentage of 97% (very valid), and (3) Technical, said to be very valid by media experts on all indicators with a percentage between 97% (very valid). Based on the results of the analysis of the electronic student worksheet based on multiple representations, the media developed is valid. This media can analyze problem-solving skills in high school physics learning. This research is expected to reference other researchers in developing physics learning media.

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INTRODUCTION

Industrial revolution 4.0 is driving technological change rapidly. High-speed internet on fiber optics has enabled cloud and server-based storage to be used

extensively (Agrawal et al., 2020). The era of the industrial revolution 4.0, or the era of disruption, has brought major changes to all areas of life, including the world of education (Darma et al., 2020;



Turcu & Turcu, 2018). In this era, the learning process becomes more dynamic, and access to information is not limited by space and time. So that the delivery of information is more practical and digital-based (Wiyono & Zakiyah, 2019).

Education 4.0 is presented as a new paradigm, but the learning model is adjusted and adapted to the learner's profile in real-time. Artificial Intelligence (AI) emerged as the main technology enabler of education 4.0. Three technologies include IoT, Virtual Reality (VR) and Augmented Reality (AR) (Almeida & Simoes, 2019). In the era of the industrial revolution 4.0, teachers are expected to be able to master technology or IoT (Internet of Things) to be presented in the learning process (Prasetyo & Trisyanti, 2019). However, in reality, only a few teachers can use technology in the learning process. However, current conditions require teachers to improve their competence in the field of technology to provide creative and innovative learning (Cholily et al., 2019). On the other hand, students are expected to be able and ready to accept fast-paced changes in the learning process.

The current Covid-19 pandemic condition requires teachers to find the right learning solutions to make it easier for students to understand the subject matter (Camacho-Zuñiga et al., 2021; Ma et al., 2021). Digital technology helps the development of teaching materials that can be used in various conditions during the Covid-19 pandemic (Sriyanti et al., 2021). During this pandemic, learning is done online, so it requires careful thinking, planning, technology development, and human resources to achieve the expected learning objectives. (Klein et al., 2020).

Learning objectives can be achieved by using suitable teaching materials to make students understand the subject matter easier. One of the teaching materials used in learning is student

worksheets (Hartini et al., 2018; Purnamasari et al., 2018; Purnawati et al., 2020). So far, the worksheets used in learning are still in the form of printed materials. The disadvantages of using student worksheets from printed materials are impractical, more complicated to carry anywhere, and more space when carried (Hidayah et al., 2020). Therefore, it is hoped that innovative teaching materials are packaged in the online form or known as Electronic student worksheets (making it easier for students to access learning anywhere and anytime via laptop/computer or smartphone). (Lathifah et al., 2021; Zahroh & Yuliani, 2021).

Learning using electronic student worksheets requires a lot of learning representation. The goal is to make it easier for students to understand the exact subject matter, especially Physics. Representations in physics learning can minimize students' difficulties learning physics (Widianingtiyas et al., 2015). The three main functions of multi-representation are to complete, limit and construct (Hasbullah et al., 2019). The first function uses representations containing complementary information or supporting complementary cognitive processes. Second, representation limits the possibility of interpretation in other uses. Third, multi-representation encourages students to build a deeper understanding of a situation. Multi-representation learning can provide complex new ideas in learning and understanding a learning material, from text narratives, pictures, tables, graphs, and others. Multi-representation learning can build new patterns in understanding a lesson (Aha et al., 2020; Ainsworth, 2006; Mahmudah & Kurniawati, 2021).

The preliminary study results made through a google form are presented in a web address that can be filled out online by students in class XI and XII who have studied physics lessons for class X odd

semesters on linear-motion kinematics material. It is informed that 83% of students find it difficult to learn physics. The difficulty in learning physics is because 64.5% of students find it difficult to learn physics. After all, the material presented is too difficult to understand. After all, it comes from a reference book, and 35.5% of students need understandable references to learn easier and more practical. Implemented.

The difficulties faced by students cannot be separated from the desire of students to have teaching materials that are easy to carry, use and understand (Sriwahyuni et al., 2019). So far, the teaching materials used are only thick reference books and many writings that must be read carefully. This requires teaching materials that make it easier for students to learn. Initially, the conventional Student Worksheet or the printed version of the Student Worksheet made it easier for students because it was more practical in understanding the material. However, conventional Student Worksheets do not provide a solution in current conditions, because they are not easy to carry anywhere (Sari et al., 2021). In this condition, an electronic Student Worksheet is needed that students can use easily. In this study analyses the electronic student worksheets based on multi-representation on valid linear-motion kinematics material in high school physics class X. The benefits obtained from the validation of electronic student worksheets based on multi-representations can be used easily, practically and efficiently by students in high school physics learning, especially linear motion kinematics material. In addition, it can be a reference for other researchers in developing teaching material media.

METHOD

The research method used is research and development (Development and Research). Using a 4D development

model consists of four steps: Define, Design, Development, and Dissemination (Elfina & Sylvia, 2020; Ernawati et al., 2018). Researchers chose the 4-D model as the right development model to develop learning tools in the form of an electronic student worksheet because it has a complete, easy to understand, and systematic explanation.

The 4D model research scheme based on the steps carried out in this study is shown in Figure 1. The definition stage includes analyzing problems in learning physics through literature studies and determining the correct application to be used in the multi-representation-based electronic student worksheet. At this definition stage, the researcher also analyzes the material into multi-representation indicators by systematically presenting learning materials from understanding concepts verbally, clarifying by illustrations and graphs, and solving mathematically. At the design stage, the researcher made a multi-representation-based electronic student worksheet basis using the Canva application. By providing background and colour variations for each different sub-material. Learning materials are presented in simple learning videos using the Wondershare Filmora application at this design stage.

At the development stage, the interactive multi-representation-based electronic student worksheet uses the wizer.me application and is packaged in one product with the publuu flupbook maker. At this stage, the product is validated by material experts and material experts to see the validity of the multi-representation-based electronic student worksheet when students in development trials will use it. After being declared valid, the multi-representation-based electronic student worksheet can be tested for development on students in SMAN 1 Unggulan Muara Enim. The research steps carried out are shown in Figure 1.

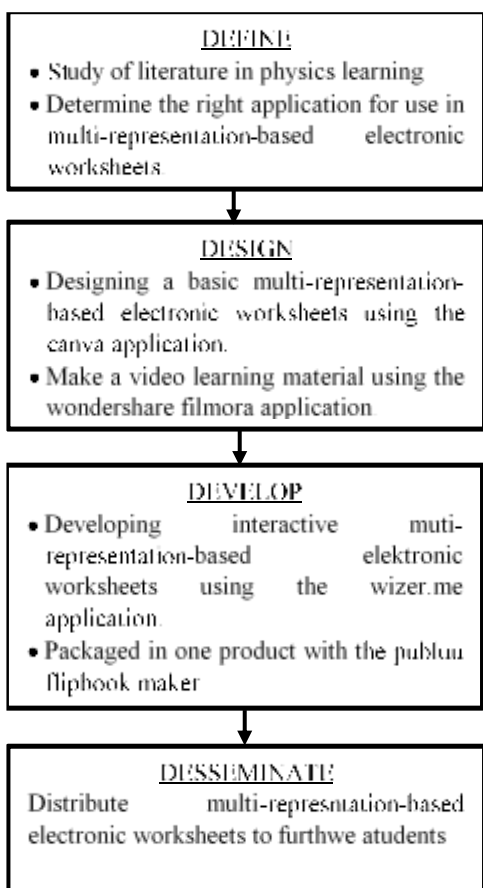


Figure 1 Research steps

After the product development trials were successful and produced useful data using a multi-representation-based electronic student worksheet. Then the next stage is the dissemination of multi-representation-based electronic student worksheets to an advanced level to a wider range of students. Analysis of the validity of the multi-representation-based electronic student worksheet with material and media expert validators. According to (Rusmini, 2020) in (Riduwan, 2013), The validity sheet data analysis technique uses the following formula.

$$P(\%) = \frac{\text{Total score result}}{\text{Criteria value}} \times 100\%$$

The results of the validation sheet assessment are then analyzed using a rating scale (Rusmini, 2020).

Table 1 Criteria for Interpretation of validation results

Percentage of completeness (%)	Criteria	Category
$P \geq 80$	Very valid	No revision
$60 < P \leq 80$	Valid	No revision
$40 < P \leq 60$	Enough Valid	Minor revision
$20 < P \leq 40$	Less Valid	Minor revision
$P \leq 20$	Very Less valid	Major Revision

RESULTS AND DISCUSSION

This research is in the form of development research. The product being developed is a multi-representation-based Electronic student worksheet. By using the 4-D model development flow. The definition stage consists of the analysis stages, namely early-late analysis, student analysis, concept analysis, task analysis, and formulation of learning objectives.

The initial analysis identifies the problems faced when carrying out the learning process during the covid 19 pandemic. This analysis is carried out by observation by filling out an analysis of the needs of students in online physics learning using the google form. On average, in this analysis, students need media for teaching materials practically used in online physics learning. Students' problem-solving ability to solve analytical problems in the online learning process is still lacking.

Student analysis is a study of student characteristics, including abilities, background knowledge and levels of cognitive development. The current student worksheets have not triggered students to hone problem-solving skills (Ernawati et al., 2018; Ramli et al., 2020). At this stage, the concepts of linear motion kinematics that will be taught are identified, detailed and

compiled. Then systematically and linked with other relevant concepts. This analysis will form a concept map of the material for linear motion.

The formulation of the text is done by mapping the materials based on the concept analysis (Herman, 2015; Satriawan & Rosmiati, 2016). The results of this analysis are divided into several sub-materials so that the material displayed on the multi-representation-based electronic student worksheet is organized into several parts. Several questions and practice questions are given to master the multi-representation-based electronic student worksheet in each sub-material. Questions are given to explain concepts to students in learning videos. At the same time, the practice questions are given to see students' problem-solving abilities in solving problems.

The formulation of learning objectives and indicators of competency achievement is made based on the basic competencies listed in the syllabus (Herman, 2015; Syaiful, 2013). The material presented in the multi-representation-based electronic student worksheet is presented following the learning objectives of the electronic student worksheet. The formulation of learning objectives and indicators of competency achievement is based on the basic competencies listed in the syllabus. The material presented on this multi-representation-based electronic student worksheet is presented according to the learning objectives of the electronic student worksheet.

The design phase aims to prepare a comprehensive guide/base for preparing a multi-representation-based electronic student worksheet. The researcher compiles the instrument, media selection, format selection, and initial design. The instrument's preparation is made based on the basic competencies included in the analytical questions. This design contains an initial plan of what will be displayed

in a multi-representation-based electronic student worksheet.

The media selection used in the multi-representation-based electronic student worksheet uses the Canva application. Canva is a graphic design platform used to create social media graphics, presentations, posters, documents and other visual content (Hapsari & Zulherman, 2021). The app also provides a variety of design examples to use. From this Canva App, the basic design of this electronic student worksheet was created. Then the results of this basic design are pdf and uploaded to the publuu-flupbook maker application, an application available on Canva.

The design stage aims to prepare guidelines/foundations for preparing a comprehensive multi-representation-based electronic student worksheet (Mahmudah & Kurniawati, 2021; Sitopu et al., 2019). The researcher compiles the instrument, media selection, format selection, and initial design at this stage. The instrument's preparation is made based on the basic competencies included in the analytical questions. This design contains an initial plan of what will be displayed in a multi-representation-based electronic student worksheet.

The media selection used in the multi-representation-based electronic student worksheet uses the Canva application. Canva is a graphic design platform used to create social media graphics, presentations, posters, documents and other visual content. The app also provides a variety of design examples to use. From this Canva App, the basic design of this electronic student worksheet was created. Then the results of this basic design are pdf and uploaded to the publuu-flupbook maker application, an application available on Canva.

Meanwhile, the media for making learning videos to explain the subject matter uses Wondershare Filmora. Moreover, the previous teaching

materials were made using Microsoft PowerPoint and simple animations to arouse students' motivation to understand the subject matter. The learning video is also equipped with the subject matter with simple animations and sample questions equipped with illustrations and graphics, solved mathematically and concluded verbally. The format used in the multi-representation-based electronic student worksheet refers to the six main elements in preparing the electronic student worksheet, including title, study instructions, basic competencies or subject matter, supporting information, assignments/exercise and competency assessment/test. The multi-representation-based electronic student worksheet format that was developed refers to the multi-representation indicators and indicators of students' problem-solving ability.

Based on the above stages, the student worksheets developed include the title, instructions for using electronic student worksheets based on multi-representation, activities to observe learning videos, activities to answer questions from observing learning videos, and activities to find solutions to essay questions. Activities to answer questions interactively can be opened on the wizer.me application. In the wizer.me application, students can directly write essay answers in sequence with the steps on the indicators of students' problem-solving abilities in physics lessons. This initial design stage is the last in designing and producing an initial product in the form of a prototype I in the form of Multi-representation-based electronic student worksheets on linear motion kinematics material to improve students' problem-solving skills in high school (Rahmawati et al., 2020; Sari et al., 2021). The development stage of the multi-representation-based electronic student worksheet before it was developed using the Canva application. and e: multi-representation-based worksheets after

being developed using the publup flupbook maker application and the wizer.me application.

In this multi-representation-based electronic student worksheet, it consists of three meetings. At the first meeting discussed linear motion with sub-discussions on the definition of position, distance, and displacement, differences in distance and displacement, the definition of speed and velocity, differences in speed and velocity, average speed and instantaneous speed, average speed and instantaneous speed, and the average acceleration and instantaneous acceleration. At the second meeting, the sub-discussion discussed uniformly linear motion, uniformly changing linear motion and the application of uniformly changing linear motion.

The material at the first and second meetings was explained using learning videos using the Wondershare Filmora application to get good results and record quality. The video is displayed only in the form of an explanation voice from the teacher and PowerPoint material made by the teacher. This learning video explains the material and examples of questions following the material being taught and refers to illustrations of questions verbally, graphs and pictures and discusses mathematically using the appropriate formula asked in the question. The steps of the problem-solving indicators order the discussion of the questions. At the third meeting, students were invited to answer the competency test as the final result of learning linear motion kinematics, find out students' understanding of the material, and see students' problem-solving abilities in solving the problems given.

The following is a cover display of the multi-representation-based electronic student worksheet before it is displayed on the development application (Figure 2).



Figure 2 Cover of multi-representation-based electronic student worksheet before being displayed in a development application

Initial screen (Figure 3a) when opening multi-representation-based electronic student worksheet in the publou flupbook maker application. The following is a cover display (Figure 3b) of the multi-representation-based electronic student worksheet after it is entered in the publou flupbook maker application. The cover display (Figure 3c), after being developed in the publou flupbook application, displays the front cover with a background that matches the front cover. In addition to the cover of the multi-representation-based electronic student worksheet, it is also equipped with an inner cover section to emphasize the illustration of the material presented in it. On the side, there is an introduction to explain the benefits and uses of this electronic student worksheet. The next display is a table of contents sheet and basic competency sheets and indicators of competency achievement on the material of linear motion kinematics in multi-representation-based electronic

student worksheets (Figure 3d). The next page displays the learning objectives and a linear motion kinematics material map (Figure 3e).

The next page displays the multi-representation indicator and the troubleshooting indicator sheets (Figure 3f). For problem-solving indicators, display material from linear motion kinematics by grouping sub-materials into four multi-representation indicators studied. The problem-solving indicators are divided into five stages, with indicators for each stage adjusted to the discussion of the questions to be solved.

The next screen displays instructions for using a multi-representation-based electronic student worksheet (Figure 3g). This guide explains how students use the electronic student worksheet, from watching learning videos to solving problem solutions to hone students' problem-solving skills. The next page shows the first encounter for linear motion by watching a video learning about distance and displacement. Below is a display of one of the learning videos at meeting one about distance and displacement (Figure 3h). On the next page (Figure 3i), students are invited to answer the solution to the analysis problem by clicking on the wizer.me application link at the bottom of the question. Here is one display of the wizer.me application that displays interactive student worksheets on the solution of problem-solving ability questions. At the end, a multi-representation-based electronic student worksheet is presented, featuring a glossary and bibliography (Figure 3j).



Figure 3 Display of multi-representation-based electronic student worksheet on the publup flupbook maker application. (a) Beginning, (b) Cover, (c) Inner cover, (d) table of contents, basic competency sheets and indicators of competency achievement, (e) learning objectives and material maps, (f) Multi-representation indicator sheets and problem-solving, (g) Instructions for use, (h) Learning videos, (i), the wizer.me application at the bottom of the questions and (j) Glosarium and bibliography.

The validator then validates this multi-representation-based electronic student worksheet, if it is not valid it will be corrected, and if it is valid it will be tested. Development trials are divided into two, namely limited development trials and advanced development trials. A limited development trial was carried out with 10 student respondents to determine the practical and effective use of a multi-representation-based electronic student worksheet. If any of these respondents is impractical and ineffective in using a multi-representation-based electronic student worksheet, a revision will be made. If it is valid, further development trials will be carried out, with 30 student respondents.

This study provides results from material and media experts for multi-representation-based electronic student worksheets showing that this multi-representation-based electronic student worksheet is valid as a medium for teaching materials for students. The researcher's initial analysis found that students felt less enthusiastic about learning physics and found it difficult to understand physics subject matter. The material presented by the teacher looks monotonous, not directed at problem-solving steps when giving examples of questions, especially in learning from the pandemic era like today. The impact now is that students are only given materials and questions. Following the data analysis obtained, the researcher developed a product in the form of a multi-representation-based electronic student worksheet. This development uses a 4D development model (Define, Design, Development, and Dissemination). Overall this research begins by checking the validity of an electronic student worksheet product based on multi-representation kinematics of linear motion. This multi-representation-based worksheet is said to be valid by material experts with several aspects of the assessment starting from

producing a valid product. There are two main aspects that we will analyze, namely: material and media. With indicators of material aspects, among others: content, presentation and language. While the indicators on the media aspect include: didactic, constructive and technical.

The results of the material expert validation are listed in Table 2.

Table 2 Material expert validation

No	Aspect	P (%)	Criteria
1.	Contents	79	Valid
2.	Presentment	80	Valid
3.	Language	80	Valid

The results of the validation of material aspects (Table 2) with indicators (1) content of material includes material breadth, material depth, material truth, material completeness, material presentation, learning evaluation, and student activities with a percentage of 79% (valid), (2) Presentment of material which includes material presentation techniques, systematics, and motivation to learn with a percentage of 80% (valid), and (3) Language which includes sentence clarity, conformity with Indonesian language rules, and very valid status sentence structure with a percentage of 80% (valid). This finding follows research in which material validation has a percentage above 80% with valid and very valid criteria and categories without revision. (Noprinda & Soleh, 2019; Rusmini, 2020; Sari & Lepiyanto, 2016; Sari et al., 2020).

The results of media expert validation are listed in Table 3.

Table 3 Validation of media experts

No	Aspect	P (%)	Criteria
1.	Didactic	80	Valid
2.	Construction	97	Very valid
3.	Technical	97	Very valid

The results of the analysis for the validation of the media aspect (Table 3) with indicators (1) Didactic, which includes the learning process, and ability development with a percentage of 80% (valid), (2) Construction which includes the accuracy of using language and sentences, paying attention to students' abilities, and has benefits, goals and identity with a percentage of 97% (very valid), and (3) Technical, said to be very valid by media experts on all indicators with a percentage between 97% (very valid). This finding is following research that has been carried out in which media validation has a percentage above 80% with valid and very valid criteria and categories without revision (Diani, 2015; Misbah et al., 2018; Rusmini, 2020)

CONCLUSION

Having successfully analyzed the validation of electronic student worksheet based on multi-representation, it can be concluded that the researcher developed a multi-representation-based electronic student worksheet on linear motion kinematics material made using the Canva application, packaged in publuu flupbook maker, with interactive displays using wizer.me. From the results of the validation of material and media experts, the multi-representation-based electronic student worksheet shows that valid multi-representation-based electronic worksheets can be used practically and efficiently.

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