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E-Worksheet Design of STEM Integrated Sound and Light Wave Materials Stoimprove Student's Knowledge and Data Literature

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ABSTRACT

The industrial revolution 4.0 is a digital revolution marked by a combination of technology. Changes that occur in this era are not just about technology but are closely related to literacy skills. One of the suitable literacy to answer the challenges in this era is new literacy. Electronic student worksheet is designed by integrating science, technology, engineering and mathematics (STEM) in order to increase students' knowledge and literacy. but after doing research, several problems were found in learning, firstly using electronic worksheet has not been carried out and learning is still using printed books, both STEM integration is still relatively low with a value of 28.57, the three materials of sound and light waves have a high level of thinking. high so that students find it difficult to understand the material, and the results of the four students' knowledge tests are still relatively low with a value of 40.25. The purpose of this study was to determine the validity of the STEM integrated electronic worksheet and the practicality of the STEM integrated electronic worksheet. This research includes development research (R&D) that uses a 4-D model to the practical stage. The validation involved three experts from Physics, FMIPA UNP. The results obtained using the Aiken's V formula are that the STEM-integrated electronic worksheet with a value of 0.82 in the valid category, and the practicality value of the STEM-integrated electronic worksheet is 95.55 with a very practical category. So the electronic worksheet for sound waves and light integrated STEM is suitable for use in physics learning.

Keywords: *Electronic worksheet; integrated STEM, sound and light waves.*

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I. INTRODUCTION

Learning is a facilitation process so that someone can learn. Learning is a unified whole[1] . In particular, learning is a learning activity carried out by teachers to form students who are moral, intelligent, develop thinking skills, creative abilities, problem solving skills and good abilities in the implementation of learning. This ability is an indispensable ability in the 21st century. Where the 21st century is colored by the digital era. This is what is meant by the industrial revolution, especially in the information industry.

Human resources today should be produced by education. Human resources must be proficient in technology, have good communication and team work skills, and be able to think creatively and innovatively to solve challenges [2]. The purpose of learning activities carried out by teachers is to build students who are moral, intelligent, who have good problem solving, thinking, and creative abilities. In the twenty-first century, this talent is very important. where the digital era has shaped the 21st century. The industrial revolution, especially in the information business, refers to this.

The rapid growth of the industrial revolution 4.0, sometimes known as the era of globalization or the information age, has created an interdependent society. For every nation, the industrial revolution 4.0 has become a challenge. The ability of a country to adapt to the industrial revolution 4.0 succeeds or fails will cause an imbalance between countries. As a result, including Indonesia, all nations must prepare for the industrial revolution 4.0. This requires us to further improve the quality of a nation by raising the standard of education and improving the quality of its own human resources.

The industrial revolution 4.0 is a digital revolution marked by the convergence of technology that disrupts the boundaries between the biological, digital, and physical worlds. Changes that occur today are not only related to technology but also have a direct impact on literacy skills. New literacy is one of the best forms of literacy to answer today's problems. Data literacy, technological literacy, and human literacy are examples of new literacy.

New literacy is needed because the use of digital technology, which is very important for this transformation, is closely related to new literacy. The industrial revolution 4.0 is a digital revolution marked by the convergence of technology that disrupts the boundaries between the biological, digital, and physical worlds. Changes that occur today are not only related to technology but also have a direct impact on literacy skills. New literacy is one of the best forms of literacy to answer today's problems. Data literacy, technological literacy, and human literacy are examples of new literacy. New literacy is needed because the use of digital technology, which is very important for this transformation, is closely related to new literacy.

The Industrial Revolution 4.0 has raised digital technology to be the center of all human endeavors. One of them is education, especially in the fields of higher education, research, and technology, which is an important component in increasing the country's competitiveness and improving the welfare and justice of the people [3]. In order to prepare for the development of education towards Creative Indonesia in 2045, the Ministry of Education and Culture of the Republic of Indonesia has created a new curriculum [4]. The use of manual and analog technology can be replaced with digital technology thanks to technological advances in the digital era[5]. Improvements in digital technology are also ongoing, as can be seen from the shift in the use of computers for educational purposes to the use of laptops that are increasingly lighter and easier to use.

The use of digital technology is increasingly widespread . Advances in digital and information technology can be utilized to accelerate the growth of education. This requires rapid innovation in the field of education and rising to the top of the development of the education system, particularly in the production of educational media. Teaching materials are one type of learning media. So that students can understand the material that has been delivered by the teacher, teaching materials are used to develop student understanding. worksheet is an example of a teaching resource. worksheet supports teachers in an effort to meet the expectations of the 2013 curriculum [6]. In accordance with the requirements of the 2013 Curriculum and the Revolutionary Era 4.0, worksheet supports teachers in the learning process. Students who use electronic worksheets can benefit from directed learning activities, influencing learning outcomes, and increasing learning independence.

However, after the initial research in the field, it turned out that the real conditions were not in accordance with the ideal conditions. The first real condition was in senior high school in Padang, namely the teacher's questionnaire. The teacher questionnaire at senior high school in Padang was filled out by one physics teacher because only one physics teacher taught in class XI. The aspect assessed is the application of the STEM integrated electronic worksheet in the learning process. Based on the results of the anget that has been done, the teacher has not used the STEM integrated electronic worksheet maximally in learning so that the results of the questionnaire are 25.0 with a low category. The second real condition is STEM integration. The instrument used was a questionnaire, the questionnaire was given to one physics teacher at senior high school in Padang. From the results of the questionnaire that has been given, the teacher is still before fully using STEM in learning so that the results of the questionnaire are 28.57 with a low category. The STEM section that the teacher understands is only the technology section, students are asked to use technology in learning, examples of technology used are the internet, and cellphones. The third real condition is the matter of sound and light waves. According to Nurul, et al, (2016) related to research that has been done shows that students have difficulty in wave material. The difficulties of students mostly lie in understanding the concept because the concept of higher order thinking is needed in the material of sound and light waves. Constraints of students in sound wave material are too many formulas, difficult to understand the concept of sound and light waves, too many questions of calculation. In order for students to be more interesting and understand the concept of sound and light waves, teaching materials are needed. One of the teaching materials is the STEM integrated electronic worksheet. The last real condition is the results of the initial knowledge test and data literacy of class XI students of senior high school in Padang. These results are obtained from the results of the analysis of daily test scores, midterm exams in semester 1 and performance assessments. The test results obtained are that students still have low knowledge and data literacy, because current learning is done online. In the online learning process the teacher does not explain the material, only shares videos from YouTube and gives students assignments, so that students cannot understand the material well. The average results obtained from the daily test scores, mid-semester examinations and performance assessments at senior high school in Padang are 40.25 which are still in the low category.

Starting from ideal conditions and real conditions in the field obtained from real conditions that have been carried out, there are gaps. This indicates a problem in the research. One solution to overcome this problem is to develop an integrated STEM electronic worksheet. This STEM-integrated electronic worksheet is packaged in a practical and attractive way so that it fosters student interest in learning Physics. With the STEM integrated electronic worksheet, it aims to improve student learning outcomes and student literacy and make it easier for teachers to deliver subject matter.

Student worksheets are teaching materials that have been prepared so that students can learn the information themselves [7]. worksheet is a teaching tool that contains a summary of the material, instructions for implementing learning tasks, and basic competency references regarding the learning objectives that have been achieved. To facilitate the implementation of teachers, worksheet functions as teaching materials that can play a

role in educators' efforts to increase student activity, teaching materials that make it easier for students to understand the information provided, teaching materials that are concise and rich in assignments and exercises [8]. The purpose of worksheet is to present teaching materials that facilitate students' interaction with topics, present assignments that improve student mastery, foster student learning independence, and facilitate giving homework to students [9].

STEM is an abbreviation of science (science), technology (technology), engineering (engineering), and mathematics (mathematics) as learning methods [10]. Through problem-solving techniques that involve material found in everyday life, the STEM learning process seeks to increase students' creative capacity. STEM education seeks to increase students' capacity to compete locally, nationally, and internationally in the field of scientific and technological innovation [11]. The implementation of the 2013 curriculum program by the government will help prepare students to face the Revolutionary Era 4.0. The development of these abilities can be supported by integrating the applied curriculum with certain techniques, such as the STEM approach. Teachers are encouraged to have a positive influence on learning activities and outcomes, and the application of STEM features in the national curriculum is maximized.

The ability to use information to acquire knowledge that serves society is known as literacy. The benefit of literacy in everyday life is to help humans solve various challenges. Through the ability to read, one can document a piece of experience that can be used as a reference in the future other than to increase knowledge [12].

Based on the real conditions that exist, the researchers are interested in researching the STEM integrated electronic worksheet. The purpose of this study was to determine the validity of using STEM-integrated sound and light wave material electronic worksheets to improve students' knowledge and data literacy and determine the practicality of using STEM-integrated sound and light waveform electronic worksheets to improve students' knowledge and data literacy.

II. METHOD

This research method belongs to the type of research and development or Research and Development (R&D). Research and development is a research method used to produce a particular product, and test the effectiveness of the product [13]. In the field of education, development research is a research model used to develop or validate products used in education and learning [14]. Where in this study the STEM-integrated electronic worksheet uses a 4-D development model. The 4-D development model is a learning device development model. The 4D development model consists of 4 main stages, namely: Define, Design, Develop, and Disseminate.

The definition stage is the stage to determine and define the conditions needed in the development of learning. This stage includes five main steps, namely initial analysis, student analysis, task analysis, concept analysis, specification of learning objectives. The design stage is this stage is carried out to identify the process needs in learning. After that, the STEM integrated electronic worksheet was designed. This worksheet will be used in the learning process. The development stage is this stage which aims to produce an integrated STEM electronic worksheet that has been revised based on input from experts and trials to students. Although at the design stage a lot has been produced, the result will be seen as an initial version that must be refined before it becomes a suitable final version. This stage consists of three steps, namely validity test, revision and trial. The purpose of this stage is to disseminate the STEM integrated electronic worksheet that has been created. At this stage the electronic worksheet is disseminated to students and students are asked to understand the worksheet.

The electronic worksheet of STEM integrated sound and light waves was developed at the validation test stage carried out by three validators. Then the researcher revised the product according to the validator's suggestions and input. This research instrument uses a validation test sheet. Before being used the validation test sheet has been assessed containing 14 assessment points. To determine the validity of the product, the validation test sheet consists of five indicators of feasibility aspects, the first is the feasibility aspect of the material substance, the second is the feasibility of the visual communication display, the third is the feasibility of the learning design, the fourth is the feasibility of using software, and the fifth is the feasibility aspect of the STEM assessment.

The research instrument uses a Likert scale from a score of 1-4. Validation data will be processed using the Aiken's V formula as follows:

$$V = \frac{\sum s}{n(c-1)}, \text{dengan } S = r - I_o \qquad (1)$$

Where:

V = content validity index
s = sum of r - I_o
r = score given by validator
I_o= lowest scoring score
n = number of validators
c = number of score range options[15]

Based on the results of the assessment, the validation value will be determined based on the assessment criteria for the validation results. The assessment of the results of the electronic worksheet validation of sound and light wave materials integrated with the STEM concept is determined based on the interpretation of Aiken's V validation as shown in Table 1.

Table 1. Interpretation of *Aiken's V* Validation

Koefisien Korelasi	Interpretasi Validitas
V>0,8	Very Valid
0,4 < V ≤ 0,8	Valid
V ≤ 0,4	Invalid

(Source: Ref [16])

At the practical stage, it was carried out at senior high school in Padang to students in class XI MIPA 5. The results of the practicality test of students were analyzed based on the practicality test sheet instrument for the STEM integrated electronic worksheet that was made. This practicality test instrument consists of four indicators, namely useful, easy to use, attractive and clear. The research instrument uses a Likert scale from a score of 1-4. Practicality data will be processed using the percentage formula as follows:

$$Value = \frac{Score\ obtained}{maximum\ score} \times 100 \qquad (2)$$

The practicality assessment is determined based on the score interpretation criteria obtained as shown in Table 2.

Tabel 2. Product Praticality Criteria

Persentase (%)	Interpretation Praticality
0-20	Very Weak
21-40	Weak
41-60	Enough
61-81	Strong
81-100	Very Strong

(Source: Ref [17])

III. RESULTS AND DISCUSSION

1. Electronic worksheet Validity Test Results

Validity data is obtained from the value given by the validator by giving a questionnaire to the validator and later the value obtained will be analyzed. In the validity questionnaire there are 5 assessments, namely material substance (A), visual communication display (B), learning design (C), software usage (D) and STEM assessment (E).

In the assessment of the substance of the material there are several indicators of assessment. The assessment indicators are the truth indicator (A1), the material coverage indicator (A2), the current indicator (A3), the readability indicator (A4). In the assessment indicators, there are several assessment points. This indicator can be seen in Figure 1.

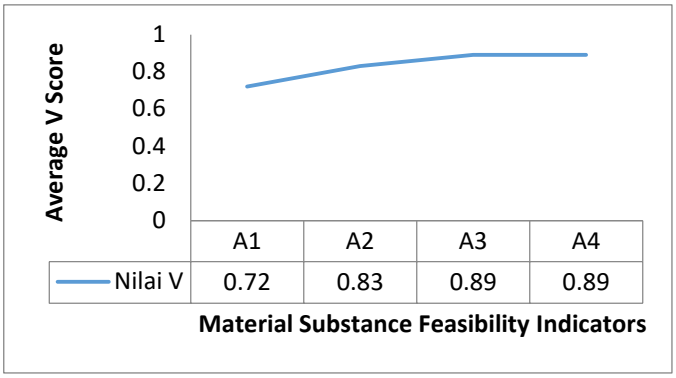
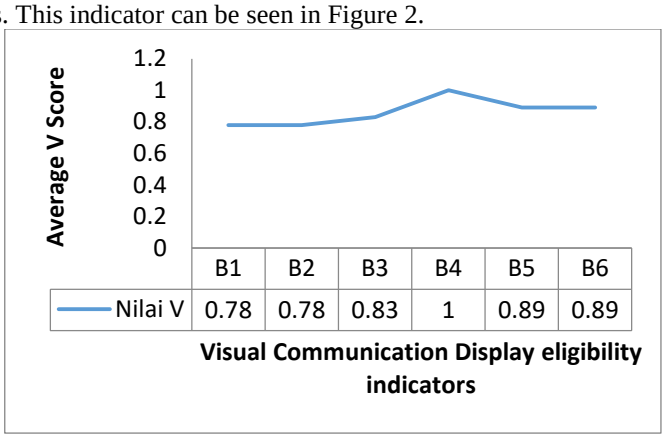


Figure 1. Material Substance

Based on Figure 3, it can be seen that the average value obtained by the truth indicator is 0.72 with a valid category. The average value obtained by the material coverage indicator is 0.83 with a very valid category. The average value obtained by the current indicator is 0.89 with a very valid category. The average value obtained by the limitation indicator is readability with a very valid category.

In assessing the appearance of visual communication, there are several assessment indicators. The assessment indicators are navigation indicators (B1), letter indicators (B2), media indicators (B3), color indicators (B4), animation indicators (B5), and layout indicators (B6). In the assessment indicators, there are several assessment points. This indicator can be seen in Figure 2.



Gambar 2. Visual Communication Display

Based on Figure 2, it can be seen that the average value obtained by the navigation indicator is 0.78 with a valid category. The average value obtained by the letter indicator is 0.78 with a valid category. The average value obtained by the media indicator is 0.83 with a very valid category. The average value obtained by the color indicator is 1 with a very valid category. The average value obtained by the animation indicator is 0.89 with a very valid category. The average value obtained by the layout indicator is 0.89 with a very valid category.

In the assessment of the learning design display, there are several assessment indicators. The assessment indicators are title indicators (C1), basic competence indicators (C2), activity objectives indicators (C3), material indicators (C4), training indicators (C5), work step indicators (C6), compiling indicators (C7), and indicators reference (C8). In the assessment indicators, there are several assessment points. This indicator can be seen in Figure 3.

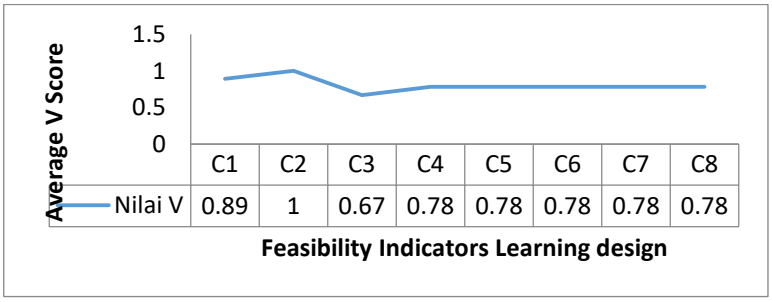


Figure 3. Learning Design

Based on Figure 3, it can be seen that the average value obtained by the title indicator is 0.89 with a very valid category. The average value obtained by the KD indicator is 1 with a very valid category. The average value obtained by the activity objective indicator is 0.67 with a valid category. The average value obtained by

the material indicator is in the valid category. The average value obtained by the exercise indicator is 0.78 with a valid category. The average value obtained by the work step indicator is 0.78 with a valid category. The average value obtained by the constituent indicators is 0.78 with a valid category. The average value obtained by the reference indicator is in the valid category.

In the assessment of software usage there are several assessment indicators. The assessment indicators are interactivity indicators (D1), supporting software indicators (D2), and originality indicators (D3). In the assessment indicators, there are several assessment points. This indicator can be seen in Figure 4.

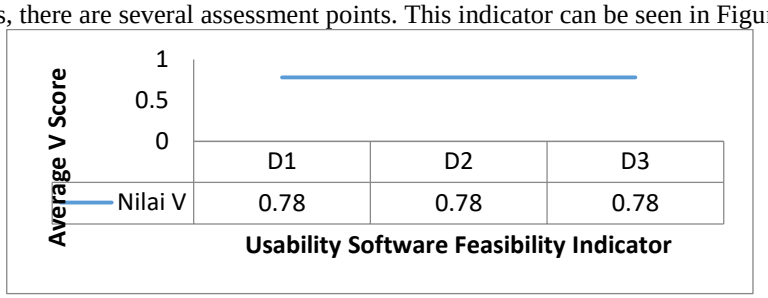


Figure 4. Software Usage

Based on Figure 4, it can be seen that the average value obtained by the interactivity indicator is 0.78 with a valid category. The average value obtained by the supporting software indicator is 0.78 with a valid category. The average value obtained by the originality indicator is 0.78 with a valid category.

Dalam penilaian integrasi STEM ada beberapa indikator penilaian. Indikator penilaiannya yaitu science indicators (E1), technology indicators (E2), engineering indicators (E3), and mathematics indicators (E4). In the assessment indicators, there are several assessment points. This indicator can be seen in Figure 5.

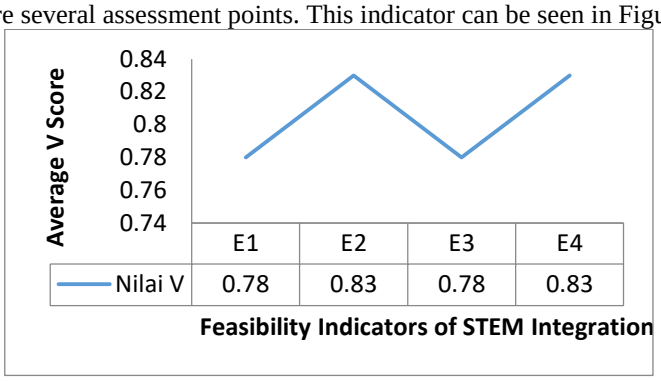


Figure 5. Integration of STEM in worksheet

Based on Figure 5, it can be seen that the average value obtained by the science indicator is 0.78 with a valid category. The average value obtained by the technology indicator is 0.83 with a very valid category. The average value obtained by the engineering indicator is 0.78 with a valid category. The average value obtained by the mathematical indicator (mathematics) is 0.83 with a very valid category.

In the validation questionnaire there are several assessments. The assessments are material substance (A), visual communication display (B), learning design (C), software usage (D), and STEM integration in WORKSHEET (E). In the questionnaire there is an assessment which can be seen in Figure 6.

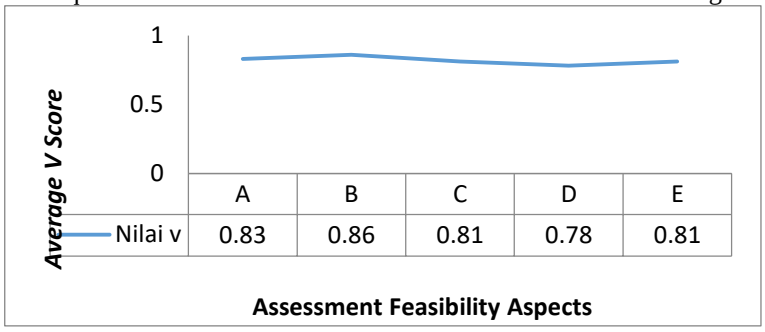


Figure 6. Aspects of feasibility assessment of practicality

Based on Figure 6, it can be seen that the average value obtained by the assessment of material substance is 0.83 with a very valid category. The average value obtained by the visual appearance assessment is 0.86 with a very valid category. The average value obtained by the learning design assessment is 0.81 with a very valid category. The average value obtained by the software assessment is 0.78 with a valid category. The average value obtained by the STEM integration assessment in the worksheet is 0.81 with a very valid category.

the results of the validation research are relevant to the research of Tiurma Banjarani, et al (2020) which says that the validation that has been carried out on worksheet is in the valid category.

2. Electronic worksheet Practical Test Results

Practical data obtained from the results of the questionnaire distributed to students and students were asked to fill out the questionnaire. The instrument used is a practicality questionnaire. In the questionnaire there are 4 indicators, namely useful (a), easy to use (b), attractive (c) and clear (d). In each indicator there are still several assessment points that must be filled in by students. students who filled out the questionnaire were class XI Mipa 4 senior high school in Padang with 36 students.

In the useful indicators there are 6 assessment points which are useful for increasing independence (a1), time efficiency in learning (a2), accelerating mastery of material (a3), virtual laboratories increasing understanding of the material (a4), improving reading, collecting, analyzing, and collect data (a5), and use the internet and technology wisely (a6). Can be seen in Figure 7.

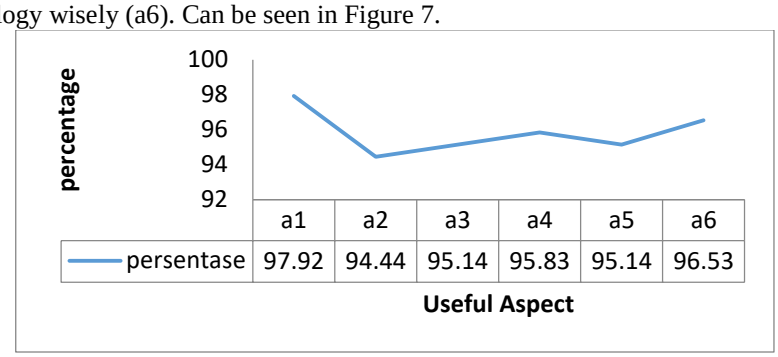


Figure 7. Useful Aspects

Based on Figure 7, it can be seen that the percentage value obtained from the assessment is useful for increasing independence, namely 97.92 with a very strong category. The percentage value obtained from time efficiency in learning is 94.44 with a very strong category. The percentage value obtained from accelerating mastery of the material is 95.14 with a very strong category. The percentage value obtained from the virtual laboratory increases understanding of the material, which is 95.83 with a very strong category. The percentage value obtained from improving the ability to read, collect, analyze, and collect data is 95.14 with a very strong category. The percentage value obtained from using the internet and technology wisely is 96.53 with a very strong category.

In the easy-to-use indicator, there are 6 assessment points, namely making it easier to understand the material (b1), can be used repeatedly (b2), easy to access without using additional applications (b3), worksheets can be used anytime (b4), the language used is easy to understand (b5), and experimental activities are easy to carry out (b6). Can be seen in Figure 8..

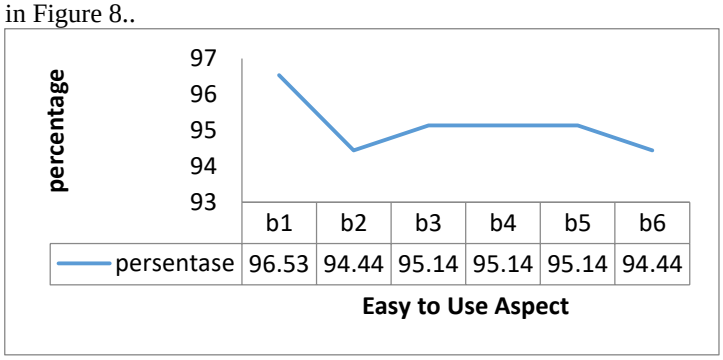


Figure 8. Easy-to-Use Aspect

Based on Figure 8, it can be seen that the highest percentage value is in providing real examples in everyday life and the lowest is on color combinations in the worksheet..

In the attractiveness indicator, there are 7 assessment points, namely the initial appearance of the worksheet is attractive (c1), the worksheet template uses a color combination (c2), the color combination of each part of the electronic worksheet is good (c3), the use of letters in the worksheet is good (c4), the image is good (c4). presented interestingly (c5), electronic worksheets make learning more interesting (c6) and provide real examples in
everyday life (c7). Can be seen in Figure 9.

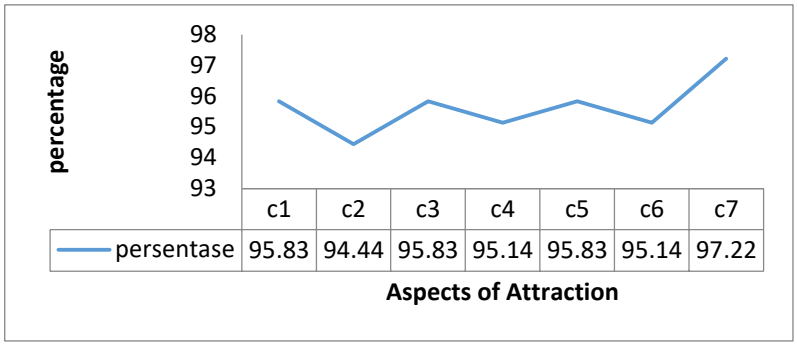


Figure 9. Aspects of Attractiveness

Based on Figure 9, the highest percentage is providing real examples in everyday life and the lowest is for color combinations in the worksheet.

In the clear indicators there are 7 assessment points, namely the electronic worksheet presents the material clearly (d1), the electronic worksheet clearly presents the indicators (d2), the objectives to be achieved in the electronic worksheet are clear (d3), the type and size of the font is clearly legible (d4), the STEM information presented is clear (d5), the material presented is clear (d6). Can be seen in Figure 10.

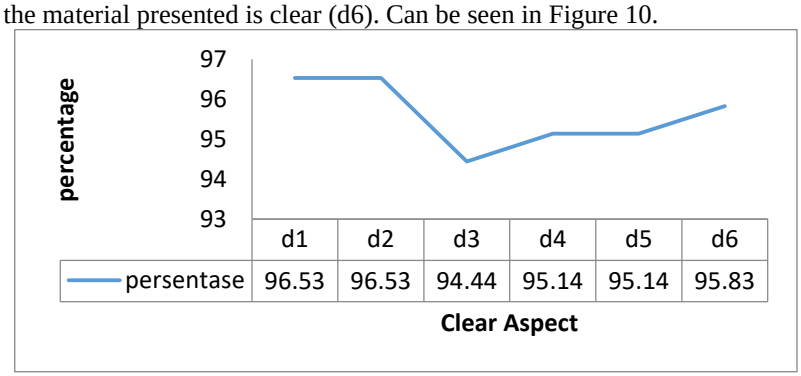


Figure 10. Clear Aspect

Based on Figure 10, the highest percentage is giving the material clearly and presenting indicators clearly. The lowest percentage of goals to be achieved in the electronic worksheet is clear

In the practicality questionnaire there are several assessments. The ratings are useful (a), easy to use (b), attractive (c), and clear (d). Can be seen in Figure 11.

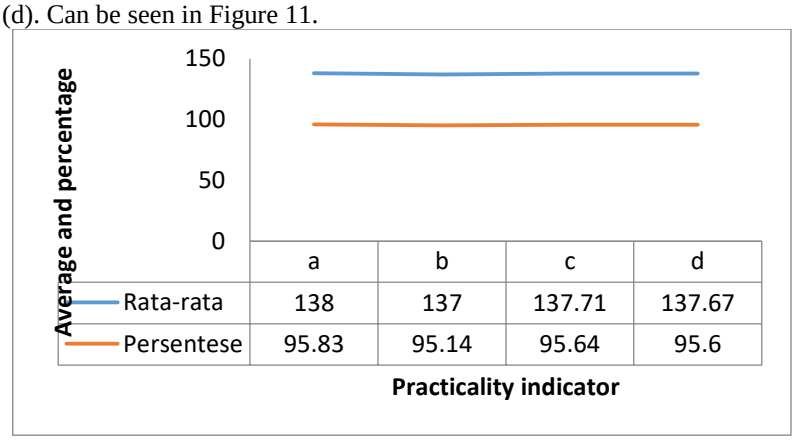


Figure 11. Practicality Indicators

Based on Figure 11, it can be seen that the useful indicator average value obtained from the useful indicator is 138 with a percentage of 95.83 with a very strong category. In the easy-to-use indicator, the average value obtained from the easy-to-use indicator is 137 with a percentage of 95.14 with a very strong category. In the attractiveness indicator, the average value obtained from the attractiveness indicator is 137.71 with a percentage of 95.64 with a very strong category. On the clear indicator the average value obtained from the clear indicator is 137.67 with a percentage of 95.6 with a very strong category.

Based on the results of product validation conducted by three experts, it contains five indicator assessments. The first indicator is the substance of the material. the validation of the substance of the material obtained valid validation results with indicators of truth assessment, material coverage, current, legibility. These results indicate that the substance contained in the STEM integrated electronic worksheet has met the standard. In accordance with previous research which states that the substance of the material must be designed in

accordance with the standards of learning objectives that are applied [18]. The second indicator is the visual communication display. The results obtained from the communication display are valid. In accordance with previous research which states that the visual communication display is the process of delivering information or messages to other parties using media, and the visual communication display is in the valid category [19]. The third indicator is learning design. The results obtained from the learning design are valid. In accordance with previous research that learning designs must be designed as attractive as possible, so that students are more interested in learning [20]. The fourth indicator is the usage software. The results obtained from the software usage are valid. The fifth indicator is the integration of STEM in worksheet. The results obtained from the STEM integration are valid with indicators for the assessment of science, technology, engineering, mathematics. STEM can improve students' thinking skills so that students can compete in an increasingly developing era .

Based on the results of practice. The practicality test was conducted for class XI students. The results of the practicality test of students were analyzed based on the practicality test sheet instrument for the STEM integrated electronic worksheet that was made. This practicality test instrument consists of four indicators, namely useful, easy to use, attractive and clear. The practical results of the STEM integrated electronic worksheet are in the very strong category. Practicality according refers to the extent to which the attractiveness and ease of use of teaching materials under normal conditions during the learning process takes place. Likewise with research , if the value of practicality is interpreted through tables and graphs, then the practicality of teaching materials assessed by students is in the very practical category. from previous research, it was found that the practicality value of worksheet was in the very practical category[21] . The teaching materials developed have practical value. So, STEM integrated electronic worksheets on sound and light waves can be used by physics teachers in class XI as one of the teaching materials to improve students' knowledge and data literacy on sound and light waves in the physics learning process at school.

IV. CONCLUSION

Based on the results of research conducted on the five aspects of evaluating the validity of the developed electronic worksheet, the average value of Aiken's V validity test of the electronic worksheet for sound and light wave materials integrated with the STEM concept is 0.68 with the validation interpretation being in the valid category. This means that the electronic worksheet material for sound and light waves is integrated with STEM to improve students' knowledge and data literacy, which is suitable for use in class XI physics learning. The results of the practicality of the STEM integrated electronic worksheet on the material of sound and light waves have very strong practicality. The practical characteristics of this product are practical in terms of being useful, easy to use, attractive and clear.

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