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How to Stimulate Students' Science Process Skill and Scientific Creativity in Physics Learning?

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Abstract

Research has been carried out to stimulate students' Science Process Skill (SPS) and Science Creativity (SC) in Physics learning on Polarization of Light through the development of problembased e-worksheet assisted with Fliphtml5. This research was a development research with the type of Design and Development Reaserch (DDR). The data from this research were in the form of validation results, assessment of students' science process skills and scientific creativity, as well as practicality test results were analyzed used mixed methods. The results of data validation show that the developed e- worksheet obtained a score of 95.5% with very high validity criteria. Assessment of students' science process skills and scientific creativity obtained a score of 87% in the highly stimulated criteria. Other results show that the practicality of the product is 89% in the very high category, the student response is 83% in the very good criteria, and the teacher's perception is 92% in the very possible criteria. Based on the results of data analysis, it can be concluded that the students' science process skills and scientific creativity in Physics learning on Polarization of Light can be stimulated through problembased e-worksheet assisted with Fliphtml5.

Keywords: *Science Process Skill, Science Creativity, e-worksheet Based on Problem, Fliphtml5*

INTRODUCTION

The development of knowledge and academics in students is a challenge in learning in the 21st century today. The government expects students to achieve various competencies by applying high-level thinking skills, which are skills in learning in the 21st century in the evaluation system in the national exam (Ariyana et al., 2018). The application of 21st-century skills requires the development of academic knowledge and understanding in students, making the world of education faced with increasingly difficult challenges (Partnership for 21st Century learning, 2015). The challenge is the achievement

of students in various CCR (Center for Curriculum Redesign) skills including creativity, critical thinking, communication, collaboration, life and career skills, as well as information, media, and technology skills (information, media, and technology skills) (Asrizal et al., 2018; Kan'an, 2018; Menggo et al., 2019). One of these skills that is currently a trending issue in the world of education is creativity. This is because creativity is considered capable of encouraging students to produce, develop, and implement ideas creatively, both independently and in groups (Bialik & Fadel, 2015).

Creativity is one of the skills that scientists must have to be able to carry out every stage of scientific research. In its implementation, using and producing scientific information at each stage contains Science Process Skills (SPS) (Shah et al., 2015). So it is clear that there is a very close relationship between scientific creativity and SPS. Scientific creativity can be improved by practicing SPS through formulating problems, making hypotheses, determining variables, fair testing, collecting data, presenting data, and explaining results. This can be applied to students by presenting problem-based learning (Akben, 2020).

Students have a very important role in the implementation of problem-based learning, especially in physics learning which is considered difficult for students (Akben, 2020). This is because through problem-based learning students are presented with real-world problem situations. In its application, problem-based learning will be effective if equipped with written instructional materials using Student Worksheets (Lee, 2014). Worksheet is one of the teaching materials created by teachers to guide students to learn and explore the concepts of a material so that students are actively involved in the learning process in the classroom (Ardina & Sa'dijah, 2016). Worksheet can be presented in printed or electronic/e-worksheet form (Haqsari, 2014). The selection of the type of worksheet as a teaching material to be used must be adjusted to the characteristics and needs of students. The behavior of students as the current generation, who are accustomed to digital platforms, will be more effective and efficient in improving students' knowledge, attitude, and skill competencies if the worksheet used by teachers is in electronic form or hereinafter referred to as e-worksheet (Hikmawati et al., 2018). Through e-worksheet which contains images and videos, not just text, it can motivate, attract, and provide fast and easy access to various new materials. Students can control their own learning and maintain their interest (Haryanto et al., 2020).

Based on preliminary research through observation, semi-structured interviews, and questionnaire distribution in several high schools in Lampung, it is known that one of the Physics materials, namely the material on light polarization, is generally only delivered conventionally. Students are asked to study further independently due to limited time allocation. Learning on this material has also not implemented a practical method, either independently or in groups, so that

students are not presented with real-world problem situations, or analyze phenomena that exist in everyday life according to the characteristics of problem-based learning. worksheet and e-worksheet for this material are also not yet available, so students have not been directed to carry out scientific activities. This shows that students' science process skills and scientific creativity have not been stimulated.

The results of literature studies related to research that has been conducted over the past 8 years on science process skills, student creativity include research by (Haryanto et al., 2020) who developed e-worksheet for science process skills using Kvisoft Flipbook, (Rizaldi, 2017) who developed a high school physics learning tool based on an inquiry model to stimulate science process skills, and (Uswatun Chasanah et al., 2016) who studied the effectiveness of the PjBL Model on students' science process skills and creative thinking abilities. However, no one has stimulated students' science process skills and creativity through the use of e-worksheet. Based on the gap between the urgency and problems in the field related to students' science process skills and Science Creativity on the light polarization material that has been described, it is important to develop a problem-based e-worksheet assisted by Fliphtml5 which is able to stimulate science process skills and science creativity.

RESEARCH METHOD

This study uses Design and Development Research (DDR) adapted from (Richey et al., 2007) with the stages of analysis, design, development, and evaluation as shown in the research flowchart in Figure 1. Analysis is a stage to collect needs assessment or analyze needs by identifying problems and expectations or conditions that should be, to then provide solutions to the gaps between the two, related to learning light polarization. The analysis stage is also carried out by collecting information through literature studies by reading books, journals, or the internet regarding light polarization material, worksheet, science process skills, and science creativity.

The design stage is carried out by researchers by designing products that are developed based on the results of the needs analysis that have been obtained. The product design process includes activities to collect references for making e-worksheet, making storyboards, and continuing with making instruments in the form of validation questionnaires, readability tests, student responses, and teacher perceptions. The evaluation stage consists of formative evaluation and summative evaluation. Formative evaluation is carried out during validation and practicality testing, while summative evaluation is carried out after small group testing.

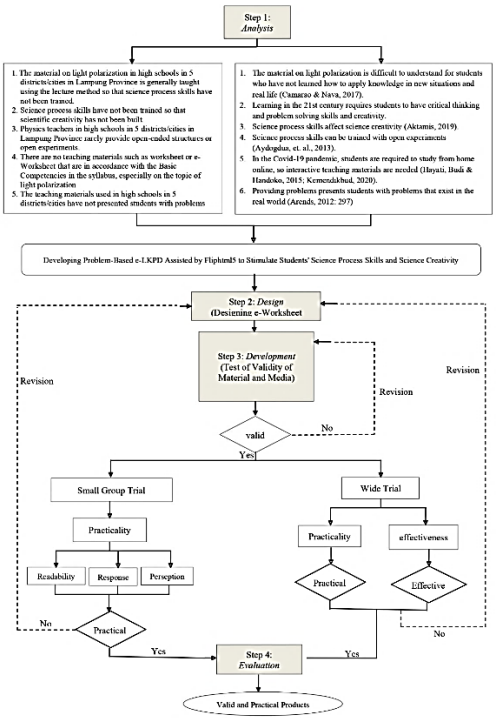

Figure 1: Research Flow Diagram

The instruments used in this development research include interview guidelines to collect need assessments, questionnaires for needs analysis, validation, readability tests, student responses, and teacher perceptions, as well as assessment sheets for science process skills and science creativity. Scoring on the validation questionnaire, readability test, student responses, and teacher perceptions uses a Likert scale adapted from (Ratumanan & Laurens, 2011) which can be seen in Table 1, while the SPS and science creativity assessment sheets use the SPS rubric adapted from (Nur, 2011).

Table 1 Likert Scale on Validation Questionnaire, Readability Test, Student Responses, and Teacher Perceptions

Options	Score
Very Good	4
Good	3
Not Good Enough	2
Not Good	1

This study uses a mixed method (Wisdom & Creswell, 2013), namely quantitative and qualitative with data analysis techniques using percentage analysis (Sudjana, 2005).

$$\% X = \frac{\sum \text{Score obtained}}{\sum \text{Maximum score}} \text{ x } 100\%$$

The percentage results obtained are converted with criteria adapted from (Arikunto, 2011) as seen in Tables 2, 3, 4, 5 and 6.

Table 2 Conversion of Product Validity Assessment Scores

Percentage	**Criteria**
0,00%-20%	Validity Very Low/Poor
20,1%-40%	Validity Low/Poor
40,1%-60%	Validity Medium/Quite Good
60,1%-80%	Validity High/Good
80,1%-100%	Very high/Very good validity

Based on Table 2, the researcher limits the product developed to be categorized as valid if it reaches the score determined by the researcher, which is at least 60% with moderate validity criteria.

Table 3 Conversion of SPS Assessment Scores and Science Creativity

Percentage	**Criteria**
0,00%-20%	Not stimulated
20,1%-40%	Less stimulated
40,1%-60%	Quite stimulated
60,1%-80%	Stimulated
80,1%-100%	Highly stimulated

Based on Table 3, the researcher provides a limitation that the developed product can stimulate SPS and scientific creativity if it reaches the score determined by the researcher,

which is a minimum of 60% with the criteria of being sufficiently stimulated.

Table 4 Conversion of Product Readability Assessment Scores

Percentage	Criteria
0,00%-20%	Not Good
20,1%-40%	Not Good Enough
40,1%-60%	Quite Good
60,1%-80%	Good
80,1%-100%	Very Good

Based on Table 4, the researcher limits that the product developed has good readability if it reaches the score determined by the researcher, which is at least 60% with fairly good criteria.

Table 5. Conversion of Response Assessment Scores for Products

Percentage	Criteria
0,00%-20%	Not Good
20,1%-40%	Not Good Enough
40,1%-60%	Quite Good
60,1%-80%	Good
80,1%-100%	Very Good

Based on Table 5, the researcher limits that the developed product is categorized as good for use in learning light polarization both online and face-to-face if it reaches the score determined by the researcher, which is at least 60% with fairly good criteria.

Table 6 Conversion of Perception Assessment Scores for Products

Percentage	Criteria
0,00%-20%	Unlikely
20,1%-40%	Less Likely
40,1%-60%	Quite Likely
60,1%-80%	Possible
80,1%-100%	Very Likely

Based on Table 6, the researcher provides a limitation that the product developed is categorized as good for use in online and face-to-face learning if it reaches the score determined by the researcher, namely a minimum of 60% with the criteria of being quite possible.

RESEARCH FINDINGS AND DISCUSSION

The results of this development research include products, validation results, assessment results of science process skills and science creativity, practicality test results, student response results, and teacher perception results.

Product (Finding 1)

The products produced from this development research are in the form of electronic Student Worksheets (e-worksheet) based on problems assisted by Fliphtml5 as in Figure 2. This product was developed to stimulate students' science process skills and science creativity in Physics learning for grade XI high school students in the even semester on the Polarization of Light material.

Figure 2: Display of e-worksheet Based on Problems Assisted by Fliphtml5

Validity (Finding 2)

The product validation results were obtained from the material expert test and the media and design expert test by 3 experts. The validation test was carried out using a validation questionnaire, then analyzed using Microsoft Excel and the data obtained in Tables 7 and 8.

Table 7 Material Expert Test Results

Number	Aspects Assessed Examiner	Score	Qualitative Statement
1	Conformity of material content	95%	Very high validity

Number	Aspects Assessed Examiner	Score	Qualitative Statement
2	Construction	95%	Validity is very high
Average		**95%**	**Validity is very high**

The results of the material expert test consist of aspects of material suitability and construction which obtained an average score of 95% or qualitatively stated as very high validity which indicates that the quality of the developed e-worksheet material is very good.

Table 8 Results of the Media and Design Expert Test

Number	Aspects Assessed Examiner	Score	Qualitative Statement
1	Cover section	95%	Very high validity
2	Content section	97%	Validity is very high
Average		**95%**	**Validity is very high**

The results of the media and design expert test consist of aspects of the cover and content sections which received an average score of 96% or qualitatively stated as very high validity. This shows that the quality of e-worksheet as a teaching material is very good.

Practicality (Finding 3)

The results of the assessment of SPS and scientific creativity show that the developed product can stimulate SPS and scientific creativity of students or not. This assessment was carried out during the small group test by asking students to do activities on e-worksheet and answer the questions with the results in Table 9.

Table 9 Results of SPS and Science Creativity Assessment

Indicators of SPS and SC	Average Percentage	Qualitative Statement
Formulating the problem	96%	Very stimulated
Making a hypothesis	100%	Very stimulated
Determining variables	92%	Very stimulated
Fair testing	83%	Stimulated
Collecting data	78%	Stimulated
Presenting data	67%	Very stimulated
Explaining results	92%	Very stimulated
Overall Average	**87%**	**Very stimulated**

Table 9 shows that the average percentage of the overall e-worksheet assessment results is 87% which is categorized as very stimulated. This shows that the developed e-worksheet can stimulate SPS and students' scientific creativity very well.

The results of the readability test were obtained from filling out the readability questionnaire by students who had worked on the e-worksheet, then the results were obtained in Table 10.

Table 10 Practicality Test Results

Statement-	Average	Score of Qualitative Statements
1	92%	Very Good
2	88%	Very Good
3	79%	Good
4	88%	Very Good
5	92%	Very Good
6	92%	Very Good
7	92%	Very Good
8	88%	Very Good
9	79%	Good

Statement-	Average	Score of Qualitative Statements
10	96%	Very Good
11	92%	Very Good
Final Average	**89%**	**Very Good**

Table 10 shows the average readability test value of 89% or qualitatively stated as very good. This shows that the readability of the developed e-worksheet is very good.

The results of student responses were obtained from the response questionnaire used to determine whether the developed product can be used in light polarization learning and can stimulate students' science process skills and scientific creativity or not. The results of student responses are shown in Table 11.

Table 11 Student Response Results

Statement-	Average	Score of Qualitative Statements
1	88%	Very good
2	88%	Very good
3	96%	Very good
4	83%	Very Good
5	79%	Good
6	79%	Good
7	75%	Good
8	79%	Good
9	96%	Very good
10	83%	Very good
11	88%	Very good
12	88%	Very Good
13	83%	Very Good
14	79%	Good
15	79%	Good
16	79%	Good
17	79%	Good
18	75%	Good
19	88%	Very good
Final Average	**83%**	**Very good**

The results of student responses were, on average, 83% with very good criteria, so this product can be used very well in light polarization learning to stimulate students' science process skills and science creativity.

The results of teacher perceptions were obtained by distributing questionnaires to 5 high school teachers in Lampung to assess the e-worksheet that was developed. The results of teacher perceptions are shown in Table 12.

Table 12 Teacher Perception Results

e-Worksheet Steps	Average Score	Qualitative Statement
Making Predictions and Finding Problems	91%	Very likely
Formulating Problems and Making Hypotheses	93%	Very likely
Determining Variables and Conducting Fair Investigations	87%	Very likely
Collecting and Presenting Data	98%	Very likely
Explaining Results	92%	Very likely
Final Average	**92%**	**Very likely**

The results of teacher perceptions show an average of 92% with a very possible category, so it can be interpreted that this product can be used in online and face-to-face learning.

Discussion

This research and development is a Design and Development Research (DDR) adapted from (Richey et al., 2007) with stages including analysis, design, development, and evaluation. This study presents a solution to stimulate students' science process skills and scientific creativity in learning Physics on Light Polarization

material through e-worksheet based on problems assisted by Fliphtml5. The analysis stage is carried out by identifying problems, expectations, and solutions. Problem identification is carried out through observation, semi-structured interviews, and distributing questionnaires to high school Physics teachers in 5 districts/cities in Lampung Province.

The results of the analysis show that science process skills and scientific creativity on light polarization material have not been trained. So far, teachers have only taught this material using the lecture method. This is supported by the results of the student questionnaire analysis which shows that 55% of students stated that light polarization material was delivered using the lecture method and only 22.2% used worksheet.

The worksheet used also does not contain science activities. Students hope that learning on this material can be packaged interactively and fun. This is the basis for the importance of stimulating students' science process skills and science creativity through e-worksheet based on problems assisted by Fliphtml5. Based on this problem identification, it is known that light polarization learning is generally only delivered through lectures. There are also those who do not deliver it due to time constraints, so students are asked to study it independently at home by searching for information via the internet or other references.

Science process skills and science creativity in general are also not trained. This is because there is no availability of interactive teaching materials such as worksheet or e e-worksheet light polarization that contain science activities that can train these skills. In addition, it can be seen that the government's expectations for the demands of the 21st century on the criteria of critical thinking and problem solving with science process skills and on the criteria of creativity are not met. In fact, if viewed from the benefits of e-worksheet, it is able to optimize interactive teaching and learning activities equipped with videos and images that can strengthen students' understanding in studying the material (Hayati et al., 2015). Especially if it contains science activities that are able to train indicators of science process skills and science creativity that play an important role in science education.

The existence of a gap between problems and expectations is used by the author as a basis for providing solutions to stimulate students' science process skills and science creativity, namely through the use of e-worksheet based on problems assisted by Fliphtml5.

The analysis stage was also carried out by the author in collecting information carried out through literature studies by reading books, journals, and the internet. The information collected is related to light polarization material, worksheet, problem-based learning, science process skills, and science creativity. The components that must be owned by e-worksheet are based on the information that has been collected, namely the e-worksheet developed is on light polarization material, problem-based that presents students with real-

world problems to be solved with activities that are able to stimulate students' science process skills and science creativity, and assisted by a platform using Fliphtml which can be accessed for free.

The design stage begins with collecting references for making e-worksheet. Next, a design (storyboard) is made by referring to the references collected. Finally, at this stage, the instrument is made, which includes a material validation questionnaire and media validation, a readability questionnaire, a student response questionnaire, and a teacher perception questionnaire. The third stage, namely development, is carried out to develop the product according to the design that has been made. E-worksheet is developed using Microsoft Word, then converted to PDF, then converted again using Fliphtml5, so that it becomes e-worksheet. Figure 7 shows the appearance of e-worksheet assisted by the Fliphtml Platform.

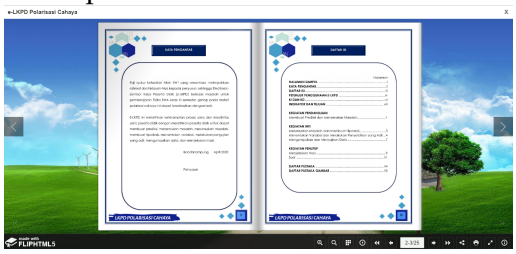

Figure 3: Display of e-worksheet Light Polarization

The table of contents of the e-worksheet shown in Figure 3 shows that this e-worksheet contains a cover page, foreword, instructions for use, core competencies, basic competencies, indicators, objectives, learning activities (introductory, core, and closing activities), bibliography, and image bibliography. The introductory activities train students in making predictions and finding problems based on images of light polarization experiments.

The score of activities train students in formulating problems, making hypotheses, determining variables, conducting investigations, collecting data, and presenting data based on videos of light polarization experiments. The closing activities train students in analyzing observation results and making conclusions based on tables of observation results and data analysis. The closing activities also contain practice questions.

This e-worksheet is called multimedia because it consists of words, images, animations, videos, and audio, so it can be used for online learning. This is in accordance with the opinion of (Mayer, 1999) and (Collins, 2002) who stated that multimedia is a message delivered through words, images, animations, and depicts a combination of video and audio, and can form distance learning materials. This e-worksheet is also assisted by Fliphtml5 so that it is included in effective e-learning to improve student creativity compared to traditional lecture methods. This finding shows that e-learning is able to encourage students to try independently in finding answers without relying on their teachers (Zare et al., 2016).

The products that have been made are then validated, assessed for SPS and scientific creativity, readability tests, student response tests, and teacher perception tests. Validation is carried out by three validators to determine the feasibility of the product. Validation consists of media and design expert tests and material expert tests.

Media and design expert tests consist of aspects of the cover and content sections. Material tests consist of aspects of the suitability of the material content and aspects of the construct. The validator also provides suggestions for improvement as shown in Table 13.

Table 13 Suggestions for Improvement from Validators

Validator-	Recommended Improvement	Corrective Action
1	Writing the image source for each image in the e-worksheet	Adding image sources to images on the cover page
1	Adding a bibliography of images	Adding a bibliography of images after the bibliography
2	Using command sentences that are directed directly to students at each step of the e-worksheet so that it is clear that the e-worksheet used is for students, not educators.	Replacing sentences in each step in e-worksheet into command sentences that are directed directly to students

Figure 4 below is a display of e-worksheet before and after being corrected based on suggestions from the validator.

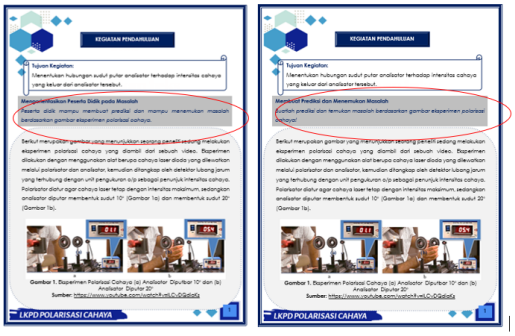

Figure 4: E-worksheet Display Before and After Improvement

Table 7 and Table 8 show the results of the material validation and the validity of the media and design which, when averaged, obtained a final score of 95.5%, so that the resulting product is categorized as very valid. This makes the product ready to be tested in small groups to stimulate students' science process skills and science creativity.

Assessment of science process skills and science creativity is carried out on students who have studied the material on light polarization. Students are given a problem-based e-worksheet access link assisted by Fliphtml5 via Whatsapp, and are asked to work on it within 3 teaching hours or equivalent to 120 minutes. Students are asked to work on it independently and ensure that when working on the e-worksheet they must be connected to the internet. Shortly after students work on and submit the e-worksheet answers, the answers can be viewed and analyzed by the researcher directly because the students' answers are directly connected to the Google form from the researcher's Google account. One example of the display of student answers can be seen in Figure 5. The achievement of the SPS indicator and scientific creativity was analyzed based on indicators from (Aktamis & Ergin, 2008) with an average overall score of 87% categorized as very stimulated. This indicates that the problem-based e-worksheet assisted by Fliphtml5 that was developed can be used by teachers or educators to stimulate SPS and scientific creativity of students in online

and face-to-face learning for light polarization material. This is in line with the opinion of (Sujatmika et al., 2019) who stated that problem-based learning carried out online can effectively increase creativity and critical thinking skills through science process skills in students.

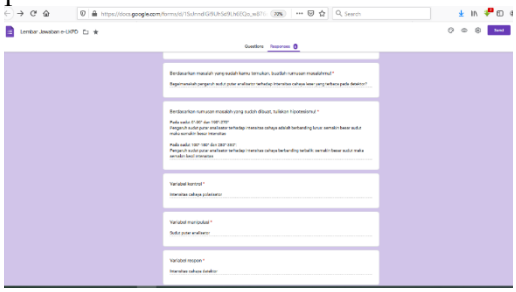

Figure 5: Student Answer Display

The readability test was conducted on 6 students who had completed the e-worksheet. The readability test was conducted using a questionnaire in the form of a google form. The results of the readability test showed an average score of 89%, which means that the problem-based e-worksheet assisted by Fliphtml5 that was developed is very good for use as a teaching material on the material of light polarization. This is supported by the opinion of (Hayati et al., 2015) who stated that e-worksheet is a teaching material that can optimize teaching and learning activities to be more interactive by not only presenting material, but also equipped with videos and images that can strengthen students' understanding in learning the material (Hayati et al., 2015). E-worksheet can lead students to learn and explore the concepts of a material. This is one way to make students actively involved in the learning process and is useful in many ways for academic achievement, for example as a supplement to textbooks, adding information for certain classes, and as an invitation for students to fill in the gaps as an opportunity to build knowledge (Ardina & Sa'dijah, 2016). The use of e-worksheet can save space and time, save costs, allow users to mark important things without fear of making them ugly because of scribbles, and is environmentally friendly because it does not use paper, ink, and so on (Haqsari, 2014).

The student response test was seen from the response questionnaire filled out by students who had worked on e-worksheet via google form and obtained an average percentage result of 83% with a very good category which means that this e-worksheet can be used by students very well. The results of these student responses show that e-worksheet based on problems assisted by Fliphtml5 helps students understand the material on light polarization because it is easy to access, interesting, and comfortable to use in online learning. This e-worksheet also improves students' science process skills and creativity after using it. In accordance with (Collins, 2002), e-worksheet which is classified as multimedia allows teachers to manage learning in new and innovative ways in order to motivate, attract, and provide quick and easy access to various new materials. Multimedia can also encourage students to control their own learning and maintain their interest.

Teacher perceptions are seen from the perception questionnaire filled out by 5 high school Physics teachers in Lampung. The results of filling out this questionnaire showed a final average of 92% which is categorized as very possible. This shows that every step in the activities in e-worksheet is very possible to be

applied to online and face-to-face learning, because this e-worksheet contains animations and narrations that can be used in a computer-based environment as well as text and illustrations in a book-based environment (Mayer, 1999) and describes a combination of video and audio, printed text and can be used as a reference book that can form distance learning materials or face-to-face (Collins, 2002).

The evaluation stage consists of formative evaluation and summative evaluation conducted to improve the e-worksheet prototype. Formative evaluation is conducted during validation, namely by improving the e-worksheet based on suggestions and input from the validator. One of the evaluations conducted at this stage is as shown in Figure 4. Summative evaluation is conducted after a small group test. The response of students who have worked on the e-worksheet shows that the problem-based e-worksheet assisted by Fliphtml5 helps students understand the material on light polarization because it is easily accessible, interesting, and comfortable to use in online learning. This e-worksheet also improves students' science process skills and creativity after using it. This is in line with the opinion of (Sulaiman, 2011) who stated that problem-based learning conducted online effectively increases creativity and critical thinking skills through science process skills in students. So that summative evaluation is no longer carried out because the results obtained are already very good.

This research certainly has advantages and disadvantages. The advantages of this research include (1) Producing e-worksheet assisted by the Fliphtml5 Platform that can be easily accessed on the web using an internet network without having to download the application and can be used in online learning or face-to-face. (2) Teachers can choose several backgrounds and e-worksheet templates on the Fliphtml5 Platform that are interesting for students. (3) The developed e-worksheet is able to stimulate SPS and students' scientific creativity in terms of achieving indicators for formulating problems, making hypotheses, determining variables, fair testing, collecting data, presenting data, and explaining results. The weakness of this research is that the page editor for adding images, videos, and links to e-worksheet assisted by the Fliphtml5 Platform can only be used for a fee, so that free users can only convert e-worksheet that already contains images and video links from PDF using Fliphtml5 without being able to edit inside.

CONCLUSION

Based on the results of the analysis of research data that has been conducted, it can be concluded that students' science process skills and scientific creativity can be stimulated through the use of valid and practical problem-based e-worksheet assisted by Fliphtml5. This e-worksheet contains science activities that train indicators of science process skills starting from formulating problems, making hypotheses, determining variables,

conducting investigations, collecting data, analyzing data, and presenting data.

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