BIO-INOVED
Jurnal Biologi-Inovasi Pendidikan
Volume 5, Issue 3, October 2023 page. 297-306

P-ISSN : 2684-9062 | E-ISSN : 2714-9803
https://ppjp.ulm.ac.id/journal/index.php/bino
DOI: 10.20527/bino.v5i3.16718

Biology learning innovation in the water pollution sub material based on sustainable development goals (SDGs) using the problem-based learning

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Article Information

Keyword:
Sustainable development goals (SDGs); Problem based learning; 360 video; Water purification; Learning outcomes

Kata Kunci:
Sustainable development goals (SDGS); Problem based learning; Video 360; Penjernihan air; Hasil belajar

History:
Received : 03/07/2023
Accepted : 04/10/2023

Abstract

Sustainable Development Goals (SDGs) are a global issue initiated by the United Nations. One goal of SDGs is "clean water and sanitation" regarding water pollution issues. This research aims to develop learning media on the material "Water pollution" in the form of 360° Videos and water purification tools to introduce Sustainable Development Goals (SDGs), determine the effectiveness of learning innovations in improving learning outcomes, and also determine the feasibility of 360° Video learning media and water purification tools. This research is developing learning media with 4D models (Define, Design, Development, and Disseminate). The media developed are 360° Video and water purification devices. The value of 360° video validation is 93.3%, and the water purification device is 91.25% with the very valid category. The learning media developed was able to improve learning outcomes with an N-Gain value of 0.508 in the medium category. The value of effectiveness is 80.66% with the effective category. 360° Videos and water purification tools improved student learning outcomes, SDGS understanding of the clean water and sanitation goals, and student enthusiasm.

Abstrak

Sustainable Development Goals (*SDGs*) merupakan isu global yang diinisiasi oleh PBB. Salah satu tujuan SDGs yaitu *Clean water and Sanitation,* berdasarkan masalah pencemaran air. Tujuan penelitian ini yaitu untuk mengembangkan media pembelajaran pada materi "pencemaran air" dalam bentuk Video 360° dan alat penjernihan air untuk memperkenalkan *Sustainable Development Goals (SDGs)*, dan menentukan efektivitas inovasi pembelajaran dan kelayakan Video 360° dan alat penjernihan air. Penelitian ini merupakan pengembangan media pembelajaran dengan model 4D (*Define, Design, Development,* dan *Disseminate).* Media yang dikembangkan yaitu Video 360° dan alat penjernihan air. Hasil validasi video 360 yaitu 93,3% dan alat penjernihan air yaitu 91,25% dengan kategori sangat valid. Media pembelajaran yang dikembangkan mampu meningkatkan hasil belajar dengan nilai N-Gain sebesar 0,508 pada kategori sedang. Pada aspek efektivitas, mendpatkan nilai 80,66% dengan kategori efektif. Video 360° dan alat penjernihan air mampu meningkatkan hasil belajar siswa, pemahaman SDGs *Clean water and Sanitation* dan antusiasme siswa.

A. Introduction

One of the Sustainable Development Goals (SDGs) goals is Clean Water and Sanitation. According to Sutopo et al. (2014), this point aims to provide universal access to safe drinking water and adjust the quantity of clean water taken (freshwater withdrawal). Environmental problems, especially water pollution, are an urgent matter to be solved, considering that water is a vital human need. As the human population grows, the potential for water pollution will also increase, and the need for clean water will increase. Sanitary water problems also occur in Salatiga City. In Saputra's research (2019), the demand for clean water in Salatiga City has increased while the availability of clean water has decreased, resulting in a pure water deficit.

This problem can be used as open material for participants taught real problems to find concepts and solutions by thinking analytically and generally. This point can be correlated with environmental pollution, especially in the context of water pollution. This aims to be an effort to answer the SDG challenges on Clean Water and Sanitation, considering that the role of education is vital in answering the SDG targets. Therefore, there is a need for a plan to provide knowledge for students in understanding SDGs and their application, which is correlated with learning material, especially Biology learning.

In Biology, the Ecosystem learning material with the environmental pollution sub-material, especially water issues, positively correlates with the SDGS goals on the Clean Water and Sanitation point. This aligns with Oktaria (2016), the environmental pollution sub-material is included in the ecosystem material students study. SDG goals can be included in water pollution material; students will be taught to understand the SDGs goals, especially in clean water quality. From these achievements, students can analyse the environmental pollution around them.

The Problem-based Learning is one type of active learning methodology. According to Hosnan (2014), Problem-based Learning gives students an authentic situation from which they can construct their knowledge, acquire skills, and boost their self-esteem. Students are invited to find solutions to the problem of coping with water pollution as part of the SDGs challenge on Clean Water and Sanitation's point. Students will study actively and freely, and they will be able to develop their knowledge based on challenges that arise, allowing them to investigate and construct concepts into new information. Problem-based Learning, according to Tapilouw (2016), can be a suitable choice for explaining environmental ideas. Learning tools are needed to raise water issues to answer the SDGs' challenges.

Research related to the development of learning media in the form of 360° videos was previously carried out by Haryono & Wijaya (2020); there was a significant influence on student learning outcomes from using 360° videos. The research results showed that the class using 360 video learning media had higher post-test scores than the control class. Apart from that, learning media in the form of an air purifier has also been carried out (Nafira, 2023), and the air filter media received an ideal response from students with a score of 95%.

Based on this, it is necessary to develop learning media in the form of 360 videos and air purification devices that are integrated with the SDGs for clean water and sanitation. Finally, this research aims to provide learning media on "Water Pollution" through 360° videos and air purification equipment to explain the Sustainable Development Goals (SDGs). Apart from that, to find out the effectiveness and practicality of learning media on "Water Pollution" in 360° videos and air purifying devices.

B. Material and Method

The research carried out was Research & Development Research (Sugiyono, 2015). This type of research is Research & Development (R&D) using the 4D model (Define, Design, Development and Disseminate) developed by Thiagarajan et al. (1974). This study aims to create media goods and learning materials about environmental pollution for Biology High School students. The goods made include 360° video learning media and water purification technologies. Lesson Plans, Student Worksheets, and practical instructions are among the learning materials produced. The study was conducted during the Semester II of the 2022/2023 academic year, from January to April 2023, at Ampel 1 Public High School, with 70 students from class X SMA N 1 Ampel.

Data collection techniques used are interviews, questionnaires, observations, and tests. The data collection instruments used were (1) Expert validation questionnaire sheets (material and media), (2) SDGs understanding questionnaires, (3) student responses, (4) teacher responses, (5) psychomotor skills observation instruments (6) learning instruments class and (7) the instrument of cognitive test questions. The data analysis technique used was initial data analysis at the define stage, product validation analysis, and teacher and student response questionnaires. Then,

the calculation of learning outcomes is using N-Gain.

The analysis was done through a questionnaire supplied to the validator and students, with a tick in the category provided using a Likert scale. The Likert scale consists of five rating scales. This score is very good, good, enough, less, and very less (Riduwan & Akdon, 2013). Product validation analysis and effectiveness is done using Formula 1 by Putra (2018).

$$P = \frac{f}{N} \times 100\% \text{.....Formula 1}$$

Description:
P = Percentage
f = Score obtained
N = Maximum score

After being analyzed, the validation results are categorized into the following criteria. This criterion is very valid, valid, moderately valid, and very invalid (Riduwan & Akdon, 2013).

Effectiveness results are categorized into ineffective, ineffective, enough effective, effective, and very effective (Sugiyono, 2015). Effectiveness is calculated using Formula 1.

Analysis of the implementation of problem-based learning syntax using Formula 2.

$$P = (\sum x/n) \times 100) \text{ .....Formula 2}$$

Description:
P = Perscentage
∑x = Total Score of implementation
n = Number of lesson plan implementation

The results are categorized into criteria: very less, less, enough, good, and very good (Pranatawijaya & Psikila, 2019). The analysis of learning outcomes was calculated using Formula 3 by Hake (1998). Then, the N-gain results are categorized into criteria: high ($g > 0.7$), moderate ($0,3 < g \leq 0,7$) and low ($g \leq 0,3$).

$$\mathbf{N-Gain} = \frac{\mathbf{(post\ test\ score)-(pre\ test\ score)}}{\mathbf{Ideal\ score-(pre\ test\ score)}} \text{....Formula 3}$$

C. Results and Discussion

The first stage is to define. During the define stage, an interview was done with the Biology teacher at SMA N 1 Ampel. The define stage was conducted by interviews with biology teachers at SMA N 1 Ampel regarding the biology learning process "water pollution". The define stage is also carried out by analysing students' needs regarding suitable learning media to accommodate learning. Curriculum analysis and learning objectives were also carried out at the define stage. Based on the results of interviews with the biology teacher at SMA N 1 Ampel, it was discovered that the use of electronic media was still limited and that learning the sub-material of water pollution has never touched on the global issue of SDGs on the point of clean water and sanitation.

At SMA N 1 Ampel, the usage of 360° videos in Biology learning has never been done. Furthermore, water quality testing practices have not been implemented for long. This is due to the teacher's limits in mastering electronic technologies, namely video learning. According to Sahaletua et al. (2018), teachers' limited age makes it harder to operate and access rising media, information, and technology. Many teachers have not utilized learning films, particularly 360° videos, as learning media.

The SDGs for Clean Water and Sanitation were never mentioned in the Ecosystem literature, particularly in the sub-chapter on water pollution. Water degradation is inextricably linked to the SDGs issue. Students should be aware of and comprehend this issue and be sensitive to water contamination in their surroundings. This is a sub-material related to water pollution to find a solution to the problem. The first step is to define. At this point, 360° video media, water purification technologies, and problem-based learning models were developed. In addition, questionnaires were distributed to students to analyze their needs.

The second stage of this study is design. The selection of media formats and the first design of the media, particularly 360° videos and water purifying tools, are completed at this stage—the preliminary concept for producing panoramic 360° videos with Theasys online media. The use of the internet is simple and free. The link for creating a 360° video with Theasys web is https://ths.li/ISXs8U. The photograph was captured at the water body of Kartini Street, Salatiga.

Figure 1 describes the area surrounding the Kartini Street water body in Salatiga. The look of the body of water is intended to provide pupils with information about the activities of inhabitants in the vicinity of the body of water.

The activities of residents affect the condition or quality of water. This practice involves the disposal of household garbage in the form of food scraps. This is the foundation for 360° videos and is practical for making water samples from leftover rice, meat, and vegetables.

Figure 1 depicts the population density along the river flow, which can potentially cause water contamination issues due to residential waste. This is also noted by Roman et al. (2016), who state a

strong link between people's habits and the reduction in water quality caused by domestic waste. Discharged domestic waste into rivers can cause changes in water quality based on physical, chemical, and biological characteristics. Based on Figure 1, students may see how the presence of residential garbage from community activities affects water contamination. This presents students with authentic challenges concerning the state of water pollution in the surrounding area and problem-based learning triggers. From this river pollution problem, students will hypothesize the factors that cause pollution as a step for students to build knowledge concepts. This is in line with the opinion of Rahmawati et al. (2014); in the PBL stage, there are steps for students to formulate a hypothesis. Namely, students develop problem-solving possibilities.

Figure 1
Water area of river body Kartini Street, Salatiga
(documented on 2 September 2022)

The third stage is the development stage. Learning media in the form of 360° videos and water purification equipment has been approved at this stage. This media validation is used to determine the worth of the learning media items created. Validation is carried out by submitting learning media items and validation sheets to the validator for evaluation. The validation outcomes of 360° videos learning medium include media validation and material validation.

Table 1 Validation results of video 360° media

Aspect	Average value	
	Validator 1	Validator 2
Visual Communication	4.71	4.2
Video Quality	5	4.5
Layout	5	4.5
Total Percentage	**93,33%**	
Criteria	**Very Valid**	

The 360° video was validated by material experts. Table 2 displays the findings of the material expert validation. The following features of the video material are evaluated: linkage with teaching materials, efficacy as a material stimulation, and education value.

Table 2 Validation results of video 360° material

Aspect	Average value	
	Validator 1	Validator 2
Linkage with teaching materials	4.6	4
Effectiveness	5	4
Educational Value	5	4.5
Total Percentage	**88,88%**	
Criteria	**Very valid**	

Table 3 Results of validation by media experts for water purification equipment

Aspect	Average value	
	Validator 1	Validator 2
Resistance	5	4.5
Efficiency	5	4.5
Aesthetics	4	4
Accuracy	5	4.5
Total Percentage	**91,25%**	
Criteria	**Very valid**	

Table 4 Validation results of 360 videos material

Aspect	Average value	
	Validator 1	Validator 2
Linkage with teaching materials	5	4.5
Effectiviness	5	4.5
Educational Value	5	4.3
Total Percentage	**96,66%**	
Criteria	**Very valid**	

At the 360° video validation step, the validator suggests adding picture spots of rubbish in the river. This seeks to educate children about organic and inorganic waste that pollutes water bodies.

Adding organic waste is intended to raise awareness among pupils that organic waste from leftover grains, veggies, and meat contributes to river pollution. Suggestions for adding this image are made to highlight real-world pollution issues. Furthermore, even though this is only a preliminary study, adopting Effective Microorganism 4.0 (EM4) may solve water pollution. According to Maryati (2018), the characteristics of Problem-Based Learning are using real-world problems as a context for students to acquire essential knowledge and concepts from the material.

At this point, 360° video is a stimulating medium that leverages real-world concerns, precisely the problem of river pollution caused by

domestic trash (leftover rice, vegetables, and meat). Students are expected to understand that water pollution is due to household waste in rivers and impacts decreasing water quality. Apart from 360° learning videos, the validator also validates learning media for simple water purification tools. The aspects of the assessed water purification media are tool durability, efficiency, aesthetics, and tool accuracy. Table 3 shows that the total percentage of eligibility for water purification equipment is 92.25% and is included in the very feasible category.

Furthermore, material expert evaluation of water purifying equipment was performed. Table 9 shows the findings of the content expert validation. The material aspects of the water purification tool that are assessed are the linkage with teaching materials, effectiveness, and educational value. Table 4 shows that the percentage of the total feasibility of the water purification equipment media is 96.66% and is included in the very valid category.

There is a proposal to vary the order of the components in the water purification tool during validation. At the bottom of the aquarium, the features that change order are filter sponges, gravel, coconut fibre, palm fibre, and styrofoam (see Figure 2). Small stone serves to filter out large-sized garbage or particles. This is by Wicaksono et al.'s (2019) opinion that gravel in a water purification device filters out extensive material. Coconut coir is placed on the top layer to filter dirt or particles that are large enough.

Improvements to the water purification equipment include adding a sponge filter and cotton to the bottom of the water purification device. The addition of this filter seeks to filter out the particles in the water that produce water turbidity. The filter material used can alter the quality of the filtered water; therefore, adding a water filter can lower the turbidity of the water. Cotton or filter sponges can potentially reduce TDS (Total Dissolved Solid) levels because they can filter dirt, particles, or tiny organisms in the water (Adi et al., 2014).

In revision, styrofoam is added at the bottom of the device to protect the glass aquarium from being broken owing to pressure from the water purification components. According to Lim and Pranoto (2022), hydrostatic pressure and water volume pressure in an aquarium affect the strength of the aquarium glass. If the calculation of the power of the mirror in holding the load is incorrect, the glass has the potential to crack or break. As a result, polystyrene was added to the aquarium's bottom to prevent the glass from directly contacting the iron that supported the aquarium. As a result, a water purifier can help to achieve the SDGs' target of "clean water and sanitation".

Figure 2 Water purification after revision

Validated learning aids include LKPD (Student Work Sheets), practicum instructions, and instructional modules. The validation findings for Student Worksheets were 96.66% (very valid), 90.69% (very valid) for practicum instructions, and 92.22% (very valid) for teaching modules. Next, learning resources that are appropriate for usage are assessed in a small group of 10 students in class X-7. With an N-Gain value of 0.623 in the medium category, the employment of learning media in 360° videos and water purification technologies can increase students' cognitive learning results. Students can gain knowledge of the SDGs through 360° video media and water purifying equipment. The results of the limited trial showed that as many as 10 out of 10 students understood the definition of SDGs; in terms of SDGs goals, 9 out of 10 students were able to explain the goals of SDGs on the Clean Water and Sanitation point. According to Magdalena et al. (2021), using E-Student Worksheets on environmental pollution material is a practical teaching medium to help achieve learning goals.

The next stage is dissemination. The Biology lesson on water pollution employs 360° videos, learning media, and water-cleaning instruments. According to Lampropoulos et al. (2021), 360 video technologies can increase the depth of impression for students. Two lesson meetings are held during

the distribution stage. In the first meeting, 360° video was used, and Student Worksheets and students worked in groups to collect water samples for a water quality testing practical. In the water quality test practicum, students make water samples from leftover rice, leftover meat, and leftover veggies based on observations made with 360° videos.

The observation sheet instrument was used in the water quality test practicum to assess learning outcomes in the psychomotor domain. The learning results of these pupils are utilized to determine the product's effectiveness in enhancing learning outcomes. The results of the psychomotor assessment were used to assess students' practical skills during the water quality test practicum. According to Simbolon (2016), indications encompassing the psychomotor domain in science learning are classified into four categories: moving, manipulating, communicating, and creating.

According to Figure 3, the most crucial psychomotor ability is generating or creating. The creating step is also the last stage of the PBL syntax. The poster on the water quality test practicum results is the product of the creating scene. According to Hendriyan (2013), the creating stage relates to the ability to solve difficulties and develop new ideas.

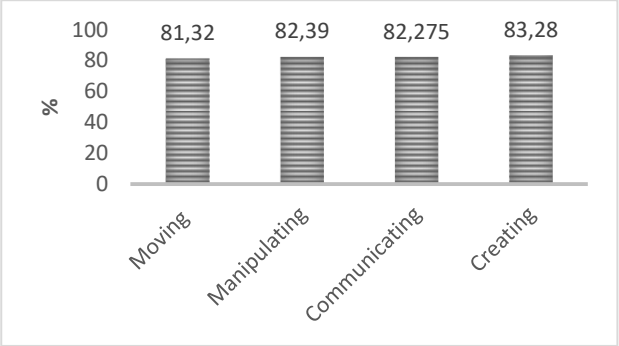

Figure 3 Results of psychomotor skills

A water purification simulation was performed during the second meeting utilizing a water purification tool (Figure 2). The sample was collected from the body at Kartini Street in Salatiga (Figure 1). TDS and pH were assessed as chemical parameters in cleared water samples. There is a change in the initial TDS value (106ppm) and final TDS (95ppm). Meanwhile, the pH of the water did not change. This shows that the water purification equipment can reduce the TDS value by 11 ppm. In addition to the water purification simulation, students analyze the results of the water quality test practicum to make a discussion and conclusion based on the practicum that has been carried out. The results of the analysis of the quality test of the water samples that have been made are concluded in the research poster. The goal is to allow students to apply their expertise to research posters. Figure 4 shows an example of the results of students' practicum posters. A title, introduction, aims, tools and materials, findings, discussion, bibliography, and conclusions are all included in this poster.

Students' cognitive learning results are assessed by administering a pre-test and a post-test in the treatment (experimental) and control groups. The test results can be seen in Figure 5. It can be seen that there was an increase in test scores in both the control class (61.57 - 76.07) and the experimental class (56.82 - 78.77).

Figure 4 One of the results of practicum poster (in Indonesian)

In addition, there is a tendency for the experimental class to score higher than the control class. This is demonstrated by the experimental class's N-Gain of 0.508 and the control class's N-Gain of 0.377, even though both are in the "medium" category.

This improvement in student learning outcomes results from a synergy between the selection of models, methods, and learning media that meet the needs of students. According to Audie (2019), the teaching process has five critical

components: objectives, resources, techniques, media, and learning evaluation. Each component affects the other components. From this statement, it is necessary to collaborate between these five components. Problem-Based Learning (PBL) was chosen to provide students with many advantages in selecting learning models and methods. Students can increase their expertise through PBL learning by using existing actual problems.

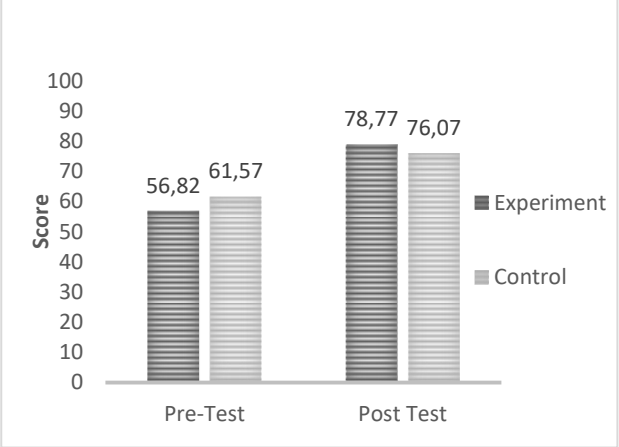

Figure 5 Pretest and post-test results

The 360° video helps students in becoming familiar with difficulties. Students were challenged with a real problem with 360° video, as the film's subject is a polluted river. Students were encouraged to learn at this step, which begins with presenting the results of observations based on the 360° video so that students could start to develop knowledge. Students also form an opinion about the video. This demonstrates that students begin to gain the ability to think frequently by making temporary conjectures. During this phase, students attempt to analyze the subject and complete the plan for correcting the water pollution problem depicted in the movie. Masrinah et al. (2019) believe using the PBL learning model will teach students to solve problems and build their knowledge through learning activities.

The first stage of PBL, namely orienting students to problems and organizing pupils to learn, is aided by Student Worksheets media. Based on the 360° videos, students will be introduced to the problem of polluted rivers in the city of Salatiga in the early part of the Student Worksheets, followed by questions about the condition of the river in the form of organic waste (rice, vegetable, and meat residue) or inorganic, and the colour of the water. "Look at the learning video at the following link," says the Student Worksheets inquiry. Write down what you get after viewing the movie (organic waste, inorganic waste, and watercolour)?" This can assist students in orienting themselves to the situation.

Furthermore, students are directed to create knowledge concepts based on 360° video observations in these questions. The PBL syntax includes this knowledge production process for organizing pupils to learn. According to Wati & Yuliani (2020), the PBL learning paradigm emphasizes students' active participation in the formation of knowledge and the discovery of concepts.

This Student Worksheet fosters students' problem-solving abilities. The existence of a 360° video about river pollution caused by household garbage is a motivator in PBL. According to Tapilouw (2016), the PBL learning paradigm can produce relevant learning, specifically on environmental pollution content. Students will be taught to solve problems in PBL learning.

Students reply to the learning done to determine the viability of 360° videos, learning media and water purification technologies from the student's point of view. Figure 6 depicts the outcomes of student responses. These comments include the importance of 360° videos, learning media and water purification equipment in capturing student interest and attention, offering student learning help, and enabling student learning opportunities to be active.

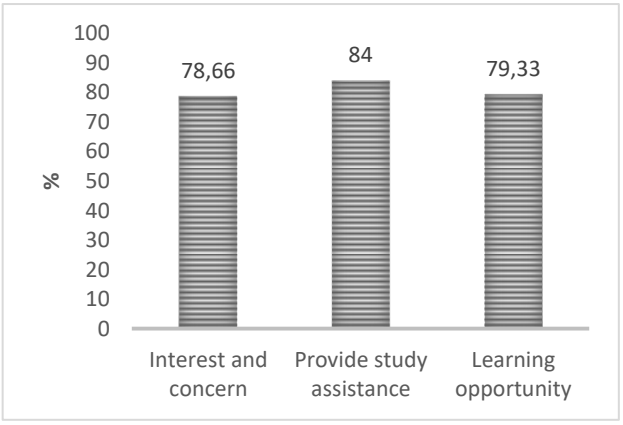

Figure 6 Results of students respons

Learning media is an element that is crucial enough to enrich students' understanding by exhibiting accurate items to pupils. According to Nurfauziah (2015), this phenomenon is that acts and curiosity are needed in the biology learning process. According to Figure 6, 360 videos of learning media and water purification equipment can raise students' interest and attention with a value of 78.66% in the feasible category. In providing learning assistance to students, a score of 84% is obtained in the very decent category. In

offering learning opportunities, a score of 79.33 is received in the appropriate category. Based on the effectiveness of learning media, 360° Video Learning Media learning tools and water purification tools are declared effective; this is based on obtaining validation results above 75%. According to Sugiyono (2015), the following learning media effectiveness categories exist: Very Ineffective (1.00-1.79), Ineffective (1.80-2.59), Effective Enough (2.60-3.39), Effective (3.40-4.19); and Very Effective (4.20-5.00). Based on these categories, the results of student answers of 80.66% (above 75%) were classified as effective, particularly in the range of 3.40 - 4.19 (68% - 83.8%).

Students' interest in paying attention to the teacher's explanation can be increased using 360° videos and this water purifying equipment. Figure 7 depicts the students' enthusiasm for using 360° videos for learning. These two learning media help students understand concepts through real problems. This aligns with Supriyono (2018), who states that psychological teaching aids in the form of learning media greatly facilitate students in terms of learning because the media can make abstract things more concrete (real).

Figure 7 Student enthusiasm

Teachers are involved in implementing 360° video learning and water purification tools paired with the PBL learning paradigm to determine the teacher's response to the learning media. The existence of 360° video learning media items and water purification solutions, according to the teacher, can make lessons enjoyable.

Learning media also seeks to make it easier for teachers to present material while also assisting students in understanding the material. Learning media is an essential component of the educational system. According to Kustandi & Darmawan (2020), the advantages of teaching media include facilitating interactions between professors and students, resulting in more effective and efficient learning activities.

An examination of the implementation of teaching modules was performed to see the performance of each PBL learning syntaxes. Figure 8 depicts the percentage of Lesson Plan implementation at Meetings 1 (87%) and 2 (90%). Through study and practice, the SDGs were introduced to students at three meetings (+ 225 minutes). For 90 minutes (two meetings), learning with the 360° video instrument and Student Worksheets is carried out, followed by the 2nd meeting, which consists of a water purification practicum and analyzing the quality of water samples. The most recent meeting featured the presentation of practicum outcomes in the form of practicum posters for 45 minutes.

At meeting 1, 87% of the Lesson Plan had been implemented, placing it in the category of very good Lesson Plan implementation. According to Pranatawijaya and Priskila (2019), the implementation category of lesson plans ranges from 81% to 100% in the case of very good interpretation. Some activities were not carried out at the first meeting, especially the closing section in the form of conclusions. Because of the reduction in class hours, the final phase, namely the delivery of conclusions, was omitted.

D. Conclusion

Based on the research above, developing 360 videos and water purification using the PBL learning model can improve student learning outcomes. The 360 video Learning Media and water purification equipment are feasible for learning. Based on the effectiveness of the media, 360 video Learning Media and water purification technologies have been pronounced effective, with validation results exceeding 75%. 360°video learning media, water purification tools combined with problem-based learning on water pollution material is an effective unit for providing students' understanding of the SDGS "clean water and sanitation". A suggestion that needs to be considered in a 360 video is to compare polluted and clean rivers' conditions. So that students can compare river conditions in real terms.

E. Acknowledgement

The author would like to thank the Principal, teachers, and students of SMA N 1 Ampel who have given permission and supported this research.

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