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IMPLEMENTATION OF ONLINE PROBLEM-BASED LEARNING ASSISTED BY DIGITAL BOOK WITH 3D ANIMATIONS TO IMPROVE STUDENT'S PHYSICS PROBLEM-SOLVING SKILLS IN MAGNETIC FIELD SUBJECT

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Abstract

The magnetic field is a more complex and abstract physics subject than other physics subjects, causing students' low ability to solve problems. So there is a need for learning instruments to overcome these problems, especially when online learning during the COVID-19 pandemic. Research creates and implements an online problem-based learning (OPBL) assisted by digital books with 3D animation to improve students' physics problem-solving skills on magnetic field subjects. Research aimed to analyze the validity, effectiveness, and student responses to the learning instruments used. The method used in this research is quantitative by using quasi-experiment and survey methods. The results showed that this learning instrument was valid and reliable to use in terms of contents and constructs. According to statistical test results, this learning instrument is also effective in improving students' problem-solving skills on magnetic field subjects. Furthermore, the student's response to this learning instrument was very positive, making this learning activity more innovative and fun. Research implies that an OPBL assisted by digital books with 3D animation instruments can be a solution to improve students' physics problem-solving skills, especially during the online learning period.

Keywords – Digital book with 3D animations, Magnetic field, Online problem-based learning, Problem-solving skills.

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1. Introduction

Problem-Solving Skills (PSS) are important skills for students to have in order to the challenges and demands of the 21st century (Ghafar, 2020; Mohd-Yusof, Helmi, Jamaludin & Harun, 2011; Nurdyansyah, Teh, Fahyuni, Rudyanto & Daud, 2021; Parno, Yuliati, Munfaridah, Ali, Rosyidah & Indrasari, 2020; Ridhwan, Sumarmi, Ruja, Utomo & Sari, 2020; Suhirman, Muliadi & Prayogi, 2020). PSS can train students in observation, reasoning, analyzing, and creative thinking to help them solve everyday problems (Devanti, Achmadi & Prahani, 2020). In addition, PSS is essential in physics subjects to improve students' conceptual understanding because it prioritizes contextual understanding (Hudha, Aji & Rismawati, 2017).

In reality, sometimes students have difficulty developing their knowledge when solving a problem (Umara, 2019). This is evidenced by the preliminary test results on 59 students, which showed that 52 (88.13%) students had low PSS scores. One of the reasons is the difficulty of visualization, which can obstruct the problem-solving process because there are some abstract and microscopic physics subjects (Cai, Liu, Wang, Liu & Liang, 2021; İbili, Çat, Resnyansky, Şahin & Billinghurst, 2020), such as magnetic field subjects. Because of the subject's high complexity and abstraction, students' PSS tend to be low and they have many misconceptions it (Bestiantono, Sa'diyah, Rachmatya, Mubarok, Adam & Suprapto, 2019; Turgut, Colak & Salar, 2016; Yilmaz & Ince, 2012). Furthermore, magnetic field subject is a prerequisite subject for electromagnetic induction with many applications in everyday life, such as power plants, fans, dynamos, and generators. Therefore, students' low understanding of concepts will affect their ability to solve a problem (Gultepe, Celik & Kilic, 2013). Consequently, it is necessary to have a learning media that can visualize students on microscopic materials, one of which is a digital book with 3D animations.

Currently, the use of digital books as physics learning media has seen a rapid increase and is very much needed when online learning during the COVID-19 pandemic (Abtokhi, Jatmiko & Wasis, 2021; Kholiq, 2020; Saraswati, Mulyaningsih, Asih, Ardy & Dasmo, 2021). Digital books are electronic versions of printed books that can be read on a device with a specific purpose (Siegenthaler, Wurtz & Groner, 2010), in this case, to improve the quality of physics learning. Digital books have many advantages, including being practical, simple, interactive, and flexible, so they can be integrated with other media such as 3D animation visualization (Siregar, Kairuddin, Mansyur & Siregar, 2021a). The 3D animation will help students provide a clear picture and understanding of the process (Wu & Chiang, 2013). For example, in the abstract magnetic field material, 3D animation can help students clearly visualize the concept of a magnetic field. Therefore, the integration of 3D animation in digital books can be applied in physics learning, especially in abstract and microscopic materials. However, using digital book media with 3D animations requires a supporting learning model that can simultaneously improve students' PSS, one of which is the Problem Based Learning (PBL) model (Chamidy, Degeng & Ulfa, 2020; Surur, Degeng, Setyosari & Kuswandi, 2020).

PBL is a relevant learning model within the Indonesian curriculum because it is a student-oriented learning system (Anazifa & Djukri, 2017; Demirel & Dağyar, 2016). Furthermore, this learning model uses a real-life problem as a basis to train students to solve the problems they face (Liu, 2017; Setyawan, Aznam, Paidi & Citrawati, 2020). It supported by Simanjuntak, Hutahaean, Marpaung and Ramadhani (2021), Suastra, Ristiati., Adnyana and Kanca (2019), Yetri, Koderi, Amirudin, Latifah and Apriliana (2019) and Yuberti, Latifah, Anugrah, Saregar, Misbah and Jermsittiparsert (2019) research which shows that the PBL is effective in improving students' PSS in physics material. However, during the COVID-19 pandemic, the learning system was done online; thus this learning model was called 'Online Problem Based Learning (OPBL).' There is no significant difference between OPBL and conventional PBL, and the difference only lies in the use of media and technology used during learning (Erickson, Neilson, O'Halloran, Bruce & McLaughlin, 2021). However, the research results by Dinata, Suparwoto and Sari (2020) show that OPBL is more efficient than conventional PBL with the same learning outcome.

Previous research has been conducted by Bakri, Sumardani and Muliyati (2019), Bogusevschi, Muntean and Muntean (2020), Dimitrienko and Gubareva (2018), Liu, Liu and Wang (2019), Pirker, Holly, Lesjak, Kopf and Gütl (2019), Sannikov, Zhdanov, Chebotarev and Rabinovich (2015)and Thees, Kapp, Strzys., Beil, Lukowicz and Kuhn (2020) have implemented physics learning media based on 3D visualization in the form of augmented reality and virtual reality. However, when implemented in online learning, the weakness of this media is expensive and requires too many devices to display the visualization. In addition, this research also has not integrated visualization media into specific learning models. There is still no research integrating the PBL with a digital book with 3D animations or visualizations in physics learning.

According to the preliminary research conducted on 61 research students, 39 (63.9%) students stated that the teacher's teaching method when learning online only gave assignments. Furthermore, while using learning media for online learning, 40 (65.6%) students stated that the contents were not understood, 23 (37.7%) students stated that they had difficulty accessing learning media, 11 (18%) students stated that they lacked image visualization of the material. Based on the survey, it can be seen that students need more engaging, innovative teaching methods and easy-to-understand learning media that are easily accessible and can provide exciting visualizations of the subject being taught. Supported by a follow-up survey that 7 (11.5%) students strongly agreed, 40 (80.3%) students agreed that OPBL assisted by digital book with 3D animation media needs to be implemented in physics learning.

Therefore, this research will create and implement an OPBL assisted by a digital book application assisted with 3D animations so that it is more attractive and can provide learning material visualization to students. This is done to optimize the achievement of students' PSS in physics learning, especially in the Magnetic Field material. With this integrated learning model and media, it is hoped to improve students' physics-PSS as one of the important skills in the 21st century. This study aims to analyze the validity, effectiveness, and student responses to the use of OPBL assisted by digital books with 3D animations to improve the ability to solve physics problems on magnetic field materials.

2. Methodology

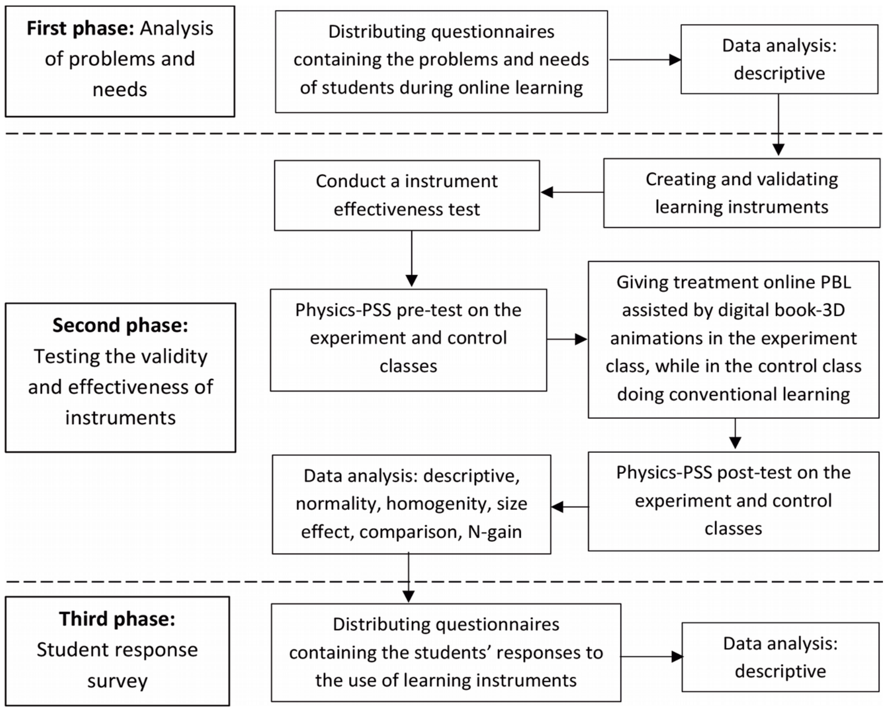

Figure 1. Stages of research diagram

The research was conducted at State Senior High School 2 Bangkalan (i.e. Indonesia) during September-October 2021 with the learning system applied at the school being online learning. The research method used is quantitative. The sample in this study was 65 students from an 11th-grade class, consisting of two classes from eight existing classes. However, when data collection has a different number of samples. It is difficult to control the sample because all data collection is done online, and some samples are easily lost. In this study, the sampling technique used was random cluster sampling because the school randomly chose the two classes.

This research is divided into three phases of data collection, namely: 1) analysis of problems and needs; 2) testing the instrument's effectiveness; and 3) evaluation of student responses with the steps as in Figure 1. Each phase is described as follows.

2.1. First Phase: Analysis of Problems and Needs

This phase was carried out to determine the problems in learning physics experienced by students during online learning. In addition, the need for relevant models and learning media can be seen so that OPBL assisted by digital books with 3D animation can be an alternative solution to the problems faced. Data collection during this phase was carried out using a survey method by distributing questionnaires containing the problems and needs of students during online learning. The sample obtained in this research was 61 students (n = 61). The research data was then analyzed descriptively to find out the problems and needs of students.

2.2. Second Phase: Testing the Validity and Effectiveness of Instruments

2.2.1. Research Design

The second phase uses a quasi-experimental type with a non-equivalent control group design (Creswell & Creswell, 2018). The study was conducted in two classes with different treatments, namely the experimental and control classes. First, both classes were given a pre-test, and then they were given different treatments between them as shown in Table 1. After that, a post-test was given at the end of the lesson. The difference between the two classes only lies in the treatment. Other things, such as materials, curriculum, number of meetings, class hours, and teachers, have the same design. The subject used in this study is a magnetic field. In addition, schools implement the COVID-19 Pandemic Emergency Curriculum with the same allocation of lesson hours but on different days. both classes have is also the same number of meetings per week, namely three meetings, and they have the same teacher.

Class	Pre-test	Treatment	Post-test
XI MIPA 3 (Experiment)	O_1	X	O_2
XI MIPA 5 (Control)	O_3	-	O_4

Note: O_1 = Pre-test experimental class; O_3 = Pre-test control class; O_2 = Post-test experimental class; O_4 = Post-test control class; X = treatment (OPBL assisted digital book)

Table 1. The difference in treatment between the experimental class and the control class

2.2.2. Sample

The research sample in the second phase only if students work on pre- and post-test questions, 59 students (n = 59) with details: in the experimental class there are 29 students, while in the control class there are 30 students. So that the sample has almost the same number in the experimental class and the control class.

2.2.3. Instruments

In this study, several instruments were used: learning implementation plans, digital books with 3D animation, test instruments (pre- and post-test), and expert validation questionnaires.

1. Lesson Plans

The lesson plans consist of several components: the syllabus, lesson plans, and assessments. The learning syllabus in both classes is adjusted to the current curriculum at school, but the lesson plans in both classes have differences in their learning approaches. The experimental class uses OPBL with five syntaxes, namely: 1) problem orientation; 2) organizing students; 3) guiding group investigations; 4) developing and presenting works and exhibitions; and 5) analyzing and evaluating the problem-solving process; the learning activities can be seen in Table 2 (Arends, 2011). The full syntax cannot be separated from the assistance of digital books with 3D animation. In the control class, learning is conducted conventionally, consisting of observing magnetic field phenomena, listening to written learning on theories, concepts, and examples of phenomena, working on questions, and discussing them with class members. The assessment is carried out by focusing on students' PSS with the ACCES rubric, namely (A) Asses the problem; (C) Create a drawing; (C) Conceptualize the strategy; (E) Execute the solution; (S) Scrutinize your result (Teodorescu, Bennhold, Feldman & Medsker, 2013). Each rubric is assessed based on three categories: correct, logical, and systematic. All learning activities are carried out online using WhatsApp media because the location of students is constrained by the internet network, meaning there is no video conference for all learning in both classes.

Syntax	Activity		PSS Indicator
	Teacher	Student	
Problem orientation	1. Prepare the learning instruments, especially the digital book with 3D animation (DB3DA). 2. Introduce the magnetic field topic and its significance in learning. 3. Orientation to magnetic field problems through contextual phenomena seen in DB3DA.	1. Download and install the DB3DA application. 2. Listen to the teacher's explanation of the magnetic field subject. 3. Observe and understand the problems to be solved.	A
Organizing students	1. Divide the students into groups. 2. Ensure that students understand the problem as well as the problem-solving process	1. Create groups based on the teacher's instruction. 2. Begin developing problem solving with the help of by BD3DA.	A, C_2
Guiding group investigations	Guides students in the problem-solving process through the student worksheet contained in the DB3DA	Conduct investigations, collect data, analyze ways of solving problems (more directed at DB3DA).	C_1, C_2, E
Developing and presenting works and exhibitions	Monitor discussions and guide problem-solving reports as in the instructions in the DB3DA.	Conduct discussions to produce alternative problem-solving, make reports, and present their ideas	E, S
Analyzing and evaluating the problem-solving process	1. Evaluation and reflection on the results of problem-solving that has been done by students. 2. Conclude the magnetic field learning subject based on BD3DA.	1. Evaluation of the extent of their acquired understanding. 2. Listen to the conclusion and ask if there are still confused	S

Note: A (Assen the problem); C_1 (Create a drawing); C_2 (Conceptualize the strategy); E (Execute the solution); S (Scrutinize your result)

Table 2. Learning activities in the experimental class (Arends, 2011)

2. Digital Book with 3D Animation

This book has an extension.*apk* in the form of an application installed on mobile phones with a file size of 67 MB. The application can be accessed offline to minimize network constraints during online learning. However, this digital book also has weaknesses, such as being not yet integrated with practical simulations and being less interactive. After the pre-test, this digital book set was used as a treatment for the experimental class. Some pictures of digital books can be seen in Figure 2. To access this digital book application, click here (https://drive.google.com/file/d/1NC0p0mXEPonuY_lYNDTqyP9ek8qyeR46/view).

3. Test Instrument

The test instrument is divided into two types, pre-test and post-test, but the tested questions are similar in both. This was done to determine the increase in the PSS of students in the experimental and control classes. Five questions are tested with the description questions with each ACCES rubric in each number. Each rubric will be assessed based on correct, logical, and systematic indicators. For example, if the student's answer represents the three indicators, the student gets a score of 3. If the student's answer only represents two indicators, then the student gets a score of 2, and so on until the student's answer does not meet all of the criteria, they will get a score of 0.

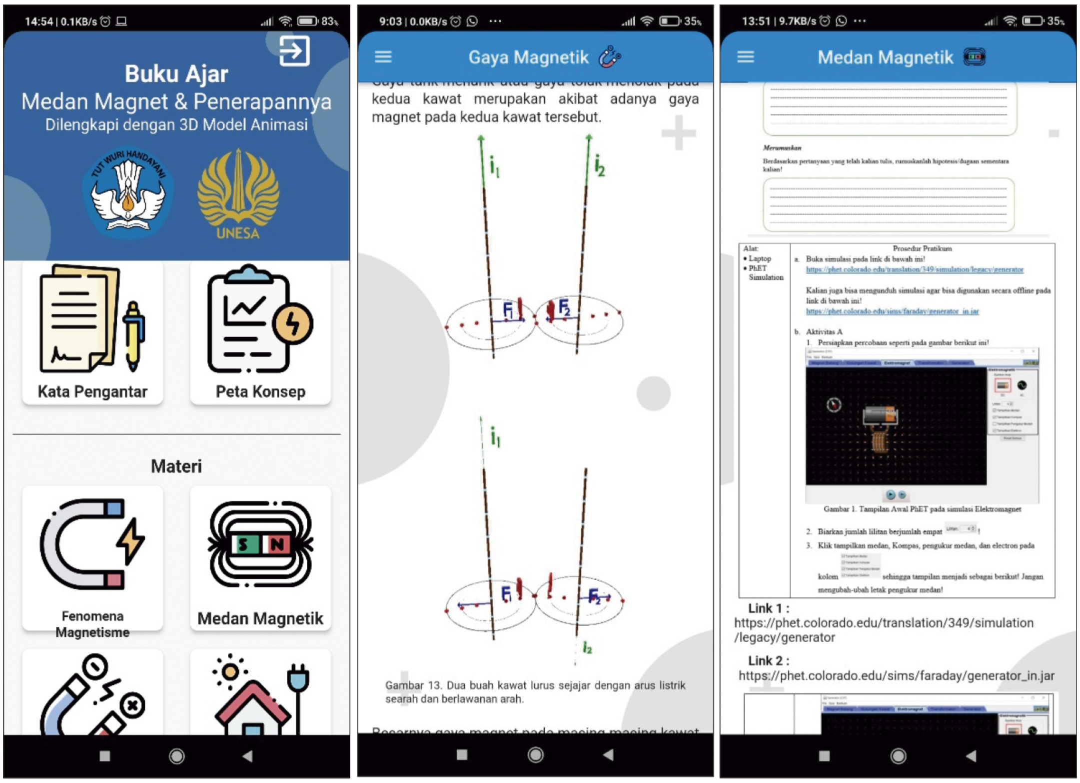

Figure 2. Some screenshots of digital book products with 3D animation (Source: Authors)

4. Expert Validation Questionnaire

The Expert validation questionnaire aims to determine the validity of the content and construct validity of the learning instruments used, namely the learning implementation plan and the application of digital books. Validation was carried out by three experts majoring in physics education.

2.2.4. Data Analysis

The validity of OPBL assisted by digital books with 3D animation models, is determined using the experts' average score of the assessment results. After that, the average assessment results will be adjusted according to the criteria in Table 3. In addition, the instrument's reliability is also assessed using the Cronbach's Alpha coefficient value, namely if the value is greater than 0.7, the instrument can be said to be reliable (Taber, 2018).

The effectiveness of these learning instruments is analyzed based on the determined assessment before and after learning. The instruments can be said to be effective if they meet the following criteria: 1) the average score of PSS is at least moderate; 2) there is a significant difference in the improvement of students' PSS abilities; 3) the effect size for the experimental class is at least medium effect; 4) the minimum n-gain value is middle for the experimental class; and 5) there is a significant difference between the experimental class and the control class. The value of the PSS score is determined by using descriptive statistics on the pre-test and post-test scores. First, the PSS scores were adjusted based on the criteria in Table 3. After that, the pre-, post-test, and n-gain data were analyzed using inferential statistics reviewed for normality using Shapiro-Wilk and homogeneity using Levene Statistic. Finally, to increase PSS, the pre-test, post-test, and n-gain values in the experimental and control classes were subjected to a paired t-test/Mann-Whitney test. The N-gain value was calculated by: (post-test score – pre-test score)/(Maximum Score – pre-test score) and the results were adjusted using Hake's criteria, as shown in Table 3 (Hake, 1999). In addition, the size of the effect was determined using Cohen's d-effect size to see the impact of field operations as shown in Table 3 (Morgan, Leech, Gloeckner & Barrett, 2012).

Validity Criteria		PSS Criteria		Hake's N-gain		Cohen's d-effect size	
Average Score Validity	Criteria	Score	Criteria	N-gain	Category	D-effect	Category
3.25 < N ≤ 4.00	Very Valid	0 – 1.0	Low	g < 0.3	Low	≥1.00	Very Large
2.50 < N ≤ 3.25	Valid	1.01 – 2.0	Medium	0.3 ≤ g < 0.7	Middle	0.8	Large
1.75 < N ≤ 2.50	Less Valid	2.1 – 3.0	High	g ≥ 0.7	High	0.5	Medium
1.00 ≤ N ≤ 1.75	Invalid					0.2	Small

Table 3. The category of learning instrument validity criteria, PSS scoring, Hake's N-gain, and Cohen's d-effect size

2.3. Third Phase: Students' Response Survey

This phase was conducted to determine student responses to OPBL, assisted by the digital book with 3D animation learning instruments that have been used during learning. Data was collected using the survey method by distributing questionnaires to the experimental class. This is because only the experimental class uses these learning instruments. The questionnaire contains ten questions that describe the use of the instrument to increase the ability of PSS in students. The research sample that filled out the questionnaire had 32 students (n = 32), so there were differences with the second phase. However, according to attendance results, it turns out that all students in the experimental class always attend every learning meeting. The results of student responses were analyzed descriptively and quantitatively and adjusted to the following criteria: (1) Response of 75% (very positive); (2) 50% response < 75% (positive); (3) 25% response < 50% (less positive); and (4) response < 25% (not positive).

3. Result and Discussion

3.1. Validity

Three physics education experts assessed the validity of OPBL assisted by digital book-3D animation learning. The instruments assessed are the content and constructs of the lesson plan, the digital book application, test instruments, and the questionnaire of problems, needs, and responses to the assessment results, as shown in Table 4. The validation results show that all aspects have valid criteria. The same as the reliability value, all aspects are reliable.

Component	Validity and reliability of OPBL assisted by digital book-3D animation			
	Score	Validity	α	Reliability
Content Validity				
1. Lesson plan	3.38	Very Valid	0.71	Reliable
2. Digital book	3.48	Very Valid	0.89	Reliable
3. Test Instruments	3.75	Very Valid	0.88	Reliable
4. Questionnaire of problems, needs, and responses	3.71	Very Valid	0.75	Reliable
Construct Validity				
1. Lesson plan	3.33	Very Valid	0.93	Reliable
2. Digital book	3.62	Very Valid	0.70	Reliable
3. Test Instruments	3.66	Very Valid	0.76	Reliable
4. Questionnaire of problems, needs, and responses	3.77	Very Valid	0.82	Reliable

Note: α = Cronbach Alpha

Table 4. The results of the assessment of the validity of the instruments by the expert

This learning instrument has a novelty in OPBL implementation, assisted by digital books with 3D animation. Unlike PBL in general, which requires student worksheets and teaching materials, these two instruments are already integrated with a digital book, so this digital book application contains complete instruments. This application has also been integrated with simulation guidelines to assist in the problem-solving process. If all learning instruments could be integrated into one application, this could further optimize the learning process (Herayanti, Fuaddunnazmi & Habibi, 2017). The involvement of the digital book application can be seen from its occurrence in every process in the OPBL syntax. In addition, the test instruments and questionnaires were also declared valid by experts. According to the validator, this learning instrument is generally valid and feasible to assess the next aspect (effectiveness) after minor revisions have been made (Plomp, 2013). After corrections were made based on their recommendations, the OPBL, assisted by digital books with 3D animations to improve physics-PSS, could be implemented for State Senior High School 2 Bangkalan students.

3.2. Effectiveness

To determine the effectiveness of PBL online learning assisted by 3D digital-animated books, see Table 5, Table 6, Table 7, and Table 8 with the following explanation.

Group	N	Lowest Score			Highest Score		
		Pre-test	Post-test	Average	Pre test	Post test	Average
Experiment	29	0.51	1.35	0.82	1.20	2.64	2.32
Control	30	0.04	0.28	0.47	1.24	2.17	1.26

Table 5. Results of descriptive statistical calculations: lowest, highest, and average scores average in both classes

Based on Table 5, it can be seen that there are differences in the pre-test and post-test abilities in both the experimental and control classes. In the experimental class, the lowest pre-test PSS score was 0.51, and the highest was 1.20, while the lowest post-test PSS score was 1.35, and the highest was 2.64. The average PSS score differs between the pre-test and the post-test: the pre-test average is 0.82, while the posttest average is 2.32. In the control class, the lowest PSS score on the pre-test is 0.04, and the highest is 1.24, while the lowest PSS score on in the post-test is 0.28 and the highest is 2.17. In addition, there is also an average difference in the pre-test, which is 0.47, while in the post-test it is 1.26. The low pre-test score is caused by students who still do not understand the tested material and do not have PSS in solving physics problems. In line with the research results by Jua, Sarwanto and Sukarmin (2018), Indonesian students' physics PSS is still relatively low. But when on post-test scores, there was an increase in PSS scores in both classes because students had learned about the subject being tested (magnetic field). When compared between the experimental class and the control class, there is a difference in values where the experimental class has a higher PSS value than the control class, especially in the post-test. This is due to the difference in treatment between the two classes, where the experimental class uses an OPBL assisted by digital books with 3D animation, while the control class uses conventional learning.

The normality test results revealed that the data in the experimental class were not normally distributed, whereas the data in the control class were normally distributed. This is due to the online treatment of PBL with the digital book with 3D animations, which causes the data to skew to the right, or most of the students' scores are high. In addition, the homogeneity test results indicate that the data is not homogeneous. Therefore, Mann-Whitney non-parametric statistical inferential analysis ($\alpha = 5\%$) was used to determine the difference between the two classes.

Based on the results of the Mann-Whitney test as shown in Table 6, it can be seen that the significance value is $p < 0.05$ which means that the hypothesis is accepted. In both classes, there is a significant difference between the pre- and post-test results. It is because there are differences in students' understanding who initially had not learned about the magnetic field subject. After being given treatment and learning about the subject, the students understood the material and increased their learning outcomes. In line with several research results, using the PBL can improve their learning outcomes (Amini, Setiawan, Fitria & Ningsih, 2019; Kawuri, Ishafit & Fayanto, 2019; Qomariyah, 2019). If viewed from the effect size, it can be seen that both classes have a very large effect category. But the experimental class has a higher value than the control class. This is because in the experimental class, learning focuses more on solving problems using the PBL, assisted by a digital book with 3D animations. While the control class only uses conventional learning. In line with (Kapi, Osman, Ramli & Taib, 2017) research, visual media can display more real physical phenomena. The use of multimedia aims to facilitate learning physics and change the paradigm of students who do not realize that many everyday events related to physics can encourage students to be actively involved in the thinking process by linking learning to real-life situations (Jabaliah, Adlim, Syukri & Evendi, 2021; Liew & Tan, 2016; Warsono, Nursuhud, Darma, Supahar & Oktavia, 2020). The use of digital book media in the experimental class can increase student learning activities so that students are more motivated than learners in conventional classes (Iskandar, Rizal, Kurniasih, Sutiksno & Purnomo, 2018).

Shapiro-Wilk Normality Test			
Group	**Test**	**p (Sig.)**	**Distribution**
Experiment Class	Pre-test	0.003	Not Normal
	Post-test	0.000	Not Normal
Control Class	Pre-test	0.025	Normal
	Post-test	0.317	Normal
Levene Statistic Homogenity Test			
Test	**Number of Sample**	**p (Sig.)**	**Homogenity**
Pre-test	59	0.002	Not Homogenous
Post-test		0.020	Homogenous
Mann-Whitney Test			
Group	**p (sig.)**	**Hypothesis**	
Experiment Class	0.000	There is a significant difference between the pre-test and post-test scores	
Control Class	0.000		
Cohen's d-effect size			
Group	**d-effect size**	**Category**	
Experiment Class	1.95	Very Large	
Control Class	1.63	Very Large	

Table 6. The test results of Shapiro-Wilk normality, Levene statistic homogeneity, Mann-Whitney, and Cohen's d-effect size for both classes

In more detail, the increase in PSS for each indicator in both classes can be seen in Table 7. It can be seen that the results of the pre-test on all PSS indicators for both classes are in the low category. After applying the OPBL, assisted by digital books in the experimental class, there was an increase in N-gain for all skills in the middle and high categories. Increased the smallest N-gain contained in the Conceptualize the Strategy (C_2) indicator. For this indicator, the students are still using strategies by applying the equation only to solve the problems as generally taught in the classroom. In line with the research results (Ceberio, Almudí & Franco, 2016; Reddy & Panacharoensawad, 2017; Riantoni, Yuliati, Mufti & Nehru, 2017), students tend not to use physics concepts to solve problems and only use memorized equations. But they can answer correctly on the Execute the Solution (E) indicator because some of the students copy each other's answers, which is indicated by the similarity of their answers. As a result, on the Scrutinize your result (S) indicator has the smallest N-gain second after C_2. On online tests, students more easily cheat on each other, so they become less confident about their work results (Cindikia, Achmadi, Prahani & Mahtari, 2020). In the control class, the increase in the N-gain value for each indicator is smaller than in the experimental class because this class uses conventional learning. The lowest increase in N-gain is found in Execute the Solution (E) indicator because students cannot apply problem-solving skills in executing solutions to the problems asked.

Group		Indicators of PSS									
		A		C_1		C_2		E		S	
EC	O_1	0.80	L	0.50	L	0.90	L	1.00	L	0.50s	L
	O_2	2.60	H	2.00	M	1.60	M	2.60	H	1.90	M
	<g>	0.80	H	0.60	M	0.40	M	0.80	H	0.50	M
CC	O_3	0.90	L	0.50	L	0.40	L	0.50	L	0.00	L
	O_4	2.40	H	1.40	M	0.80	L	0.50	L	1.00	L
	<g>	0.60	M	0.30	M	0.10	L	0.00	L	0.30	M

Note: EC (Experiment Class); CC (Control Class); O_1 (Pre-test experimental class); O_2 (Post-test experimental class); O_3 (Pre-test control class); O4 (Post-test control class); A (Assen the problem); C1 (Create a drawing); C2 (Conseptualize the strategy); E (Execute the solution); S (Scrutinize your result); L (Low); M (Middle); H (High)

Table 7. The increase in PSS for each indicator in both classes

The comparison of the average N-gain results in the experimental class with the control class can be seen in Table 8. It can be seen that the average N-gain value between the experimental class is 0.688 including the middle criteria, while in the control class is 0.282 including in the low criteria. So, the N-gain value of the PSS students in the experimental class is greater than the control class. Furthermore, the results of the normality test on the N-gain data of both classes showed that the experimental class was not normally distributed, while the control class had a normal distribution. This is because the N-gain value in the experimental class is skewed to the right, which means more high-value data. Furthermore, the homogeneity test results showed that the data were homogeneously distributed. Thus, to determine the significance of the difference between the N-gain of the two classes, non-parametric inferential statistics were used, namely the Mann-Whitney test.

Group	Descriptive Statistic		Shapiro-Wilk Normality Test		Levene Statistic Homogeneity Test		Mann-Whitney Test
	Average N-Gain	Criteria	p (Sig.)	Distribution	p (Sig.)	Criteria	p (Sig.)
EC	0.688	Middle	0.000	Not Normal	0.091	Homo-geneous	0.000
CC	0.282	Low	0.601	Normal			

Note: EC (Experiment Class); CC (Control Class)

Table 8. The test result of descriptive statistic, Shapiro = Wilk normality, Levene statistic, and Mann-Whitney for increasing PSS in both classes

It can be seen that the *p*-value < 0.05, which means that there is a significant difference in the N-gain value between the experimental class and the control class statistically. This is because OPBL assisted by digital books with 3D animation can help students improve their PSS. The PBL that focuses on problem-solving makes students accustomed to solving problems and applying them to physics problems. In addition, in learning activities, students are given assignments in the form of physics questions that must be done in stages with problem-solving indicators. Students who receive OPBL-based learning also have PSS to easily answer physics problems compared to conventional learning models who are not trained in problem-solving. In line with some research results that PBL emphasizes more on PSS aspects such as analyzing in choosing the right concepts and principles needed in solving problems so that it is better than conventional classes (Docktor, Strand, Mestre & Ross, 2015; Docktor & Mestre, 2014; Parno, Yuliati & Ni'Mah, 2019; Valdez & Bungihan, 2019). This finding is consistent with research by (Sari, Sumarmi, Utomo & Astina, 2021; Sota & Peltzer, 2017), which reveals that problem-solving skills need a problem understanding process, whereas the OPBL syntax is found in the problem orientation process. Through this process, students can be guided to understand the problem, formulate a solution design, execute problem-solving according to plan, and re-examine the problem-solving process. Another study by (Septian, Inayah, Suwarman & Nugraha, 2020; Syafii & Yasin, 2013) agrees with increasing PSS through PBL because this ability can be developed through practice. Students can have excellent thinking skills and justify with scientific evidence to find alternative problem-solving. With OPBL, students will practice problem-solving through student worksheets or structured assignments.

In terms of learning theory, this findings also reinforced by the John Dewey's learning theory that the class should be a laboratory in solving real-life problems (Arends, 2011). In addition, PBL is also based on cognitive constructivism learning theory by Piaget. Through the PBL, students can actively construct their own knowledge by interacting with their environment through the assimilation and the accommodation process (Arends, 2011). PBL is also reinforced by Vygotsky, which reveals that the learning process will occur when students work in the Zone of Proximal Development (Schunk, 2011). During problem-based learning, students will be in a top-down process, where students start with complex problems to solve and then solve or find (with the teacher's help) the basic skills needed (Slavin, 2011). The results of this study are also supported by Bruner's discovery learning theory, where students are required to be active in solving existing problems and are assisted by teachers to provide scaffolding (Moreno, 2010).

Digital books also support the OPBL with 3D animation that make it easier for students to understand the concept because the animation can help students visualize abstract and complex magnetic field subjects. In line with several studies showing that the use of 3D animation can improve visual understanding, spatial abilities, cognitive understanding, and student learning outcomes (Bakar, Sugiyarto & Ikhsan, 2019; Benzer & Yildiz, 2019; Cai, Chiang & Wang, 2013; Dori & Belcher, 2005; Kumar, 2016; Mystakidis & Berki, 2018; Park, Lee & Han, 2016). This finding is supported by (McKnight, O'Malley, Ruzic, Horsley, Franey & Bassett, 2016) research which explains that the use of technology in learning (such as digital books) can replace the roles of teachers and students, where a teacher's guide, ask questions, and facilitate students to find their own answers and construct their knowledge. Meanwhile, students are more flexible, accessible, and active in seeking what knowledge is relevant to learning to become deep learners. This certainly supports the implementation of student-centered OPBL learning. The integration between this digital book and the OPBL model can support the learning process and improve students' PSS. Supported by research by (Chao, Tzeng & Po, 2017; Siregar, Kairuddin, Mansyur & Siregar, 2021b) also agrees that the use of digital books and 3D animation can help students to solve problems, so it is very relevant when combined with the OPBL model. This digital book can make physics learning better because the learning media used is the right mix of verbal channels (in material text) and visuals (3D animated images). This is reinforced by the dual coding theory by Paivio that information received by a person is processed through one of two channels, namely verbal and visual channels that can function either independently, parallel, or integrated (Paivio, 2013).

In general, the results of the analysis on the effectiveness of the learning instruments show that 1) the average problem-solving score of students in the experimental class is 2.32, which means it is in the high category; 2) the increase in the PSS ability of students has a p-value of < 0.05 so that there is a significant difference; and 3) the effect size for the experimental class is 1.95, so it is included in the very large category; 4) the value of n-gain for the experimental class is middle; and 5) between the experimental class and the control class has a p-value < 0.05 indicating that there is a significant difference between the two. Thus, PBL online learning assisted by digital books with 3D animation effectively increases students' physics-PSS on magnetic field subjects.

3.3. Students' Responses

The results of a survey of a sample of 32 students ($n = 32$) to find out their response to PBL online learning activities assisted by digital books with 3D animation can be seen in Table 9. The calculation results show that the category's average score agrees and strongly agrees with 80.60%, while disagreeing and strongly disagree with 19.40%. Thus, according to students, this learning activity is included in the very positive criteria. The use of the OPBL is a more innovative and exciting learning model because so far, the learning that has been carried out has only focused on working on tasks independently so that students are easily bored. Especially for learning physics, which is considered complex and complicated by them. In addition, the use of digital book applications with 3D animation is a new learning medium for them to help create more enjoyable learning through the media provided. This finding is supported by research by (Abdinejad, Talaie, Qorbani & Dalili, 2021; Sin & Al-Asmari, 2018) that the majority of students agree with the use of 3D animation-based learning media to help their understanding through object visualization. This is because conventional learning methods are limited in describing difficult visual concepts. So the use of 3D animation can be used in magnetic field materials to facilitate the learning process by adding motion and trajectories to describe spatial and visual information effectively (Rieber, 1991).

Average Responses	Responses (%)			
	Very Agree	Agree	Disagree	Very Disagree
	16.25	64.35	16.59	2.81

Table 9. Average student responses in the experimental class regarding learning activities that have been carried out.

3.4. Limitations, Recommendations and Implications

This research still has limitations, such as: 1) It has not been tested practically on the models and learning media used; 2) the sample used is only two classes; and 3) the validity assessment only focuses on lesson plans and digital book products. In addition, there are also limitations in the products made, such as: 1) the size of the application is still too big, so it requires a large enough storage space; 2) 3D animation is still less interactive; 3) the application is not yet integrated with the practical simulation; 4) it is not known whether it is compatible with for all types of operating systems; 4) The material available is only Magnetic Field.

There are recommendations, including 1) conducting a practical test of the models and learning media used; 2) increasing the number of research samples up to 4 classes; and 3) conducting validity assessments for other learning instruments, such as test instruments and survey questionnaires. There are also recommendations for digital book application products: 1) compressing the file size to become smaller; 2) making animations more interesting and interactive; 3) integrating applications with virtual practicums; and 4) performing compatibility tests for all kinds of operating systems.

This research implies that the results of the research product in the form of an OPBL assisted by the digital book with 3D animations can be applied by teachers in learning physics material during online learning. It is hoped that the application of these products can improve students' PSS while at the same time solving real-life problems that students will face related to the concept, especially in magnetic field subjects.

4. Conclusions

It can be concluded that the OPBL assisted with digital book applications with 3D animation learning instruments to improve students' PSS on Magnetic Field material. This learning instrument meets the validity aspect with very valid and reliable criteria both from the content component and the construct. These learning instruments are also effective in improving students' PSS. The survey results to students showed that students responded very positively to this learning instrument. We recommend that further researchers conduct practicality tests, develop applications, or test their effects on other 21st century skills.

Declaration of Conflicting Interests

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