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# DIGITAL PROBLEM-BASED WORKSHEET WITH 3D PAGEFLIP: AN EFFORT TO ADDRESS CONCEPTUAL UNDERSTANDING PROBLEMS AND ENHANCE DIGITAL LITERACY SKILLS

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## ABSTRACT

This study aims to provide digital teaching materials in the form of problem-based worksheets with 3D PageFlip presentations that are valid, practical, and effective in overcoming conceptual understanding problems and enhancing digital literacy skills in high school students. The research approach employed was a mixed method based on Thiagarajan's (1974) 4D development model, which consists of four stages: define, design, develop, and disseminate. Three experts conducted the validity test and a limited field test involving ten high school students. Furthermore, the large-scale field test was carried out at another high school with 60 students utilizing the static pretest-post-test design. Data for the study were gathered through observation, tests, and questionnaires. Qualitative data analysis was done descriptively using the percentage technique, while quantitative data was analyzed using statistical tests. According to the results, the problem-based digital worksheet with the 3D PageFlip display has an average content validity of 8.83 and an average construct validity of 8.91. It has been proven practical with a digital worksheet implementation rate of 89.39 and positive student responses. Conceptual understanding that occurs before learning can be overcome through images and videos embedded in digital worksheets. The difference in concept knowledge and digital literacy progress between the experimental and control groups demonstrates the usefulness of this teaching material. Thus, problem-based digital worksheet teaching materials with 3D PageFlip can overcome conceptual understanding problems and improve students' digital literacy.



Keywords: 3D pageflip; conceptual understanding; digital worksheet; digital literacy

## INTRODUCTION

Knowledge and skills must be well mastered and communicated to others in the 21st century. Conceptual understanding is critical for knowledge mastery (Ariyana & Putra, 2021). Conversely, conceptual understanding problems have become one of the challenges encountered in the learning process (Okuboyejo et al., 2021; Biney et al., 2023; Mufit et al., 2023). Various studies have demonstrated that conceptual understanding problems often arise in science learning such as chemistry (Susilaningsih & Aprilia, 2022; Jammeh et al., 2023) and physics (Abdullah et al., 2018; Amalia et al., 2019; Kurniawan et al., 2019; Maharani et al., 2019; Tumanggor et al., 2020; Diani et al., 2023). Learning process constraints can cause conceptual understanding problems during the COVID-19 pandemic (Distrik et al., 2021). The daily experiences of teachers and students, the books used by teachers, and the learning models applied do not match the characteristics of the material and learning objectives (Resbiantoro et al., 2022). The same thing is conveyed by Erman (2017) that conceptual understanding problems can occur because the books

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used are not valid and reliable, and teachers do not master the material.

The learning process continues to shift from face-to-face to online learning and subsequently to limited face-to-face learning. The limited time available during this learning significantly impacts conceptual understanding. Conceptual understanding problems are common, particularly in physics learning (Distrik et al., 2021). Conceptions are considered the most critical factor in addressing physics problems (Karpudewan et al., 2016; Yuningsih et al., 2021). Learning physics without facts and data makes concepts difficult to understand. Furthermore, the cause of conceptual understanding problems is students' lack of initial knowledge. As a result, suitable measures are required to correct students' conceptual understanding problems.

Various efforts have been made to overcome conceptual understanding problems in learning, such as conducting simulation-based experiments, contextual learning, inquiry-based learning, and concept mapping (Resbiantoro et al., 2022). Overcoming many conceptual understanding problems is also done by worksheets that have been used in some previous studies to overcome conceptual understanding problems (Atasoy et al., 2011; Suyono & Sabtiawan, 2019; Wityanita et al., 2019; Siong et al., 2023). Worksheets are educational resources that can provide students with active and positive learning experiences. Students can actively participate in the learning process and increase their conceptual understanding. Worksheets have been widely utilized in learning to increase creative thinking (Umriani et al., 2020), critical thinking (Rozi, 2020), conceptual understanding (Primanda et al., 2019; Suherman et al., 2021), communication (Yerizon et al., 2019), and science processes (Mutlu, 2020). Worksheets based on learning models have also been developed further, such as worksheets based on APOS theory (Amawa et al., 2019), problem-solving (Syafina & Suparman, 2019), and HOTS (Ramadhan et al., 2020). Because there is a strong association between conceptual knowledge and physics problem-solving skills, worksheets based on problem-based learning are the best instructional tools for overcoming conceptual understanding problems (Distrik et al., 2021). Furthermore, problem-solving can actively engage students in problem-solving (Distrik & Saregar, 2022). Good conceptual knowledge can help students solve issues more efficiently and vice versa (Abdullah et al., 2014).

Worksheets are available in both printed and digital formats. Electronic worksheets are also known as digital worksheets. Digital worksheets are a type of 21st-century learning technology. Digital worksheets are more convenient than non-digital worksheets since students can access them anytime and anywhere. Participatory components such as video, audio, animation, and simulation are also included in digital worksheets, making learning more exciting and interactive for students. Using digital worksheets also helps students visualize abstract topics, which can assist in reducing conceptual understanding problems. Furthermore, using digital worksheets in learning can improve students' digital literacy skills, including understanding, skills, and behavior in effectively using digital technology. Students learn to recognize, choose, and evaluate material digitally by using digital worksheets.

Various digital worksheet research and development projects have been undertaken, including digital worksheets in the form of flipbooks for environmental literacy and pedagogical competence (Sumarmi et al., 2021), digital worksheets with digital puzzles to identify student metacognition (Agung et al., 2023), and digital worksheets based on inquiry level for science process skills (Dewi et al., 2023). The creation of problem-based learning worksheets has also been utilized to increase critical thinking (Syafina & Suparman, 2019), problem-solving skills (Ponjen & Suparman, 2020), and concept-building (Yerizon et al., 2022). However, this problem-based learning worksheet is currently only available in the printed version. As a result, the worksheet employed cannot be used to improve students' digital literacy. Thus, this study aims to create a digital problem-based worksheet with a 3D PageFlip presentation that is valid, practical, and useful in eliminating conceptual understanding problems and increasing digital literacy skills in high school students.

## METHODS

The research approach was a mixed method based on the 4D development design with four stages: define, design, develop, and disseminate (Thiagarajan, 1974). The define stage was done for preliminary research, including conducting needs analysis with theoretical and empirical studies, formulating indicators and learning objectives, and determining the model used in digital worksheets. The design stage was to design and create a digital problem-based worksheet format with 3D page flipping, compiling storyboards, test instruments, validation sheets, and learning plans. The development stage was conducted to carry out product validation tests (content and construct validation tests) by three experts. The dissemination stage was done to test the product's practicality and effectiveness in a small field test. At this stage, a field test was carried out with a nonequivalent pretest-posttest control group design. The research design for testing the practicality .

**Table 1.** The Research Design

| O1 | X | O2 |
|---|---|---|
| O1 | - | O2 |

O1= Pretets, O2=Posttest, X= treatment

Figure 1 depicts the flow of research using the mixed method.

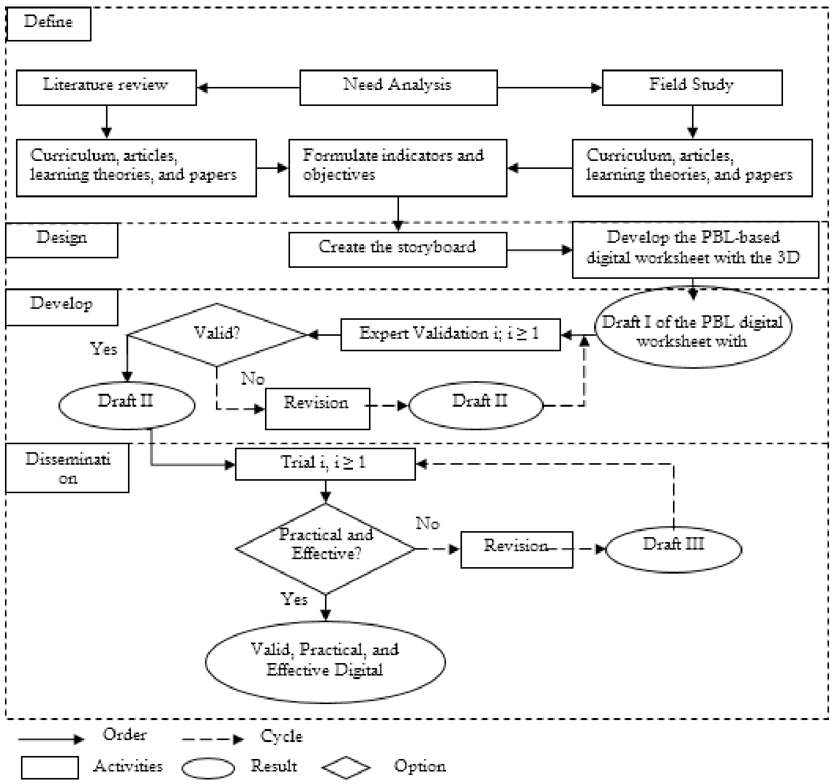


**Figure 1.** Flowchart of Research Design by Applying the Digital Worksheet

During the limited field test stage, the research population consisted of 164 students from the eleventh-grade students of SMAN 1 Padang Cermin, Pesawaran, Lampung, Indonesia, divided into four classes. Based on the results of the preliminary test analysis, the sig. 2-tailed, higher than 0.05, was obtained in the four classes comprising the population. It means that the four classes had the same starting ability. The research sample was drawn using a cluster random sampling technique, with 30 students each, and divided into experimental and control groups. Learning was done face-to-face and online throughout the limited field trial. Face-to-face learning employed a digital problem-based worksheet with a 3D PageFlip display for the experimental class and an inquiry-based worksheet and discussion for the control class, while online learning was limited to assignments and presentations.

The research instruments comprised a questionnaire, validation sheets, observation sheets, and instrument tests for conceptual understanding and digital literacy. The questionnaire was used to collect data about students' difficulties in learning physics, the need for teaching materials, and student responses during learning using PBL-based digital worksheets with 3D PageFlip. The validation sheet was used to validate digital worksheets and test instruments. The observation sheet was utilized to observe the implementation of PBL-based digital worksheets with 3D PageFlip during learning. Data on product practicality was gathered through implementation and student responses to learning. A conceptual understanding test with indicators of interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining (Anderson & Krathwohl, 2021) and a digital literacy questionnaire consisting of internet searching, hypertextual navigation, content evaluation, and knowledge assembly were used to collect data on product effectiveness (Gilster, 1997).

The learning implementation observation sheet and student response questionnaire assessed product practicability. Data on implementation and student answers were analyzed descriptively, specifically by grouping data and categorizing it as low, medium, or high implementation. The student responses were divided into two categories: positive and negative. The effectiveness of the PBL-based digital worksheet with 3D PageFlip was compared between experimental and control groups using an independent t-test on N-gain of conceptual understanding and digital literacy. The N-gain test can be performed using the gain formula from Meltzer (2002).

The calculation results were interpreted using normalized gain according to Meltzer's classification in Table 2. Differences in N-gain in conceptual understanding and digital literacy between the experimental and control groups were analyzed using an independent sample t-test. Students' conceptual understanding problems in understanding physics concepts were analyzed using the percentage technique.

**Table 2.** Classification of N-Gain Value

| Normalized N-gain | Interpretation |
|---|---|
| $g > 0,7$ | High |
| $0,3 < g \leq 0,7$ | Medium |
| $g \leq 0,3$ | Low |

## RESULTS AND DISCUSSION

The PBL-based digital worksheet with 3D PageFlip was proven valid, practical, and effective after descriptive and inferential tests. The digital worksheet's validity is made up of content and construct validity. The compatibility of core competence, basic competence, indicators and objectives, novelty, and currency are all components of content validity. Design, creativity, compatibility with existing theories, interrelationships between words, and compatibility between letters and pictures all contribute to construct validity. Table 3 summarizes the results of the experts' validation of content validity.

**Table 3.** Results of Content Validity of PBL-based Digital Worksheet with 3D PageFlip

| No | Aspects | Expert Validation | | | Average | Category |
|---|---|---|---|---|---|---|
| | | I | II | III | | |
| 1 | The relationship between basic competencies and objectives | 87.75 | 88.25 | 86.50 | 87.50 | Valid |
| 2 | Novelty | 88.00 | 90.00 | 85.00 | 87.67 | Valid |
| 3 | Up-to-date | 89.00 | 86.00 | 85.00 | 86.67 | Valid |
| 4 | Goal achievement | 90.00 | 95.00 | 88.00 | 91.00 | Valid |
| | Average | 88.69 | 89.81 | 86.13 | 88.21 | Valid |

Table 3 shows that the PBL-based Digital Worksheet with 3D PageFlip is valid regarding content. All three experts agreed that the digital worksheet was new, prepared according to objectives, and up-to-date. However, there were several improvements, especially in studying material and images. All teaching materials used in learning must meet valid content and constructs. Valid constructs display design, theory, images, and language. The validation results by three experts are shown in Table 4.

**Table 4.** Results of Construct Validity of PBL-based Digital Worksheet with 3D PageFlip

| No | Aspects | Expert Validation | | | Average | Category |
|---|---|---|---|---|---|---|
| | | I | II | III | | |
| 1 | Design | 89.00 | 87.00 | 88.00 | 88.00 | Valid |
| 2 | Originality | 87.00 | 86.00 | 86.00 | 86.33 | Valid |
| 3 | Appropriateness of theory | 89.00 | 89.00 | 87.00 | 88.33 | Valid |
| 4 | Appropriateness between letters and pictures | 92.00 | 92.00 | 91.00 | 91.67 | Valid |
| 5 | Language | 91.00 | 91.00 | 92.00 | 91.33 | Valid |
| | Average | 89.60 | 89.00 | 88.80 | 89.13 | Valid |

Table 4 shows that the digital worksheet is construct valid. A PBL-based digital worksheet with 3D PageFlip was developed following the problem-based learning approach. The first step of each subject matter introduces difficulties that students have encountered or learned, which are then linked to the problems to be discussed, allowing students to grasp the concept readily. Afterward, students can observe using videos (virtual labs) in the digital worksheet. Figure 2 depicts a template that may be downloaded online.

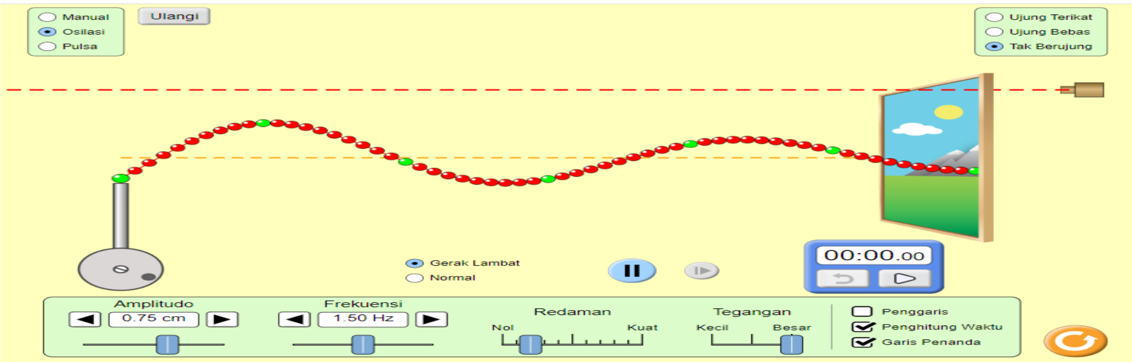


**Figure 2.** The Transverse Wave Virtual Lab

Students work in groups to complete all the problems in the video by answering all the questions on the digital worksheet. To help students validate the answers they come up with, the digital worksheet includes many reviews of a real-life event that is comparable to the problem they are working on. The analysis of an event depicted in the video is provided in plain terms, progressing from studying the simplest material to studying complicated material (inductive technique). The information is organized following the updated 2013 curriculum and the emancipated learning. The PBL-based digital worksheet with 3D PageFlip adheres to cognitive learning theory and constructivism in that students actively seek answers to the issues presented (Artayasa et al., 2018). Scaffolding is only provided by the teacher at particular stages. The material in the digital worksheet is organized following the learning objectives. The information is organized based on the student's learning environment, specifically the generated waves (Figure 3).

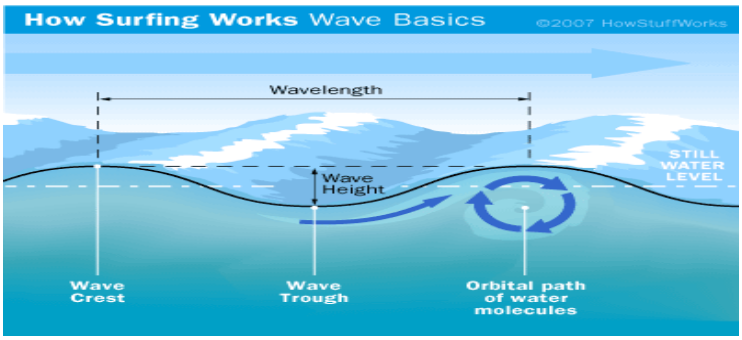


**Figure 3.** Ocean Waves

The PBL-based digital worksheet with 3D PageFlip features animations, graphics, videos, and virtual laboratories that engage students with the material, especially during observation or experiment activities. Students' access to electronic media has various advantages and qualities. When it comes to the benefits of electronic media, it can make the learning process more fascinating because teachers and students can read from various angles with 3D effects. The teaching materials in the form of 3D PageFlip will bring a new nuance to the classroom learning process.

The PBL-based digital worksheet with 3D PageFlip meets the elements of novelty and sophistication, as the material study is created following the expectations of the Indonesian curriculum, and the observation/experiment activities are tailored to the surrounding environment. Students are guided through each learning activity to comprehend ideas better and improve their digital literacy skills. Five indicators are described in the learning activities to ensure that students understand the concepts correctly: (1) explaining data from observations, (2) interpreting, namely making predictions or interpreting data or information, (3) classifying data, (4) comparing the data obtained with theories or laws/arguments whose truth is undeniable, and (5) drawing conclusions based on data or observation results. The activities in the PBL-based digital worksheet with 3D PageFlip are also designed to help students develop their digital literacy skills, such as searching and assessing material online and understanding the integrity and authenticity of information sources obtained via an internet connection.

Teachers can quickly apply a PBL-based 3D digital worksheet to physics lessons. The teacher provides an issue relevant to the content to be explored during the learning process. Students in groups conduct observations or experiments that can be accessed directly through a digital worksheet in the form of a video or link. Students can directly write student learning activities, such as creating problems and hypotheses in the digital worksheet. Furthermore, students collect and analyze data and solve all tasks on the digital worksheet. Table 5 displays the findings of observations of learning implementation utilizing PBL-based digital worksheets with 3D PageFlip.

**Table 5.** The Implementation of Digital Worksheet with 3D PageFlip Based on PBL

| No | Implementation Indicators | Meeting | | | Average |
|---|---|---|---|---|---|
| | | I | II | II | |
| 1 | Syntax application | 87.75 | 88.25 | 86.50 | 87.50 |
| 2 | Social system | 87.00 | 90.00 | 85.00 | 87.33 |
| 3 | Reaction principles | 90.00 | 96.00 | 85.00 | 90.33 |
| 4 | Supporting system | 91.00 | 93.00 | 90.00 | 91.33 |
| 5 | Instructional and accompanying effects | 90.00 | 90.00 | 90.00 | 90.00 |
| | Average | 89.15 | 91.45 | 87.30 | 89.30 |

Based on the data in Table 4, teachers can implement learning by applying a digital worksheet with a 3D PageFlip based on PBL. The syntax application, social systems, reaction principles, supporting systems, and instructional and accompanying effects achieved an average above 85 from a maximum score of 100. In learning, students can construct problems and hypotheses in digital worksheets based on the outcomes of watching videos or animated visuals embedded in digital worksheets. Students can also access videos or animated images that are similar to the videos or animated images embedded in the digital worksheet. Learning through observation can help students comprehend concepts better and avoid conceptual understanding problems. Distrik et al. (2022) support these findings by demonstrating that observational learning utilizing films and animated visuals can improve students' conceptual understanding and problem-solving in physics learning. Based on PBL, a digital worksheet with 3D PageFlip can improve the social system (group work and discussion), the reaction principle (allowing students to give answers that differ from the teacher's or other student's answers), and instructional and accompanying effects (increasing motivation to learn, searching for new information via the internet).

Students respond positively to the digital worksheet with 3D PageFlip based on PBL. The PBL-based digital worksheet with 3D PageFlip is easy to understand, conveys information, and employs simple language, according to 90.44% of students. Table 6 displays students' responses to the PBL-based digital worksheet with 3D PageFlip.

**Table 6.** Students' Responses to the PBL-based Digital Worksheets with 3D PageFlip

| No | Responses | Percentage |
|---|---|---|
| 1 | Positive | 90.44% |
| 2 | Negative | 9.56% |

Links to download similar media or resources that can boost students' understanding are offered in the PBL-based digital worksheet with 3D PageFlip to urge students to explore alternative reading sources online, which can develop students' digital literacy skills. Using a PBL-based digital worksheet with 3D PageFlip in physics instruction is theoretically correct and practical. However, it also effectively eliminates conceptual understanding problems and enhances students' digital literacy. Table 7 displays the pretest and posttest findings for each measure of conceptual understanding.

**Table 7.** Pretest and Posttest Results on Conceptual Understanding of Experimental and Control Groups

| Group | Test | Interpret | Explain | Classify | Example | Compare | Infer | Average |
|---|---|---|---|---|---|---|---|---|
| Expe. | Pretest | 37.50 | 25.00 | 25.00 | 25.00 | 37.50 | 25.00 | 29.17 |
| | Posttest | 77.86 | 71.79 | 66.43 | 65.36 | 69.64 | 70.36 | 70.24 |
| Control | Pretest | 36.07 | 35.36 | 27.50 | 30.36 | 36.43 | 33.21 | 33.15 |
| | Posttest | 74.29 | 67.86 | 55.00 | 48.57 | 51.07 | 54.64 | 58.57 |

Students' conceptual understanding remains low in the experimental and control groups before the learning. The experimental and control groups experience increased conceptual understanding after learning with a PBL-based digital worksheet with 3D PageFlip. Still, the increase in conceptual understanding in the experimental group is significantly different. The conceptual understanding in the experimental group is in the good category, whereas the control group is in the medium category. Most students have conceptual understanding problems and do not understand wave content before learning. Because items can move from one point to another, most students state that waves are mass propagation; only a few students write that waves are energy propagation. Students also state that the sign of mines demonstrates that waves propagate from right to left, and they employ the number quadrant system. Another challenge is differentiating between wave number and wavelength, phase and phase angle. Some conceptual understanding problems about wave material can be addressed after learning with a PBL-based digital worksheet with 3D PageFlip. Figure 4 depicts the growth in conceptual understanding (N-gain) for each indication of conceptual understanding.

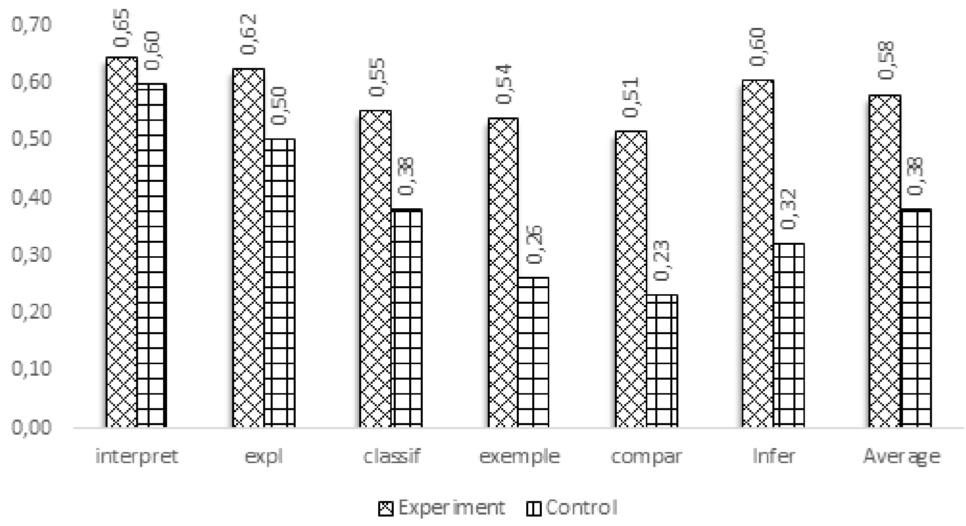


**Figure 4.** The N-gain of Conceptual Understanding Indicators of the Experimental and Control Groups

According to Figure 4, the experimental group's average N-gain of conceptual understanding is in the medium range, while the control group has a low N-gain. The interpretation indicator has the largest N-gain when comparing experimental and control groups. Students can adequately anticipate the shape and size of transverse waves using the formula but struggle to distinguish between phase, phase difference, and phase angle. After seeing the video in the digital worksheet, students can comprehend the difference between phase, phase difference, and phase angle.

Although some students grasp digital literacy, it is rarely implemented in learning. The digital literacy skills of high school students at the start of learning are still very low. Table 8 displays the results of students' digital literacy skills before and after studying.

**Table 8**. Students' Digital Literacy Skills Before and After Learning

| Group | Test | Internet Searching | Hypertextual Navigation | Content Evaluation | Knowledge Assembly | Average |
|---|---|---|---|---|---|---|
| Experimental | Before | 50.00 | 50.54 | 47.62 | 38.71 | 46.59 |
| | After | 81.90 | 82.86 | 78.81 | 76.96 | 80.42 |
| Control | Before | 50.00 | 50.00 | 45.71 | 38.57 | 46.11 |
| | After | 67.86 | 66.25 | 69.05 | 59.29 | 65.32 |

The N-gain of each indicator in the experimental group is moderate, while the control group is low. The N-gain of digital literacy indicators for the experimental and control groups is shown in Figure 5.

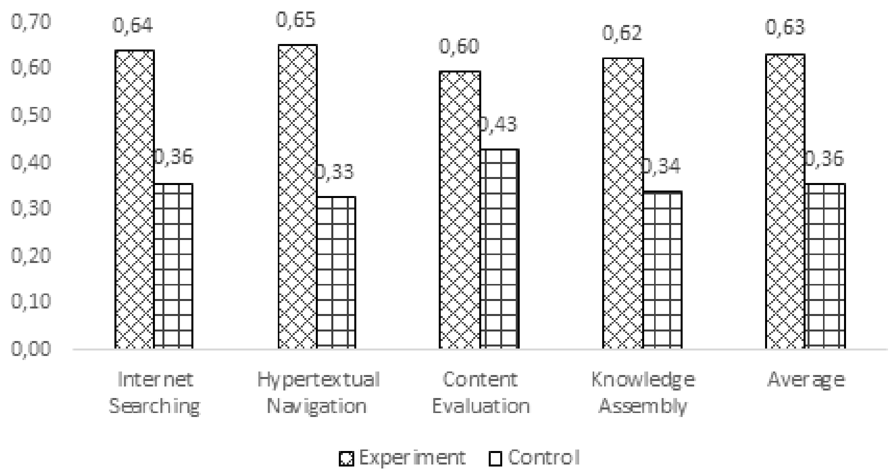


**Figure 5.** The N-gain of Digital Literacy Indicators in the Experimental and Control Groups

The results of the N-gain difference test for conceptual understanding and digital literacy between the experimental and control groups are presented in Table 9.

**Table 9.** N-gain Test Results of Concept Understanding and Digital Literacy

| Aspects | Group | N-gain | Category | P. n-gain |
|---|---|---|---|---|
| Conceptual understanding | Experimental | 0.58 | Medium | 0.000* |
| | Control | 0.38 | Low | |
| Digital literacy | Experimental | 0.63 | Medium | 0.000* |
| | Control | 0.36 | Low | |

*p < 0.05, Significant difference at the confidence level 95%

According to Table 9, the difference in N-gain in conceptual understanding and digital literacy between experimental and control groups is sig (2-tailed) less than 0.05. This finding suggests that the PBL-based digital worksheet with 3D PageFlip used in learning effectively removes conceptual understanding problems and develops students' digital literacy skills in physics. This outcome is confirmed by prior research, which finds that worksheets can help students overcome misconceptions about AC circuit electrical content (Siong et al., 2023). The digital worksheet is employed with a cartoon presentation in the study to increase student interest in the digital worksheet. According to research by Pohan et al. (2020), worksheets can help students overcome misconceptions and increase their conceptual knowledge of motion and force content. Worksheets and simulation laboratory experiments are employed in the course of the experiment. Worksheets can also help students grasp concepts in mathematics (Suherman et al., 2021; Ramlah-Abadi et al., 2023), fluids (Mujasam et al., 2019), and Newton's laws (Atasoy & Ergin, 2017). Worksheets can help students develop digital literacy skills and overcome misconceptions (Pratama & Widowati, 2022). However, none of the many worksheet studies have found that worksheets may help students overcome conceptual understanding problems and improve their digital literacy skills on a problem-based learning basis.

PBL-based digital worksheets direct students' attention to problem-solving. PBL-based learning significantly improves students' digital literacy skills (Priadi et al., 2021; Kashyap et al., 2023). Similar research findings are conducted by Yustina et al. (2022), who discovered that PBL-based learning can improve students' digital literacy skills. In physics, problem-solving is done step by step with the correct sequence of concepts. Some abstract physics concepts rely on complex mathematics (Supurwoko et al., 2017; Ismail et al., 2019; Sari et al., 2020). Students can increase their grasp of subjects through group work and teacher support, preventing conceptual understanding problems (Kolić-Vehovec et al., 2022). PBL-based digital worksheets allow students to build communication amongst groups, allowing them to correct their understanding of a wave occurrence and its attributes. Some students struggle with estimating the speed of propagation of waves at a given point in wave material. This problem arises because students do not understand the subject, not because of conceptual understanding problems. Students comprehend wave phase but cannot distinguish between wave phase and phase angle. Some students grasp the wave equation formula but cannot demonstrate its formulation.

The 3D PageFlip in digital worksheets can assist students in gaining access to materials and searching for similar sources of information, hence improving students' digital literacy skills. Students' digital literacy skills are generally good, yet some still struggle with evaluating content (Chan et al., 2017; Ussarn et al., 2022). Students are less adept at tracking comparable content and lack conceptual understanding (Hofer et al., 2018). Some students are lacking in choosing illustrations of transverse wave motion, so conceptual understanding problems occur because of misinterpretation of images, such as transversal waves being waves whose direction of motion is parallel. Students display the motion of ocean waves with more than one wave moving parallel. However, the direction of propagation and the vibrating direction of transverse waves are perpendicular. The role of the teacher as a facilitator directs students to return to see the simulation of wave motion on the rope.

Learning using digital worksheets allows teachers to provide more interactive physics lessons (Sari et al., 2022; Nurulsari et al., 2023; Wong & Chuah, 2023) and engage students in exploring concepts through observation. Using page-flip 3D digital worksheets makes learning more exciting and effective, helps students understand concepts better (Andriati et al., 2022), and motivates them to explore the world of physics in different ways.

## CONCLUSION

PBL-based digital worksheets with 3D PageFlip are declared valid, practical, and effective. Content validity shows an average value of 88.21 and construct validity 89.12, including very valid categories. Practicality is shown by the implementation of digital worksheets in learning, which is an average of 89.30, and student responses are very positive, namely 90.44% of students state that they are motivated and can help understand complex concepts. Effective is demonstrated by significant differences in N-gain in conceptual understanding and digital literacy skills between experimental and control groups. Applying the PBL-based digital worksheet with 3D PageFlip in physics learning can eliminate conceptual understanding problems, increase students' conceptual understanding of wave material, and boost students' digital literacy. Increasing understanding of digital concepts and literacy makes students more critical in thinking and reviewing each concept by effectively utilizing the information available in the digital world.

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