The Effectiveness of A Multiple Representation-Based Flipbook to Improve Students' Problem-Solving Ability on The Topic of Wave

Bunga Lili Annisa, Sarah Miriam, & Suyidno[*]

Physics Education Study Program, Universitas Lambung Mangkurat, Indonesia

*Corresponding Author: suyidno_pfis@ulm.ac.id

Abstract - *Flipbook with multiple representation designed through flip pdf professional software to improve problem-solving ability is still unavailable. Therefore, this study aimed to analyze the effectiveness of a Multiple Representation-Based Flipbook (MRBF) in enhancing students' problem-solving skills on the topic of waves. This research uses the ADDIE development model with 32 students of XI MIPA of one senior high school in Banjarmasin, South Kalimantan, Indonesia, as its subject of study. The data were collected through a problem-solving test to measure the indicators of visualizing problems, presenting, planning problem solving, implementing, and evaluating solutions. The results showed that the average value of students' problem-solving before and after the MRBF was applied increased from very poor to very good. In addition, the Wilcoxon test results obtained a Sig (2-tailed) value of 0.00 < 0.05 which means that the increase was significant. It was concluded that MRBF effectively improves students' problem-solving abilities in learning physics.*

Keywords: *Mechanical waves; multiple representation; problem-solving ability*

INTRODUCTION

The use of information media and digital technology has accelerated and improved knowledge in all fields in the 21st century. The world of education in the 21st century is expected to prepare students to solve problems (Laksana, 2021). In general, teachers and students are dominant determining factors in education, as both play a role in the learning process, according to the national goals of instruction described in Law No. 20 of 2003. The learning process is at the core of the educational process, which aims to change students' behavior. (Kirom, 2017).

The 2013 Curriculum aims for high-quality human resources that are expected to be able to compete in the 21st century and industrialization 4.0 in the globalization era with abilities (Wirahmawati et al., 2022). 21st-century learning encompasses competencies such as creativity and innovation, critical thinking to solve problems, communication and collaboration. In addition, students and educators have competence in having

information, media, and technology; in other words, they can take advantage of digital technology in the form of the internet and use gadgets in learning at school, one of which is learning physics (Effendi & Wahidy, 2019). Siswanto (2019) said that mastering physics material requires understanding concepts. Students are expected to be active learners who seek out sources or materials for learning on their own via e-books, websites, and textbooks. The availability of learning resources can help students better understand physics material. In physics, abstract symbols represent conceptual knowledge (Doyan et al., 2018; Suhandi & Wibowo, 2012).

The results of the researcher's initial study, conducted through interviews with physics subject teachers at one of Banjarmasin's senior high schools, revealed that the teacher only gave physics questions at the cognitive levels of defining (C1) and understanding (C2). In contrast, questions C3-C6 are still rarely taught to students. The physics teacher also stated that students

struggled to comprehend physics material. The limited availability and the high cost of books contribute to the decline in students' interest in learning. According to Nurwahyuningsih et al. (2019), the teaching and learning process of physics in the classroom tends to override problem-solving abilities. Students usually struggle to answer physics questions. Burhendi (Nurdiansah & Makiyah, 2021) also claims that while studying online, some students have difficulty understanding concrete and abstract physics concepts without questioning how the physics concept was obtained. This is a problem because, in online learning, students learn independently, and communication activities between students and teachers take place without face-to-face interaction. Even if the teacher has provided online learning materials or videos as a facilitator, because students are required to learn independently, it has been discovered that they have different results in capturing or understanding the material. This is in line with Suteja et al. (2014) that students have specific abilities that are more prominent than others. There are students whose verbal skills are more noticeable than their spatial and quantitative abilities, and vice versa. This issue can be solved by employing multiple representations.

Multiple representations mean re-explaining the same concept in different formats, such as written sentences (verbal), mathematics (symbols), pictures and graphics in conveying information or research data (Hasbullah et al., 2019; Ramadayanty et al., 2021). Multiple representations can build understanding through various forms of representation. If students fail to understand a concept through one form of representation, they can use other forms of representation (Wati et al., 2020). According to Apriliana et al. (2022), learning with electronic worksheets necessitates many learning representations. The goal is to help students understand the

subject matter, particularly physics. Multiple representations can help students learn and build a concept for overcoming a problem, solving problems, and addressing problems (Irwandani, 2014). This is also consistent with Astuti's (Ramlah et al., 2018), in which multiple representations promote the formation of information understanding. Multiple representations also assist students in describing problems, sketching and physical situations of problems, and directing students to understand information and knowledge to solve problems. According to Krisnaningsih et al. (2021), multiple representations' role in improving problem-solving skills is critical. Learning physics can be supplemented with multiple representation. Before moving on to mathematical equations, students should understand a concept and visualize the problem. This can address one of the challenges of the 21st century in education, where students are expected to be problem solvers. To support the use of multiple representations, it is possible to use flipbooks as a teaching medium.

Rahmawati et al. (2017) successfully created a flipbook of object motion material appropriate for junior high school students. Ramadayanty et al. (2021) made an e-module based on multiple representations of optical instrument materials that could be used to practice high school students' problem-solving skills. Furthermore, Amiroh et al. (2021) used a multiple representation approach to enhance conceptual mastery and problem-solving in wave material. The findings indicate that multiple-representation learning can increase conceptual skills, improve students' problem-solving abilities, and shift student behavior from novice to expert in solving wave problems. Busyairi et al. (2021) successfully developed an e-module based on a multiple representation approach that can be used to improve the understanding of motion kinematics material.

Based on the above background, to build students' problem-solving abilities in Industry 4.0 era, a flipbook of multiple representational wave material was developed to improve students' problem-solving skills by reviewing the effectiveness of the flipbook developed. The material chosen in the development of the flipbook is the wave material because it has a lot to do with everyday phenomena, and it will later be related to the following physics material. The competencies for the material direct students to perform at the analytical stage, such as problem-solving. So, this study aims to analyze the effectiveness of a multiple representation-based flipbook (MRBF) in improving students' problem-solving skills on the topic of waves.

RESEARCH METHODS

This research includes research and development with the ADDIE (Analysis, Design, Develop, Implement, and Evaluate) model by Dick & Carry in 1996.
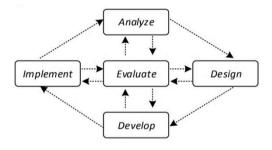

Figure 1. ADDIE research design
(Sugihartini & Yudiana, 2018)

Based on Figure 1, the previous stage (ADD) has produced teaching materials with validity and reliability values for multiple representation-based flipbooks (3.39, 0.81), lesson plans (3.45; 0.69), and problem-solving tests (3.42; 0.96); so that the teaching materials are valid and reliable for use in the implementation test in the classroom.

In this study, the implementation stage will use a one-group pre-test post-test design, namely by comparing the results of the problem-solving ability test of students before and after using the developed flipbook. The MRBF implementation was tested on 32 students of class XI MIPA of one of the senior high schools in Banjarmasin, South Kalimantan, Indonesia. The data collection instrument used was a learning outcome test, which, in this study, is in the form of a description question. Test questions were made identical for the pre-test and post-test. The test contains problem-solving questions that refer to the problem-solving ability indicators by Heller et al. (Kalsum et al., 2018), including visualizing problem and presenting problems, planning solutions, implementing problem solving, re-checking and evaluating.

The student's problem-solving ability test results are then averaged on each indicator. The results are categorized based on the criteria: very good > 80, 80 ≥ good > 60, 60 ≥ enough > 40, 40 ≥ less > 20, 20 ≥ very poor (Widoyoko, 2016).

The data from the students' problem-solving ability test results are then analyzed using the Wilcoxon test and SPSS 22. This test was chosen because the pre-test and post-test data on problem-solving did not meet the criteria for normality and homogeneity. The Wilcoxon test relies on the following criteria for decision-making:

1. If Asymp.Sig (2-tailed) < 0,05, H_0 is rejected and H_a is accepted
2. If Asymp.Sig (2-tailed) > 0,05, it is H_0 is accepted dan H_a is rejected.

Note:

H_0: There is no average difference between students' problem-solving abilities in the pre-test and post-test

H_a: There is an average difference between students' problem-solving abilities in the pre-test and post-test.

RESULTS AND DISCUSSION
Results

Flipbooks were developed using flip PDF professional software so that they can contain various multiple representation features. Besides that, flip PDF professional can also be accessed by all computers and smartphones without the need for additional software or other hardware. Here is an initial view of the MRBF.

Figure 2. The initial appearance of the flipbook when accessed via a computer

The flipbook was developed per the revised 2013 curriculum and discussed wave material. It was divided into three meetings with an allocation of about 45 minutes. The distribution of material for each session is as follows; the first meeting discussed waves; the second meeting discussed wave phases & symptoms (dispersion & reflection); and the third meeting discussed wave symptoms (refractions, diffraction, interference, & polarization). The flipbook is equipped with learning indicators, motivational videos or pictures, material descriptions, sample questions, guided exercises, and an understanding check column which contains a question link along with a link for collecting assignments and a summary of the material.

Flipbooks contain materials which emphasize visualization, such as verbal representations, images, graphics, mathematics, and audio-visual (video or simulation), aiming to improve students' problem-solving abilities. The following is an example of a presentation of various representations in the flipbook.
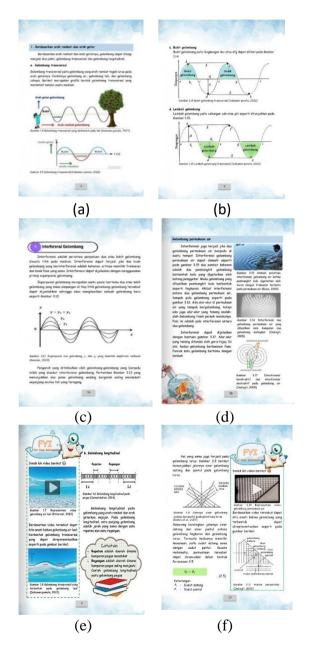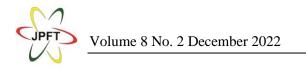

Figure 3. Explanation of the material with various representations such as (a) verbal and picture, (b) picture, (c) verbal and graphic, (d) verbal, animated, and visual, (e) video and image; (f) video, image, and mathematical formula
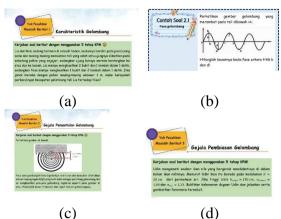
(a)

(b)

(c)

(d)

Figure 4. Various problem formats, including; (a) verbal, (b) graphic, (c) picture, and (d) mathematical

Example questions include solutions equipped with steps of problem-solving abilities adapted from Heller et al., namely; visualizing problems, describing the problems as physics concepts; planning solutions; carrying out problem solving; and re-checking and evaluating, as shown in the following figure.

Figure 5. Problems with problem-solving skills

Example questions, guided exercises, and follow-up exercises also contain multiple verbal, image, graphic, and mathematical representations. The following is an example of a question format presentation in the flipbook.

MRBF that has met the content and construct validity criteria is then tested in physics learning in the classroom. The results of the students' problem-solving ability are contained in Table 1.

Table 1. The results of the analysis of students' problem-solving abilities

Indicators	Pre-test		Post-test	
	Mean	Criteria	Mean	Criteria
Visualizing	0.00	VP	58.34	F
Presenting	21.39	L	94.45	VG
Planning	12.78	VP	86.95	VG
Implementing	10.78	VP	78.83	G
Evaluating	3.75	VP	78.96	G
Average	**12.17**	**VP**	**84.80**	**VG**

Note: VP = Very Poor, L = Less, F = Fair, VG = Very Good

Based on Table 1, there are stages of student problem-solving abilities after they have been given the treatment. At the stage of visualizing the problem, it meets the good category. The stage of presenting and planning a solution meets very good category. The stage of problem-solving, re-checking, and evaluation meets the good category. However, the average problem-solving ability before and after the flipbook was implemented increased from 12.17 (very poor) to 84.80 (very good). This is confirmed by the Wilcoxon test results in Table 2.

Table 2. Wilcoxon test results

N	Z	Asymp.Sig(2-tailed)
20	-3.920	0.000

Table 2 shows that the results of the Wilcoxon signed test obtained a Z value of -3.920 and Asymp. Sig (2-tailed) value of $0,00 < 0.05$, meaning that H sub 0 is rejected and H sub is accepted, meaning that there is an average difference between students'

problem-solving ability at the pre-test and post-test with the post-test being greater than the pre-test by 3.920. Thus, the flipbook that was developed was effectively used in physics learning.
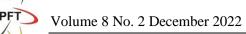
Discussion

Effectiveness is the suitability of a person to carry out a task to the intended target where the influence and results obtained from the implementation of the study are by the specified goals or objectives (Rohmawati, 2015). Product effectiveness is defined as the achievement of learning objectives carried out by students and the learning receiving a positive response from students. The effectiveness can be known through student learning outcomes. Rahmatullah et al. (2022) said that less effective learning tends to produce poor learning outcomes.

The student's learning outcomes in this study were in the form of pre-test and post-test questions, as many as six description questions, in line with the statement of Rahmatullah et al. (2022). The latter also said that so far, physics students' problem-solving ability is still low. This is to the results of students' problem-solving skills based on the pre-test, as shown in Table 2, because at the time of the pre-test, most of the students were still unable to visualize problems, present problems into physics concepts, plan solutions, carry out problem-solving, and evaluate or re-check and evaluate. Only a few students can present, design, and implement problem solving; even then, the answer is still not entirely correct.

After learning using multiple representations based on the flipbook, an increase in the students' problem-solving is obtained, as shown in Table 1 for the post-test. Some improvements vary from very good to good to moderate. This is because

students are still not fully precise in visualizing the problem but can correctly answer the variables that are known and asked in the questions. Students incorrectly determined the formula and problem-solving because several questions fall into the cognitive domain of C4 (analysis). According to Widhiyani et al. (2019), questions with the level of analysis, namely questions that separate material into its constituent parts and determine their relationship, both between legs and as a whole. More emphasis is placed on operational critical thinking at the level of analysing students. The analysis level consists of the ability or skill to distinguish, organize, connect and present the questions in the form of an image format. In addition, the possibility of students experiencing errors in translating questions, students' lack of understanding in solving problems, and counting errors resulted in students not understanding how to work on questions wholly and correctly (Nabilah et al., 2020).

The limited time allocation in learning is also one of the reasons why some stages of problem-solving abilities in each question get a good category. This is because the researchers did not have time to explain some of the questions to completion due to limited learning time, causing students to make mistakes in working on these questions. Although there are several problem-solving ability questions whose indicators or stages reach the good category, this research continues to experience improvement in each question's overall stage of problem-solving ability. This is because students' problem-solving scores will increase. After all, each meeting is continually trained on problem-solving steps (Ramadhanti et al., 2020). Overall, the achievement of students' problem-solving abilities was first tested from the pre-test, then given treatment using a flipbook based

on multiple representations, followed by doing the post-test to get an increase.

The Wilcoxon test has been developed to determine the effectiveness or ineffectiveness of a flipbook containing multi-representation. Table 2 shows no decrease in scores from pre-test to post-test and that 20 students experienced an increase in scores from pre-test to post-test. The conclusion from the Wilcoxon test results in Table 3 shows that asymp.sig (2-tailed) has a value of $0.00 < 0.05$, so H_0 is rejected and H_a is accepted. This means that flipbook with multi-representation can be said to be effective because there is an increase from the pretest to the post-test, as seen from the Z value of -3.920, which means the post-test is greater than the pretest. If the H_a is accepted, there is a difference in value between the pre-test and post-test. Based on this, the flipbook has been effectively used in learning physics. This is in line with the opinion of Rohmawati (2015), who says that effectiveness is the level of success of the objectives of the learning process using the developed product.

CONCLUSION

Multi-representational flipbooks effectively improve students' problem-solving abilities in physics learning because the study results show that the application of flipbooks significantly impacts students' problem-solving abilities from very poor to very good. Through this flipbook, students are accustomed to using technology to visualize problems, present, plan and implement problem solving, as well as evaluate the resulting solutions. Further research is large-scale research unearthing students' problem-solving and multiple representation abilities.

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