Effectiveness of E-Worksheets on Problem-Solving Skills: A Study of Students' Self-Directed Learning in the Topic of Ratios

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Article Info

Abstract

This study investigates the effectiveness of E-Worksheets in enhancing students' problem-solving skills, with a specific focus on self-directed learning, in the topic of ratios. The research examines the impact of technology-based learning tools on students' ability to solve problems and explores the relationship between self-directed learning and problem-solving abilities. The study employs a control group design, comparing the performance of students using E-Worksheets with those in a control group. The findings indicate that the use of E-Worksheets significantly improves students' problem-solving skills compared to the control group. Moreover, the analysis reveals a positive association between students' level of self-directed learning and their problem-solving abilities. These findings support the integration of technology in the learning process to create interactive and engaging experiences that foster problem-solving skills. The study emphasizes the importance of cultivating students' self-directed learning and recommends strategies for educators to promote independent problem-solving and collaboration among students. The implications of this research contribute to the understanding of the role of E-Worksheets and self-directed learning in enhancing problem-solving skills and provide valuable insights for future research and educational practices.

Introduction

Advancements in science can serve as an effective and efficient means to support the learning process (De Jong, 2006). Utilizing a wide range of technology-based multimedia tools can make the learning process more engaging (Sarker et al., 2019). Information technology has become essential in society, including the field of education (Zuboff, 2015). The development of information technology has had a significant impact on various aspects of life, particularly in education, leading to an improvement in the quality of education (Palvia et al., 2018). The balanced and appropriate use of smartphones and the internet, especially in the realm of education, can drive progress and development in the field, in alignment with the advancements in information and communication technology (Mitra, 2023). The

use of smartphones and the internet has been introduced even in kindergarten and playgroups (Kapaniaris & Zampetoglou, 2021). Similarly, both teachers and students engage with computer-based media and the internet for their educational activities at school (Almaiah et al., 2020).

In 2020, learning patterns in Indonesia underwent a shift from offline to online systems to support government policies in preventing the spread of COVID-19 (Setiana et al., 2021). As a result, teacher-student interactions no longer took place directly at school but rather through virtual/online media (Neuwirth et al., 2021). Online learning utilizes various technologies such as Google Classroom, WhatsApp, Zoom, and others (Singh et al., 2020). Mathematics, as an area of education, plays a crucial role in enhancing the quality of life by equipping students with problem-solving skills applicable to everyday situations (Firdaus & Herman, 2017). Mathematics is a subject taught to all students but is often perceived as challenging (Depaepe et al., 2013). Its purpose is to develop students' logical, analytical, systematic, critical, creative, and cooperative thinking abilities (Yayuk & As' ari, 2020). Therefore, alternative learning methods are needed to make mathematics less monotonous and more engaging for students (T. L. Toh et al., 2017). Learning mathematics helps cultivate students' problem-solving mindset (Laurens et al., 2017), and the process of actively addressing a given problem is referred to as problem-solving (Schoenfeld, 2016).

Problem-solving is one of the objectives in the learning process (Dumas et al., 2016). The importance of problem-solving in learning is also emphasized by the National Council of Teachers of Mathematics (NCTM). NCTM (2000) stated that the mathematical thinking process in mathematics learning includes five main standard competencies: problem-solving skills, reasoning skills, connection skills, communication skills, and representation skills (Al-Mutawah et al., 2019). The low ability in problem-solving will result in low quality of human resources, as reflected in their limited problem-solving skills (Korkmaz et al., 2020).

The problem-solving process is one of the important elements for students in incorporating real-life problems, so that by incorporating problems into real life, students will be able to easily solve problems, especially math problems that exist in everyday life (Docktor et al., 2015). Therefore, instilling problem-solving skills in students is important so that they can become accustomed to solving problems effectively, both in mathematics and in everyday life, enabling them to face challenges (Kusumaningrum et al., 2020). One of the subjects in mathematics lessons that is related to problem-solving is Ratio, due to the application of comparison concepts found in everyday life (Shield & Dole, 2013). Solving ratio problems usually requires a clear understanding and often takes the form of story problems (Pisano, 2015). The lack of student learning independence is one of the factors that can contribute to this problem (Falloon, 2013).

Self-directed learning refers to the independent pursuit of knowledge, skills, and achievement without relying on external assistance. It involves individuals taking control of their own learning process by determining and managing their own study materials, schedule, learning environment, and utilizing various educational resources (Abidah et al., 2020). This autonomy allows individuals to take

ownership of their learning, cultivate a strong sense of responsibility, and effectively utilize available learning resources (Tarrant & Thiele, 2016). Self-directed learning is also valuable in equipping individuals with the ability to address challenges and solve problems by drawing upon their existing knowledge and competencies (Lee & Hannafin, 2016). Insufficient independence in student learning, particularly in the context of mathematics education, can hinder the comprehension of subject matter and subsequently impact students' problem-solving abilities (Laurens et al., 2017).

In reality, students' proficiency in solving comparison problems remains subpar, as evidenced by their low scores in mathematics assessments related to comparison topics (Hill & Chin, 2018). Many students tend to passively receive information presented by teachers and rely heavily on them for guidance (Chase et al., 2019). There is a lack of initiative in seeking information from alternative sources. Consequently, fostering learning independence becomes crucial to instill a sense of responsibility and self-discipline in students, as well as to enhance their ability to independently develop their learning skills (ŞİMŞİR & DİLMAÇ, 2020). To support students' problem-solving abilities and foster their independence, the use of appropriate learning media is essential. These learning materials should enable students to gain a better understanding of mathematics concepts and topics.

The utilization of interactive E-worksheets as a form of current online learning media has been shown to effectively enhance student learning independence (Asrial & Ernawati, 2020). Moreover, it has proven to be instrumental in improving problem-solving skills in the context of mathematics education. The creation of these interactive E-worksheets can be facilitated through platforms such as Liveworksheet, an online application that enables the development of interactive materials and student worksheets. Liveworksheet offers a range of features, including the incorporation of learning videos from YouTube, PowerPoint presentations, links, multiple-choice questions, drop-down questions, matching exercises, drag-and-drop activities, listening exercises, voice responses, and essay-type answers (Prabjandee, 2023). The student activity sheets encompass tasks that students are required to complete.

Based on the observations, it is concluded that distance learning is being conducted through WhatsApp Group and Google Classroom, utilizing PowerPoint as a medium, and supplemented with assignments. The incorporation of interactive E-Worksheet media aims to provide students with easier access to PowerPoint presentations and learning videos without the need to open YouTube separately. This integration is expected to enhance students' comprehension of the material and promote greater independence in their learning process.

In an effort to address this challenge, it is crucial to provide students with effective learning media that aligns with the current online learning environment and facilitates a better understanding of mathematics topics. Additionally, there is a need for easily accessible learning materials that do not burden students while enhancing their problem-solving skills and promoting their independence. Therefore, the researcher aims to investigate the following research questions: (1) Is there a variation in problem-solving ability among students with high, medium, and low levels of independence? (2) Does

the use of e-worksheets significantly affect students' problem-solving ability compared to traditional learning methods? (3) Is there an interaction effect between e-worksheets and learning independence on students' problem-solving ability?

Method

This research is a quantitative research with a quasi-experiment approach (Mishra & Alok, 2022). In this study there were two classes used, namely the experimental class and the control class. The design used in this study was Post-Test Only Control Group design. The subject retrieval technique uses cluster random sampling where the researcher divides the population into several separate groups and takes class VII C and class VII D with 29 students and 31 students respectively. The data collection technique uses documents to collect initial ability data, questionnaires are used to determine the level of student independence, and tests are used to determine students' problem-solving skills. The instruments used in this study are student learning independence questionnaire and problem-solving ability test. Data analysis in this study used inferential statistical analysis. Inferential statistical analysis consists of prerequisite analysis test (normality test and homogeneity test), t test, hypothesis test, and further test. Hypothesis testing uses variance analysis with the help of SPSS with a significant level = 0.05. The test criteria with $sig < 0.05$ then Ho is rejected or $H1$ is accepted.

Results

The results of this study were conducted by giving a learning independence questionnaire to determine the level of student learning independence in the experimental class and control class. After filling out the questionnaire, each class was given material and worked on practice questions. The experimental class used e-worksheet media while the control class did not use e-worksheet media. Then students complete the problem-solving ability test questions to determine the level of problem-solving ability.

Questionnaire Results
Based on the questionnaire given to the experimental class and control class in class VII students of SMP Negeri 3 Sewon, differences in the level of student learning independence were obtained. The following is the difference in the level of student learning independence in the experimental and control classes presented in Figure 1.
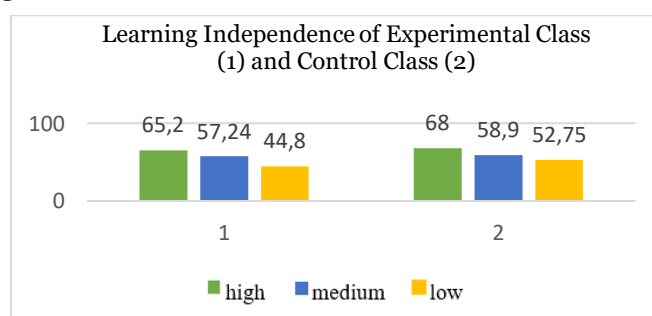

Figure 1. Average Student Learning Independence

The learning independence of experimental class students is not much different from the learning independence of the control class (see Fig.1). In the experimental class, there were 5 students with an average independence level of 65.2, 21 students with an average independence level of 57.24, and 5 students with an average independence level of 44.8. Then in the control class, the level of high independence category was 5 students with an average of 68, the level of moderate independence was 20 students with an average of 58.9, and the level of low independence was 4 students with an average of 52.75. The level of moderate independence occupied the largest number in the experimental and control classes.

T t9oest

The t test is used to determine whether the initial ability data have the same average or not. Initial ability data is taken from 2021/2022 UAS data for classes VII C and VII D. The t test criteria are accepted if the sig. (2-tailed) value> 0.05 then there is no difference in average if the sig. (2-tailed) value <0.05 then there is a difference in average. This t test can be done if the data is homogeneous and normally distributed. Based on the results of the calculation, the significance value of the initial ability data is 0.264. This shows that the sig value = 0.264 <0.05 means that there is no difference in average so that the initial ability of experimental and control class students is the same.

Problem Solving Ability Test Results

Based on the results of the test scores given to the experimental class whose learning used e-worksheets, there was a more significant increase in problem solving ability than the control class whose learning did not use e-worksheets. The following is the difference in the test scores of the problem-solving ability of the experimental class and the control class presented in Table 1.

Table 1. Difference in Problem Solving Ability Score

Statistics	Statistical Value	
	Experimental class	Control Class
Number of Samples	31	29
Lowest Score	70	61
Highest Score	98	90
Average Value	81,87	68,10
Standard Deviation	16,90	15,51

The problem-solving ability of the experimental class treated in the learning process using e-worksheets through Liveworksheet.com shows a significant average compared to the control class (see Table 1). This means that the problem-solving ability of students in the experimental class is better than students in the control class.

Normality Test

The normality test aims to determine whether the sample used comes from a normally distributed population or not. One of the statistical tests of normality test is Kolmogorov-Smirnov test. Data is said to be normal if the significance value is> 0.05, while if the significance value is <0.05 then the data is said to be not normally distributed. The following are the results of the normality test in Table 2.

Table 2. Normality Test Results

Data	Sig Value	Description
Experimental Class Initial Ability Score	0,099	Normal
Initial Proficiency Score of Control Class	0,170	Normal
Experiment Test Score	0,079	Normal
Control Test Score	0,052	Normal

The significance value using the Kolmogorov Smirnov test statistic is> 0.05, so it can be concluded that the sample data for the initial ability scores and test scores of the experimental and control classes are normally distributed (Table 2).

Homogeneity test

The homogeneity test of the sample aims to conclude whether the sample groups used come from a population that varies equally or not. Levene's test is one of the homogeneity tests. Data will be homogeneous if the sig value > 0.05 if the sig value < 0.05 then the data is not homogeneous. The following are the results of the homogeneity test conducted in Table 3.

Table 3. Homogeneity Test Results

Data	Sig Value	Description
Preliminary Ability Score	0,412	Homogen
Test Score	0,465	Homogen

The initial ability value and test score are > 0.05, meaning that the initial ability value data sample and the test scores of the experimental class and control class have the same variance or homogeneous (see Table 3).

Hypothesis Test

After the prerequisite test is carried out and it is proven that the data processed are normally distributed and homogeneous, then proceed with hypothesis testing. Hypothesis testing uses the help of IBM SPSS Statistic 25. Hypothesis testing criteria are if the sig value> 0.05 then H0 is accepted H1 is rejected, if the sig value <0.05 then H0 is rejected H1 is accepted. The following ANOVA test results have been carried out in Table 4.

Table 4. Hypothesis Test Results

Tests of Between-Subjects Effects					
Dependent Variable: tes_ek					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4719.595[a]	5	943.919	3.799	.005
Intercept	210030.158	1	210030.158	845.218	.000
Class	1793.546	1	1793.546	7.218	.010
Learning Independence	1836.756	2	918.378	3.696	.031
Class * Learn Indep	58.792	2	29.396	.118	.889
Error	13418.588	54	248.492		
Total	357591.000	60			
Corrected Total	18138.183	59			
a. R Squared = .260 (Adjusted R Squared = .192)					

The significance value in the learning independence row = 0.031 > 0.05 then H0 is accepted and H1 is

rejected (see Table 4). This means that there is a difference in problem solving ability between students who have low, medium, and high learning independence. The significance value in the class row = 0.010 < 0.05 then H0 is rejected and H1 is accepted. This means that there is a difference in problem solving ability between students whose learning uses e-worksheet and without using e-worksheet. The significance value in the row of class * learning independence = 0.889 > 0.05 then H0 is accepted and H1 is rejected. This means that there is no interaction between the use of e-worksheet in terms of learning independence on students' problem-solving skills.

ANOVA Post-Test

In hypothesis testing there are two hypotheses that are proven, namely the first hypothesis there are differences in problem solving skills between students who have high, medium, and low independence. Then the second hypothesis there is a difference in problem solving ability between students whose learning uses e-worksheet and does not use e-worksheet. The marginal mean test was conducted to show these differences systematically. The following marginal mean results are shown in Table 5.

Table 5. Marginal Averages

| Class | Level of Learning Independence | | | Marginal Mean |
	High	Moderate	Low	
Experiment	88,8	82,5	72,4	81,23
Control	78,8	68	55,8	67,53
Marginal Averages	83,8	75,25	64,1	

The marginal mean in the experimental class is 81.23 and the marginal mean in the control class is 67.53 (see Table 5). It shows that the problem solving ability of students whose learning uses e-worksheet is better than students whose learning does not use e-worksheet. Then seen in between columns shows that learning independence in the high-medium category and the medium-low category does not show a significant difference, but in the high-low category learning independence shows a significant difference.

Post anova post-test was carried out using the Scheffe method. The Scheffe test was conducted to determine which significant difference in problem solving ability with math learning independence was better. The following Scheffe test results are shown in Table 6.

Table 6. Scheffe Test Results

Multiple Comparisons: Scheffe Test						
					95% Confidence Interval	
(I) learning independence	(J) learning independence	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	8.43	5.560	.324	-5.56	22.43
	3	18.80*	7.243	.042	.57	37.03
2	1	-8.43	5.560	.324	-22.43	5.56
	3	10.37	5.803	.212	-4.24	24.97
3	1	-18.80*	7.243	.042	-37.03	-.57
	2	-10.37	5.803	.212	-24.97	4.24
Based on observed means.						
The error term is Mean Square(Error) = 248.492.						
*. The mean difference is significant at the .05 level.						

Based on the results of the analysis presented in Table 6, it shows that the sig. value on learning independence between the high and medium categories (1-2) is 0.324> 0.05 then H0 is accepted and H1 is rejected. This means that there is no significant difference in problem solving ability between students who have high independence and students who have moderate independence. The sig. value on learning independence between high and low categories (1-3) is 0.042 < 0.05, so H0 is rejected and H1 is accepted. This means that there is a significant difference in problem solving ability between students who have high independence and students who have low independence. The sig. value on learning independence between the medium and low categories (2-3) is 0.212 > 0.05 then H0 is accepted and H1 is rejected. This means that there is no significant difference in problem solving ability between students who have moderate independence and students who have low independence.

Discussion

This research demonstrates that the use of E-Worksheets significantly improves students' problem-solving skills compared to the control group that did not use E-Worksheets. These findings indicate that technology-based learning approaches, such as E-Worksheets, can provide tangible benefits in developing students' problem-solving abilities. Previous research supports these findings, as Puspita et al. (2022) concluded that the use of technology-based learning tools can enhance students' problem-solving skills and critical thinking abilities. This suggests that the integration of technology in the learning process can provide a more interactive and engaging learning experience, thereby strengthening students' problem-solving abilities.

The Scheffe test analysis results indicate a relationship between students' level of self-directed learning and their problem-solving abilities. Students with high levels of self-directed learning demonstrate better problem-solving abilities than those with low levels of self-directed learning. This supports the constructivist learning theory, which emphasizes the active role of students in learning (Xu & Shi, 2018). According to this theory, when students have high levels of self-directed learning, they are more likely to take initiative, think critically, and independently overcome challenges. As a result, they have better problem-solving abilities. Previous studies have also shown a relationship between self-directed learning and problem-solving abilities. Research by Hwang and Oh (2021) found that students with high levels of self-directed learning have better problem-solving abilities. This highlights the importance of developing students' self-directed learning in efforts to enhance their problem-solving abilities.

The use of E-Worksheets as a learning tool can be recommended to improve students' problem-solving abilities (Kusno & Setyaningsih, 2021). Through the integration of technology in learning, teachers can provide a more engaging, interactive, and adaptive learning experience, which can enhance students' motivation and engagement in the learning process (Fachrunisa et al., 2022; Lestari et al., 2022; Parisa et al., 2023; Puspita et al., 2022; Wulandari et al., 2022). It is important for educators to pay attention to and develop students' self-directed learning. Adequate support and guidance can help students

develop their self-directed learning, which, in turn, strengthens their problem-solving abilities (Zhoc et al., 2018). Teachers can implement teaching strategies that encourage students to take initiative, think critically, and seek solutions independently. Additionally, collaborative learning can be used to promote self-directed learning, where students work together in groups to solve problems and support each other (Mentz & Van Zyl, 2018).

The importance of developing students' self-directed learning can also be integrated into the curriculum and assessment (W. Toh & Kirschner, 2020). Learning that focuses on the development of problem-solving skills and self-directed learning can be systematically measured and evaluated (Wong et al., 2021). Teachers can use assessment rubrics that measure students' abilities to identify problems, formulate strategies, implement appropriate methods, and evaluate problem-solving outcomes.

Based on the findings of this research, there are several implications and recommendations that can be proposed for future research and learning practices. The use of E-Worksheets as a learning tool can be more widely implemented in educational contexts. Teachers can integrate this technology into their instruction to enhance student engagement and learning effectiveness. It is important to give special attention to the development of students' self-directed learning. Teachers can design learning strategies that promote self-directed learning, such as assigning tasks that require independent problem-solving, providing opportunities for students to take initiative in the learning process, and providing feedback that facilitates reflection and self-assessment.

This research provides valuable contributions to our understanding of the use of E-Worksheets and students' self-directed learning in improving problem-solving abilities. The implications and recommendations generated can serve as a foundation for further research and development efforts in enhancing learning and student outcomes in the future.

Conclusion

This study highlights the effectiveness of E-Worksheets in enhancing students' problem-solving skills, particularly when combined with a focus on self-directed learning. The findings indicate that the integration of technology-based learning tools, such as E-Worksheets, can significantly improve students' ability to solve problems. Moreover, the analysis reveals a positive relationship between students' level of self-directed learning and their problem-solving abilities. The results align with previous research, emphasizing the importance of technology integration and the development of students' self-directed learning for enhancing problem-solving skills. Teachers can utilize E-Worksheets to create engaging and interactive learning experiences, fostering students' motivation and involvement in the learning process. Cultivating students' self-directed learning skills through appropriate support and guidance can further strengthen their problem-solving abilities.

It is recommended that educators incorporate E-Worksheets as a valuable learning tool and consider

strategies that promote self-directed learning within the curriculum. By providing opportunities for students to take initiative, think critically, and collaborate with their peers, teachers can enhance problem-solving abilities and overall learning outcomes. Furthermore, assessing and evaluating problem-solving skills and self-directed learning can be integrated into the assessment process through the use of appropriate rubrics and evaluation methods. This research contributes to the existing body of knowledge on the effectiveness of E-Worksheets and the significance of self-directed learning in the context of problem-solving. The implications and recommendations provided can guide future research and inform educational practices to optimize learning experiences and outcomes for students. The findings underscore the value of technology integration, particularly the use of E-Worksheets, in promoting students' problem-solving skills, while emphasizing the importance of nurturing self-directed learning abilities to further enhance their problem-solving capabilities.

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