

Evaluating the Impact of Web-Assisted Teaching at the Right Level (TaRL) in Improving Mathematical Problem Solving Skills

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Abstract

This research was motivated by the observed low ability of students to solve mathematical problems effectively. To address this issue, the Teaching at the Right Level (TaRL) approach, which adapts instruction based on students' current learning levels, was applied in combination with web-assisted learning tools to enhance engagement and accessibility. The web-assisted TaRL approach integrates adaptive teaching with online materials such as concept maps, interactive videos, and assessments tailored to student needs. The study aimed to evaluate the effect of this approach on students' mathematical problem-solving skills. Using a posttest-only control group design, 70 students were purposively sampled and divided into an experimental group (34 students) receiving the web-assisted TaRL intervention, and a control group (36 students) undergoing conventional learning. The assessment consisted of three validated descriptive questions measuring problem-solving ability. Results showed that the experimental group achieved a higher average score (82.45) compared to the control group (65.65). Both groups met assumptions of normality and homogeneity, confirming the appropriateness of parametric testing. The independent samples t-test revealed a statistically significant improvement ($p < 0.05$) in the experimental group's problem-solving skills. While these findings support the effectiveness of the web-assisted TaRL approach, limitations include the relatively small sample size and short intervention duration. Future research should consider larger, more diverse populations and explore long-term effects to strengthen generalizability and further optimize the integration of technology in adaptive learning.

Keywords: *mathematics, problem solving, TaRL, Web*

Introduction

Education is one of the best investments. In education, individuals are trained to develop (1) critical thinking skills, skills that can develop the ability to logically analyse information, solve problems, and make informed decisions (Facione, 2011), (2) collaboration skills, improving the ability to work with others to achieve goals (Johnson & Johnson, 2009), (3) digital literacy skills, the ability to search, use, evaluate and develop digital technology (Ng, 2012), (4) effective communication skills, the ability to express orally, in writing, express ideas through graphs, tables (Hodiyanto, 2017), (5) problem-solving skills, is one of the abilities that students must master as a basic cognitive process to survive in the modern world (Md, 2019). In mathematics, the development of these abilities is given since basic education. Because mathematics is the basis of various other sciences, it trains students to think logically, effectively, creatively and systematically so that students are expected to face various problems (Sharma, 2021). Mathematics emphasises the thinking process (Nizaruddin & Kusmaryono, 2023). The thinking process was needed to solve problems (Purwanto et al., 2019). Therefore, structured and reflective thinking skills become the key to effectively developing problem-solving abilities.

The development of problem-solving skills through education contributed to the formation of individuals who were independent, innovative, and able to adapt to change (Tan et al., Kim et al., 2018; Kivunja, 2014). Mathematical problem-solving was the basis of action, the driver of change and the foundation of mathematics learning (Muhtarom, 2024). In problem-solving, individuals can critically analyse situations, evaluate various alternatives and get the best solution based on available information (Alkhatib, 2019). There was a need to involve and train students in problem-solving creativity (Hobri et al., 2018). Accurately teaching materials help improve problem-solving skills (Alghiffari et al., 2024) (Wulansari et al., 2023). Participation in students' confidence to be active, creative, and independent played a role in problem-solving skills (Nugroho, Aryo Andri, 2019).

The OECD report (Know & Do, 2019) stated that from the 2018 Programme for International Student Assessment (PISA) results involving an average of 600,000 students aged 15 years from various countries, for mathematics skills, Indonesia obtained an average score of 379 out of 489. This means Indonesia's mathematics skills were far below the world average (Laela et al., 2024; Prima Riyani & Muhamad Sofian Hadi, 2023). Over 60% of children from low- and middle-income countries do not have minimum maths and reading proficiency (Sawada et al., 2024). From research (Rahmadi et al., 2024) in solving description problems, students' problem-solving skills were still weak. The same thing was reinforced by (Nugroho, Aryo Andri, 2019; Yuwono, Timbul, Mulya Supanggih, 2018) students' weaknesses in problem-solving are identifying and writing down important information.

Teaching at the Right Level (TaRL) is an effective learning approach to developing problem-solving skills. The TaRL approach allows students to learn at their own pace to gradually build an understanding of the concepts and skills needed for problem-solving. Teachers have a big role in creating learning that suits students' needs and characteristics (Al-Mahasneh, 2018; Isman, A. & Dabaj, 2004; Vermunt, 2007). TaRL is an inclusive and effective teaching solution that empowers students (Ananda, I.I. Ulfa, J.F., & Yorianda, 2024). TaRL is a methodology for improving reading and maths skills (UNICEF, 2023). TaRL is a programme that has high effectiveness in improving learning outcomes (Indah Melati Sukma et al., 2024; Mustafa et al., 2024; Najah et al., 2024; Tailor, 2022).

In the study by Muammar et al.(2023) stated that the TaRL approach increased the completeness of the average score from 66 to 81.36, and the number of students who completed from 20 students to 33 students increased by 86.84%. This is reinforced by the research of Rofiqi & Ervina (2024), which found that the completeness of learning outcomes with the TaRL approach classically was 91.67%, and discussion skills were 85.67%. Moreover, the research of James and Abubakar (2024) stated that TaRL is effective in improving primary school counting skills. Khaerunisa's research (2024) showed an effective increase in ability after using the TaRL approach, as shown by the significant difference between the pretest and posttest results. Overall, these findings indicate that the TaRL approach, especially when supported by web-based media, consistently has a positive impact on improving students' academic achievement and mathematical skills, particularly in problem-solving.

The TaRL approach that emphasises learning differentiation can be optimally realised through Web-based learning media. This digital platform allows teachers to create learning activities tailored to individual students' needs and interests. The web is a cost-effective multimedia tool used globally (Killedar, 2008). It was an effective learning medium process (Manzoor et al., 2012; Satriani et al., 2024). Interactive websites were highly recommended to improve problem-solving skilpuls (Alkhatatneh, 2023). Kay's research (2014), which stated that web media improved student learning outcomes, was reinforced by (Al-Duhani et al., 2023) which stated that the web as a virtual laboratory improved student cognition. Thus, the

integration of web technology into TaRL strengthens the effectiveness of this approach in enhancing student engagement and learning outcomes, particularly in mathematical problem-solving skills.

The purpose of this study is to evaluate the impact of integrating web technology into the Teaching at the Right Level (TaRL) approach in improving students' mathematical problem-solving skills. Specifically, this research aims to determine the extent to which web-assisted learning can enhance the effectiveness of TaRL in improving students' academic achievement, engagement in the learning process, and their ability to analyze, understand, and systematically solve mathematical problems. This study also seeks to provide empirical evidence on the potential synergy between ability-level-based pedagogical approaches and the utilization of technology within the context of mathematics education at the elementary school level.

Method

This study used a quasi-experimental method with a posttest-only control group design. In this design, two groups of students are compared based on the results of the posttest after the treatment is given, without a pretest beforehand. This design was chosen to avoid potential pretest effects that could affect student learning outcomes.

Table 1. Research Design

Class	Treatment	Posttest
Experiment Class	X_1	O
Control Class	X_2	O

Description:

X_1 = Web-assisted TaRL approach treatment

X_2 = Conventional treatment

O = Final test after treatment

This research was conducted di kelas sepuluh at SMAN 4 Semarang in November 2024. Furthermore, two sample classes were used in the study. Sampling was done using a purposive sampling technique; sampling from the population was not randomised but determined by the researcher.

Of the 70 students as research subjects, the experimental class followed 34 students (48.57%) and the control class 36 students (51.43%), consisting of 27 male students (38.57%) and 43 female students (61.43%), where the ability of 10 students (14.28%) in the high category and 60 students (85.72%) in the medium category. The data is presented in Table 2.

Table 2. Demographics of the research sample

	Demographic	Frequency	Presentation
Class	Experiment	34	48,57 %
	Control	36	51,43 %
Gender	Male	27	38,57 %
	Female	43	61,43 %
Ability Level	High	10	14,28 %
	Medium	60	85,72 %

In the experimental class, the research was conducted with a web-based Teaching at the Right Level (TaRL) approach. The first thing to do was to analyse students' initial abilities. The

results of the analysis were used to create web-assisted learning media. While in the control class, learning was done conventionally, without the help of learning media.

This research instrument refers to Polya's problem-solving skills (Jatisunda & Nahdi, 2020; Yuwono et al., 2018), namely: (1) understand the problem or identify information from known data. (2) plan and identify information obtained as a strategy to get a solution. (3) perform calculations using methods/procedures/algorithms that are mastered. (4) conclude the results of the calculations that have been done after checking again.

According to Polya, the indicators are derived into sub-indicators and student question responses. The scoring guidelines were adopted according to Aryani's (2017).

Table 3. Problem-Solving Indicators

Table 3: Problem Solving Indicators			
Problem-Solving Indicators	Sub Indicators	Score	Student Response to Problems
Understanding the Problem	Identifying important elements in Problem	1	There is an attempt to identify known elements asked, but it is still wrong.
		2	Can identify the elements known and ask to obtain part of the solution, but it is still incomplete.
		3	Identification of elements is complete and correct.
Planning the Solution	Formulate a solution strategy using trigonometric concepts	1	The strategy is irrelevant and leads to the wrong answer.
		2	The strategy is correct.
Performing Calculations	Performing Calculations	1	There is a solution, but it is still wrong.
		2	Solved the problem, but there was a mistake in the calculation..
		3	Able to solve the problem and perform calculations correctly.
Concluding Results	Concluding the calculation results	1	The conclusion given is wrong.
		2	The conclusion given is correct.
Maximum Score		10	

Three questions were used as a posttest of problem-solving ability and tested for validity and reliability. The validity test used the Pearson Validity formula, consulted on the r table with $\alpha = 5\%$ and the reliability test used the Cronbach-Alpha Reliability formula, consulted on the -table value at $\alpha = 0.05$ with $n = 70$. From the results of the validity and reliability of the questions, the following data were obtained:

Table 3. Validity of questions

	Problem 1	Problem 2	Problem 3
r_{xy}	0,692	0,823	0,843
r table (95%, 70)	0,235	0,235	0,235
Description	valid	valid	valid

Table 4. Reliability of questions

Variant Item	Total Var Item	Var Total	Reliability
2,8491	13,4663	24,6170	0,6795
3,5644			
7,0528			

Based on Table 3 and Table 4, the three questions meet the validity and reliability criteria, and then the questions can be used to measure the post-test of problem-solving ability. Data on post-test results will be used to analyse the normality and homogeneity of both experimental and control classes. The data was declared normally distributed with homogeneous variance if the sig value obtained was $> 5\%$. Meanwhile, to test whether the TaRL approach with the help of the web influences problem-solving ability, the independent t-test is continued. Terms used if the value of sig $> 5\%$, the TaRL approach, with the help of the web, influences the ability to solve problem-solving skills for the technical analysis of this data using IBM SPSS 27 statistical calculations.

Results

The TaRL approach was implemented through a web platform that provided materials aligned with students' needs, including clearly defined learning objectives, concept maps, ebooks or instructional videos, interactive games, formula summaries, and assessments. The web-based format allowed for more manageable content organization and enabled students to access the materials at any time.

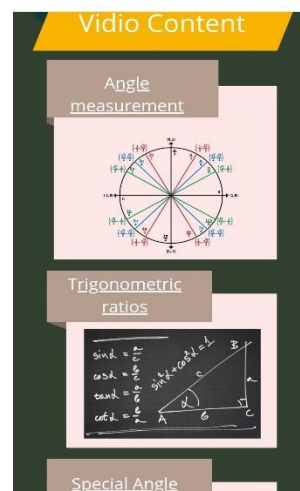


Figure 1. Web Content

The results of the research that has been carried out can then be reported as follows:

Table 5. Descriptive Statistics of Problem-Solving Ability

Class	N	Min Score	Max Score	Mean	Std. Deviation	L Count	L Table
Experiment	34	60,00	96,67	82,45	11,35	0,0947	0,1519
Control	36	16,67	93,33	65,65	16,63	0,0589	0,1477

Table 5 is the calculation of the normality test using the Lilliefors Test. The experimental class obtained an average value of 82.45, and the control class 65.65. With a standard deviation

in the experimental class of 11.35 and the control class of 16.63. In the experimental class $L_{count} = 0,0947 < L_{table} = 0,1519$, from the provisions that have been described, it was concluded that the data of the two samples were usually distributed. The control class obtained $L_{count} = 0,0589 < L_{table} = 0,1477$. It can also be concluded that the data was normally distributed.

Furthermore, the homogeneity test was conducted to determine whether the two sample classes had the same variance.

Table 6. Homogeneity Test		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	82,45098	65,64815
Variance	128,8275	276,7108
Observations	34	36
df	33	35
F	0,465567	
P(F<=f) one-tail	0,014835	
F Critical one-tail	0,562598	

Based on the results in Table 6, the calculated F value (0.465567) is less than the critical F value (0.565739), indicating that the variances of both groups are homogeneous. Therefore, the assumptions for parametric testing are satisfied, and an independent samples t-test was performed.

Table 7. Independent sample t-test

		Levene's Test for		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Differen	Std. Error	95% Confidence	
post_test	Equal variances assumed	2,116	0,150	4,909	68	0,000	16,802	3,423	9,973	23,632
	Equal variances not assumed			4,961	62,211	0,000	16,802	3,387	10,032	23,573

The experimental class was shown using IBM SPSS statistic 27 in Table 7. Sig value of $0.000 < 0.05$, indicating a difference in student learning outcomes between the experimental and control classes. It was concluded that applying the web-assisted TaRL approach to mathematical problem-solving skills had an effect.

Discussion

Mathematical problem-solving ability is important because it helps individuals overcome daily life problems (Özreçberoğlu & Çağanağa, 2018). Mathematical connections in the form of facts/data, concepts, principles, representations, and procedures were effective tools for problem-solving (Pambudi et al., 2020). Teachers must be able to develop learning approaches and teaching materials that improve students' problem-solving skills (Ulandari et al., 2019). Teaching at the Right (TaRL) was an appropriate pedagogical approach to addressing secondary school education (Ananda, I.I. Ulfa, J.F., & Yorianda, 2024). The TaRL approach provides a learning process that adapts students' abilities (Ananda, I.I. Ulfa, J.F., & Yorianda, 2024).

Teaching at the Right Level (TaRL) is an approach based on data and evaluation. It provides a learning process that adapts to students' abilities, and using learning aids, there is collaborative interaction. Website is an application that can be used as a learning tool,

customised to the student's learning needs. Applications that provide unlimited access to information are flexible and inclusive. Based on the research data, using web applications with the Teaching at the Right Level (TaRL) approach positively impacts the learning process, measured by mathematical problem-solving ability.

Referring to the research of Palayukan & Felix (2018), which was strengthened by Wulandari's research (2020), the cause of student errors in solving class x trigonometry problems was errors in understanding concepts and principles, so approaches and teaching media were needed that could strengthen student understanding in trigonometry material. The implementation of the research begins with analysing students' initial abilities to provide clues for researchers about what approaches and media are suitable for students so that learning can be adapted to the characteristics of students. Another research by (Mukti & Anggraeni, 2020; Pubian & Herpratiwi, 2022), stated that websites based on Google Sites are exciting learning media and can be developed by teachers to improve student learning outcomes.

The researcher also interviewed four students regarding the web as a learning medium. From the results of the interview, students like website media for learning; this is by research (Hasnaa & Sahronih, 2022; Rukun & Irfan, 2020; Wahyuni & Sudarma, 2018) that the delivery of material with website-based media will create active, effective and interactive learning, besides making it easier for students to understand the material because the material has been grouped according to student needs and proven to improve student learning outcomes. The content of the website can be in the form of audiovisuals needed by students to help students learn according to their learning style needs (Firdausia et al., 2020; Rahayu et al., 2019; Wahyuni & Sudarma, 2018). The website can also be used for learning wherever and whenever (Dinc, 2017; Sundresan et al., 2023).

Conclusion

The implementation of the Teaching at the Right Level (TaRL) approach assisted by web-based learning shows that students' mathematical problem-solving abilities improve compared to those in conventional learning settings. The web platform supports independent learning by allowing students to engage with materials tailored to their individual learning styles and abilities. Additionally, the flexibility to access the learning media anytime and anywhere enhances students' learning opportunities.

Despite these advantages, several factors need to be addressed to maximize the effectiveness of the web application, such as enriching the content to be more complete and engaging. As facilitators of education, teachers should actively utilize web-based learning media to align instructional materials with students' learning needs. This alignment is essential to boost student motivation and increase active participation throughout the learning process.

Acknowledgment

Thank you to Universitas PGRI Semarang, Postgraduate Programme in Mathematics Education and SMA Negeri 4 Semarang for helping to complete this research.

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