International Journal of Education, Vocational and Social Science
https://e-journal.citakonsulindo.or.id/index.php/IJEVSS
E-ISSN : 2963 4954
IJEVSS

The Effect Of The RUDIE Model On Senior High School Students' Digital Problem-Solving Skills

Rudi Ihwono
Universitas Muhammadiyah Malang, Indonesia
Mohammad Syaifuddin
Universitas Muhammadiyah Malang, Indonesia
Abdulkadir Rahardjanto
Universitas Muhammadiyah Malang, Indonesia

Corresponding Author: rudiihwono@webmail.umm.ac.id

Abstract

This study aims to analyze the effect of the RUDIE model on high school students' digital problem-solving skills. The RUDIE model consists of five stages, namely Reach, Unravel, Design Project, Implementation, and Evaluation, which are designed to develop higher-order thinking skills through project-based and technology-integrated learning. This study employed a quantitative approach with a quasi-experimental design using a nonequivalent control group design. The participants were 64 eleventh-grade students at SMA Muhammadiyah 1 Gresik, divided into an experimental group and a control group. The research instrument was a questionnaire measuring digital problem-solving skills across four dimensions: problem understanding, solution design, solution implementation, and evaluation and reflection. The results showed a significant effect of the RUDIE model on students' digital problem-solving skills. This is indicated by the higher post-test mean score of the experimental group compared to the control group, as well as the results of the independent samples t-test with a significance value of 0.000 < 0.05. These findings indicate that the RUDIE model is more effective than conventional learning in improving students' digital problem-solving skills. Therefore, the RUDIE model can be considered an effective and innovative learning approach to support the development of 21st-century skills, particularly in technology-based learning contexts such as Arduino.

Keywords: RUDIE model, digital problem-solving, project-based learning, Arduino, 21st-century learning.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

International Journal of Education, Vocational and Social Science
https://e-journal.citakonsulindo.or.id/index.php/IJEVSS
E-ISSN : 2963 4954
IJEVSS

INTRODUCTION

The development of learning at the senior high school (SMA) level is currently increasingly influenced by global changes in 21st-century education, which demand the integration of digital technology as part of the teaching and learning process. Digital learning now includes the use of virtual classrooms, blended learning, and digital resources that support flexible access and personalized learning. In this context, the use of technology is not merely an addition, but has become a crucial component in preparing students to face the challenges of future skills such as critical thinking and collaboration, which are relevant to the demands of the digital era (Redhana, 2024). Digital problem-solving skills have become an essential component of digital learning because they play a vital role in helping students analyze information, develop solutions, and make decisions in complex situations typical of the digital world (Blanc et al., 2025). Digital literacy, which is the main foundation in achieving these skills, provides students with the ability to critically filter digital content and apply technological knowledge to address learning problems and real-world contexts. (S. Pratama et al., 2025).

Along with the importance of digital learning and problem-solving skills, various modern educational policies emphasize rules and frameworks that support the effective operation of technology in schools. These policies aim to ensure that technology is not only available but also used meaningfully, including thru digital competency standards for students and teachers, the development of digital curricula, and ethical guidelines for technology use in the educational context (Greiff et al., 2017; UNESCO, 2024). (Sari Dewi, 2025) These policies must be accompanied by adequate training for educators to enhance their digital competencies, thereby creating a more inclusive and effective learning environment (Zakarya & Suwadi, 2025). It is important for educational institutions to ensure fair access to technology and training for all teachers so that they can effectively implement this policy.

Although digital learning has great potential to enhance student engagement and learning outcomes, the reality in many schools shows that conventional teaching practices still dominate (Mu'ti, 2023). Traditional learning that focuses on lectures and written assignments often falls short in developing higher-order thinking skills such as creativity and problem-solving in a digital context (Dehghanzadeh & Jafaraghaee, 2018). Whereas digital-based learning allows for more interactive activities and multimedia learning experiences that can facilitate skills such as critical thinking, collaboration, and the application of knowledge in real-world situations (na et al., 2025; Nur, 2025). Nevertheless, various reports and studies indicate a significant gap in teachers' mastery of classroom learning, where the issue is no longer about access to technology, but the

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

ability to use it meaningfully for educational purposes (Hargittai, 2002). Teachers may be proficient in using technology personally, but often struggle when it comes to integrating it into effective learning design (Prodani et al., 2022).

As an alternative, research using the RUDIE Model, which stands for Reach, Unravel, Design Project, Implementation, and Evaluation, is designed to develop students' critical thinking and digital problem-solving skills thru structured project-based learning. This model consists of five sequential stages. The Reach stage emphasizes the identification of relevant problems, ensuring that the chosen issues have significant meaning and context. In the Unravel stage, students uncover the root of the problems to gain a deep understanding of the underlying factors. The Design Project stage focuses on planning and developing feasible project solutions, encouraging creativity and strategic thinking. During the Implementation stage, students apply the designed solutions in a practical context, thereby encouraging experiential learning and active engagement. Finally, the Evaluation stage emphasizes reflective assessment, where students critically review the results and implementation process to reinforce learning and identify areas for improvement (Ihwono et al., 2025). This model provides a systematic framework that integrates problem identification, analytical reasoning, solution design, practical implementation, and reflective evaluation, with the aim of comprehensively developing students' cognitive and digital competencies.

With the RUDIE Model, which is rooted in project-based learning and blended learning and emphasizes higher-order thinking processes, the use of the RUDIE model allows students to develop their own solution strategies, test hypotheses, and systematically evaluate project outcomes. This is in line with the finding that the implementation of project-based learning models can enhance students' critical thinking skills (Nourma, 2024). However, the implementation of the RUDIE learning model has not yet spread widely in many high schools because most educators still tend to use conventional teaching approaches that do not explicitly emphasize digital problem-solving. Obstacles such as limited teacher training, uneven digital infrastructure, and old pedagogical habits remain major challenges (Orhan, 2024). Therefore, this research is important to examine the influence of the RUDIE model on high school students' digital problem-solving abilities as part of efforts to enrich digital learning practices in the continuously evolving technological era.

RESEARCH METHOD

This study uses a quantitative experimental approach with a quasi-experimental design.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

The purpose of this research is to evaluate the extent to which the RUDIE Model affects students' digital problem-solving abilities. This experiment is of a trial nature, as the research is conducted to test the application of the RUDIE Model in the context of Arduino material learning, thereby assessing the effectiveness of the model in enhancing students' digital problem-solving skills. This research was conducted at SMA Muhammadiyah 1 Gresik in the even semester of the 2025/2026 academic year.

In this study, students were given an intervention using the RUDIE Model, which consists of the stages of Reach, Unravel, Design Project, Implementation, and Evaluation, and their digital problem-solving skills were measured thru test instruments and observations before and after the intervention. The quasi-experimental approach was chosen because full random assignment of subjects was not possible, but it still allowed for systematic measurement of the model's impact on the variables being studied. Data analysis was conducted to compare changes in students' digital problem-solving abilities before and after the implementation of the RUDIE Model, allowing for conclusions to be drawn regarding the effectiveness of this model in the context of project-based learning and digital competence development.

This quasi-experimental research uses the Nonequivalent Control Group Design, which is a type of quasi-experimental design that includes a treatment group and a control group, although the two groups are not randomly selected. This approach is often used in educational research when full randomization is not practically feasible.

Table 1. Research Design

Group	Pre-test (O)	Treatment (X)	Post-test (O)
Experiment	O_1	X_1	O_2
Control	O_3	X_2	O_4

Explanation :
O_1 = Experimental group given a pretest
O_3 = Control group given a pretest
O_2 = Experimental group given a posttest
O_4 = Control group given a posttest
X1 = Experimental group participates in learning activities using the RUDIE model
X2 = Control group participates in learning activities using the Conventional model

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

PARTICIPANTS AND RESEARCH CONTEXT

The research population consists of 64 eleventh-grade students in the 2025/2026 academic year. This study uses a non-probability sampling technique in the form of saturated sampling (total sampling), which means that every individual in the population is selected and included in the sample. Because the population size is limited and it is still feasible to study the entire population, the number of population members is divided into two groups, namely 32 students from class A designated as the control class, and 32 students from class B designated as the experimental class.

Table 2. Student Distribution Table

Group	Number of Student	Learning Intervention
Experiment	32	RUDIE Model (Reach, Unravel, Design Project, Implementation, Evaluation)
Control	32	Conventional Learning

This design uses a pre-test and post-test framework to assess changes between groups before and after the intervention. This approach allows for the evaluation of the effectiveness of the RUDIE Model, even tho the groups used are not fully statistically equivalent. By incorporating baseline measurements in both groups, this design minimizes threats to internal validity while still considering the limitations arising from non-random assignment, making it a reliable approach for assessing intervention outcomes in applied educational research.

RESEARCH INSTRUMENTS

The data collection technique for this research uses questionnaires. The questionnaire is used to measure students' digital problem-solving abilities. Digital problem-solving skills refer to Polya's digital problem-solving theory, which includes understanding the problem, planning, implementing, and evaluating (Santos & Miguel, 2019). Additionally, the measurement of digital problem-solving refers to the digital competence framework used as the basis for digital problem-solving, technology use, and digital needs identification (Stephanie et al., 2017; Vuorikari et al., 2022). Digital problem-solving also pertains to digital learning and 21st-century international problem-solving, the PISA framework, technology-based and computational problem-solving,

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

adaptive learning, and solution evaluation and reflection (Csapó & Funke, 2017; Greiff et al., 2017). Digital problem-solving skills are measured thru four dimensions. Based on the study, problem-solving indicators have been analyzed and developed to be used in this research into four dimensions. Dimension 1: Understanding and identifying digital problems. Dimension 2: Strategy and design of digital solutions. Dimension 3: Implementation and exploration of digital solutions. Dimension 4: Evaluation and reflection on digital solutions. Each of the four dimensions is developed into indicators needed to assess and measure digital problem-solving. In detail, the assessment indicators are presented in Table 3. The assessment of digital problem-solving indicators uses a 1-4 Likert scale, which includes 4 = very good, 3 = good, 2 = less good, 1 = not good, with each indicator having its own assessment description for each item.

Table 3. Digital Problem-Solving Indicators

No.	Dimension	Indicator
1	Understanding and Identification of Digital Problems	1. Identifying problems in the Arduino system 2. Interpreting digital information (code, datasheet, error) 3. Structuring problems systematically
2	Strategy and Design of Digital Solutions	1. Determining resolution strategies Memilih 2. Choosing appropriate Arduino tools/components 3. Designing solutions (circuit & program flow)
3	Implementation and Exploration of Digital Solutions	1. Implementing Arduino programs 2. Exploring alternative solutions 3. ffectiveness of technology use
4	Evaluation and Reflection of Digital Solutions	1. Evaluating solution outcomes 2. Identifying errors 3. Reflection and improvement

Table 4. Digital Problem-Solving Assessment Rubric

No.	Indicator	Description	Score
1	Identifying problems in the	Accurately identifies the problem (e.g., wiring, code, or sensor errors) with a comprehensive explanation.	4

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

No.	Indicator	Description	Score
	Arduino system		
		Identifies the problem with reasonable accuracy, but the explanation is incomplete.	3
		Identifies the problem, but the identification is inaccurate or incomplete.	2
		Unable to identify the problem.	1
2	Interpreting digital information (code, datasheets, error messages)	Accurately reads and understands Arduino code/programs and error messages.	4
		Demonstrates adequate understanding of the code/error messages but still requires assistance.	3
		Demonstrates limited understanding of the code/error messages.	2
		Unable to understand the code/error messages.	1
3	Formulating problems systematically	Formulates the problem systematically with clear input–process–output relationships.	4
		Formulates the problem clearly but lacks systematic organization.	3
		Formulates the problem unclearly.	2
		Unable to formulate the problem.	1
4	Determining problem-solving strategies	Determines logical and effective solution strategies (e.g., debugging and step-by-step testing).	4
		Determines appropriate strategies, but they are less efficient.	3
		Determines inappropriate solution strategies.	2
		Unable to determine a solution strategy.	1

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

No.	Indicator	Description	Score
5	Selecting appropriate Arduino tools and components	Selects the most appropriate hardware components (e.g., sensors, resistors) and software.	4
		Selects appropriate components and software but not optimally.	3
		Selects inappropriate components or software.	2
		Unable to select appropriate components or tools.	1
6	Designing solutions (circuit and program flow)	Develops a complete and accurate circuit design and program flowchart.	4
		Develops a generally accurate design with minor deficiencies.	3
		Develops an inaccurate design.	2
		Unable to design the solution.	1
7	Implementing the Arduino program	The program operates perfectly according to the intended objectives.	4
		The program operates with minor errors.	3
		The program operates only partially.	2
		The program does not operate.	1
8	Exploring alternative solutions	Independently explores various alternative solutions by modifying the code and/or circuit.	4
		Explores alternative solutions with assistance.	3
		Rarely explores alternative solutions.	2
		Does not attempt alternative solutions.	1
9	Effective use of technology	Uses the Arduino IDE, libraries, and tools efficiently and appropriately.	4

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

No.	Indicator	Description	Score
		Uses the technology adequately and appropriately.	3
		Uses the technology ineffectively.	2
		Unable to use the required tools.	1
10	Evaluating solution outcomes	Critically evaluates the solution outcomes based on Arduino output data.	4
		Provides an adequate evaluation but lacks depth.	3
		Provides an inadequate evaluation.	2
		Does not evaluate the solution outcomes.	1
11	Identifying errors	Accurately identifies and explains errors in the code and/or circuit.	4
		Identifies errors but provides unclear explanations.	3
		Demonstrates limited ability to identify errors.	2
		Unable to identify errors.	1
12	Reflection and improvement	Provides in-depth reflection and proposes meaningfull improvements to the solution.	4
		Provides adequate reflection.	3
		Provides limited reflection.	2
		Does not provide reflection.	1

DATA ANALYSIS TECHNIQUES

Quantitative data analysis in this study was conducted using IBM SPSS Statistics version 26. First, descriptive statistical analysis was conducted to summarize the main characteristics of students' pre-test and post-test scores, including the mean, standard deviation (SD), minimum score, and maximum score. The distribution of data was also visualized thru histograms to examine the spread of students' digital problem-solving ability scores before and after the intervention. The data analysis technique used is the independent samples t-test. The significance level used for decision-making is set at $\alpha = 0.05$, where the null hypothesis (H_0) will be rejected if the Sig. (2-tailed) value < 0.05, indicating a significant influence of the RUDIE Model on students'

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

digital problem-solving abilities.

RESEARCH RESULTS

After all problem-solving score data have been collected, prerequisite tests are conducted using normality and homogeneity tests. The testing was conducted on both the pretest and posttest scores of the experimental and control groups. The normality test of the pretest scores data is presented in Table 5, and the results of the homogeneity test are presented in Table 6.

Table 5. Results of the Pretest Data Normality Test

Group		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
Score	Experiment	.080	32	.200*	.979	32	.772
	Control	.096	32	.200*	.979	32	.768
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

Table 6. Results of the Pretest Data Homogeneity Test

Levene Statistic	df1	df2	Sig.
.656	1	62	.421

The results of the normality test for the pretest scores of the experimental group obtained Sig. .200 on the Kolmogorov-Smirnov test and Sig. .200 on the Shapiro-Wilk test. Meanwhile, the control group data testing obtained Sig. .200 on the Kolmogorov-Smirnov test and Sig. .768 on the Shapiro-Wilk test. The results of the homogeneity test for the pretest scores showed Sig. .421 on the Levene test. All pretest score data are normally and homogeneously distributed. Next, the post-test data on digital problem-solving ability were subjected to a t-test presented in Table 8.

Table 7. Mean Pre-test Digital Problem-Solving Ability

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score	Experiment	32	39.19	5.974	1.056
	Control	32	39.97	5.223	.923

Table 8. Results of the Pretest T-test on Digital Problem-Solving Ability

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Score	Equal variances assumed	.656	.421	.557	2	.580	-.781	1.403	-3.585	2.023
	Equal variances not assumed			.557	0.915	.580	-.781	1.403	-3.586	2.024

The results of the mean pretest scores for digital problem-solving ability in Table 7 show that the experimental group obtained a mean score of 39.19 and the control group obtained a mean score of 39.97. The results of the pretest data analysis using the independent samples t-test indicate no difference in scores between the experimental group and the control group, with a Sig. (2-tailed) value of .580 > .050. These results indicate that there is no difference in the initial problem-solving abilities of the students in both the experimental and control groups.

Table 9. Results of the Postes Data Normality Test

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Group	Statistic	df	Sig.	Statistic	df	Sig.
Score	Experiment	.105	32	.200*	.966	32	.386
	Control	.091	32	.200*	.972	32	.563
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

Table 10. Results of the Post Data Homogeneity Test

Levene Statistic	df1	df2	Sig.
.000	1	62	1.000

Post-test data on digital problem-solving ability underwent a normality prerequisite test presented in Table 9. The results of the normality test show that the experimental group in the Kolmogorov-Smirnov test obtained Sig. .200 and the Shapiro-Wilk test obtained Sig. .386. The

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

normality test of the control group shows that the Shapiro-Wilk test obtained Sig. .200 and Sig. .563. The results indicate that all post-test data are normally distributed. The results of the homogeneity test in Table 10 show that the Levene's test obtained Sig. 1.000, indicating that the data are homogeneous.

Table 11. Mean Scores of Digital Problem-Solving Ability

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score	Experiment	32	91.93	5.097	.901
	Control	32	86.98	4.992	.882

Table 12. Post-test Results of Digital Problem-Solving Ability

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Score	Equal variances assumed	.000	1.000	3.924	62	.000	4.948	1.261	2.427	7.469
	Equal variances not assumed			3.924	61.973	.000	4.948	1.261	2.427	7.469

The acquisition of the mean score of students' problem-solving abilities thru post-test scores is presented in Table 11. The results show that the experimental group obtained a mean of 91.93, while the control group obtained a mean score of 86.98. The acquisition of digital problem-solving skills was higher in the group of students who participated in learning activities using the RUDIE Model. The results of the independent samples t-test, presented in Table 12, showed a Sig. (2-tailed) of .000 < .050. There is an influence of the RUDIE learning model on students' digital problem-solving abilities.

DISCUSSION

The research results show that the application of the RUDIE Model has a significant impact on the digital problem-solving abilities of high school students. This is indicated by the difference in post-test scores between the experimental group (mean = 91.93) and the control group (mean

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

= 86.98), as well as the results of the independent samples t-test with a significance value of 0.000 < 0.05. These findings affirm that the RUDIE Model is more effective than conventional learning in enhancing students' digital problem-solving skills. The project-based learning model allows students to construct knowledge thru direct experience, exploration, and the development of real solutions, thereby significantly enhancing problem-solving skills (Aini et al., 2023; Murtiyasa & Budiningsih, 2022). Additionally, problem-based learning encourages students to think critically, analyze situations, and formulate solutions systematically, which is the core of problem-solving skills (Rohmana et al., 2025). Other research also shows that both PjBL and PBL are consistently effective in improving students' problem-solving abilities compared to conventional learning because both involve processes of investigation, collaboration, and reflection (A. I. Pratama et al., 2025). Thus, the integration of these two approaches in the RUDIE Model becomes the main factor explaining the significant improvement in students' digital problem-solving skills in this study.

Conceptually, this improvement can be explained because the RUDIE Model is designed based on project-based learning and blended learning, which emphasize active student involvement in solving real-world technology-based problems. This approach aligns with constructivism, which emphasizes that knowledge is actively constructed thru meaningful and contextual learning experiences (Piaget, 1983; Vygotsky, 1979). Additionally, the integration of blended learning allows for flexible learning and expands access to digital learning resources, thereby supporting a deeper and more independent thinking process (Cassidy & Fennimore, 2000; Kretchmar, 2021). Unlike conventional learning, which tends to be teacher-centered, the RUDIE Model provides space for students to directly experience high-level thinking processes, from problem identification to solution evaluation. This process reflects the stages of higher order thinking skills in the revised Bloom's taxonomy, namely analyzing, evaluating, and creating (Anderson et al., 2001). This aligns with the view that project-based learning can enhance critical thinking and problem-solving skills because students are engaged in exploratory and reflective processes (Nourma, 2024).

Furthermore, the effectiveness of the RUDIE Model can be analyzed thru the contribution of each of its stages to the development of students' digital problem-solving skills. First, the Reach stage plays a role in enhancing students' abilities in the dimensions of understanding and identifying digital problems. At this stage, students are faced with contextual problems based on Arduino that require them to identify system errors, read data, and understand the situation thoroughly. This activity directly trains indicators such as identifying problems, interpreting digital information, and formulating problems in a structured manner. This stage aligns with Polya's

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

theory, which emphasizes the importance of understanding the problem as the initial step in problem-solving.

Second, the Unravel stage strengthens students' analytical skills in uncovering the root of the problem. Students not only identify problems but also analyze their causes in depth, for example, thru code debugging or circuit analysis. This process contributes to the development of critical and analytical thinking skills, which are at the core of digital problem-solving. These findings are in line with the research by (Greiff et al., 2017), which states that system analysis skills are crucial in technology-based problem solving.

Third, the Design Project stage significantly contributes to the dimensions of strategy and digital solution design. At this stage, students design solutions in the form of projects, select appropriate Arduino components, and create flowcharts or program algorithms. This activity trains indicators such as determining problem-solving strategies, selecting the right tools, and designing solutions systematically. This design process encourages students to think creatively and strategically, as emphasized in the digital competence framework that solution planning is an important part of digital literacy (Stephanie et al., 2017).

Fourth, the Implementation stage provides students with hands-on experience in applying the designed solutions. At this stage, students program the Arduino, test the circuit, and explore various alternative solutions when errors occur. This stage greatly contributes to the dimensions of implementation and exploration of digital solutions, particularly in the indicators of program implementation, exploration of alternative solutions, and the effectiveness of technology use. This practice-based learning has proven to enhance both the conceptual understanding and technical skills of students, as stated by Csapó & Funke (2017) that digital problem-solving requires the integration of knowledge and hands-on practice. Fifth, the Evaluation stage plays a role in developing students' reflective abilities in the dimensions of evaluation and reflection on digital solutions. Students evaluate the project results, identify mistakes, and make improvements. This stage trains the indicators of outcome evaluation, error identification, and improvement reflection. This reflection process is very important because it allows students to learn from mistakes and improve the quality of the solutions produced. This aligns with the concept of reflective learning, which is an important part of developing 21st-century skills.

In addition, the results of this study also show that the indicators used to measure digital problem-solving skills are accurate and comprehensive. The four dimensions used, namely (1) understanding and identifying problems, (2) strategy and solution design, (3) implementation and exploration of solutions, and (4) evaluation and reflection, have fully reflected the entire digital

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

problem-solving process. The indicators integrate Polya's theory, the digital competence framework, and the PISA problem-solving framework, thereby being able to measure students' abilities comprehensively from cognitive, technical, to reflective aspects. Thus, the instrument used not only measures the final outcome but also the students' thinking process in solving digital problems.

The findings of this study are also supported by various relevant previous research. Research by Dehghanzadeh & Jafaraghaee,(2018) shows that interactive-based digital learning can enhance students' higher-order thinking skills. Furthermore, Astuti and Wardhani (na et al., 2025) state that technology-based learning provides a more meaningful and contextual learning experience. Another study by nurul jubaedah (2025) also emphasizes that the use of digital media and project-based learning can enhance students' problem-solving and collaboration skills. Thus, the results of this research strengthen empirical evidence that the integration of innovative project-based learning models and technology, such as RUDIE, is effective in improving digital problem-solving abilities.

Overall, this research successfully addressed the problem posed, namely the low digital problem-solving skills of students due to the dominance of conventional learning. The RUDIE model has proven to be an effective alternative solution because it provides a systematic, contextual, and student-centered learning framework. This model not only improves learning outcomes but also develops critical, creative, and reflective thinking skills that are highly needed in 21st-century learning. The implications of this research indicate that teachers need to adopt innovative learning models like RUDIE to enhance the quality of digital learning. In addition, support in the form of teacher training and the provision of adequate technological facilities is needed so that the implementation of this model can run optimally in various school contexts.

CONCLUSION

Based on the research results and data analysis that have been conducted, it can be concluded that the RUDIE Model has a significant effect on the digital problem-solving abilities of high school students. This is evidenced by the significant difference between the experimental group and the control group, where students who learned using the RUDIE Model achieved higher results compared to students who followed conventional learning. The improvement in digital problem-solving skills occurred because the RUDIE Model provides a systematic learning experience thru the stages of Reach, Unravel, Design Project, Implementation, and Evaluation. Each stage integratively trains students to understand problems, design solutions, implement

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

them, and reflectively evaluate the results. Thus, the RUDIE Model has proven effective in developing digital problem-solving skills that encompass the cognitive, technical, and reflective aspects of students.

IMPLICATIONS

The results of this study provide several important implications for the development of learning in the digital era. First, theoretically, this research reinforces that the integration of project-based learning and problem-solving models, such as the RUDIE Model, is effective in enhancing higher-order thinking skills, particularly digital problem-solving. This model can serve as an innovative alternative in the development of 21st-century learning that emphasizes critical, creative, and reflective skills. Second, practically, the RUDIE Model can serve as a reference for teachers in designing more interactive and meaningful technology-based learning. The application of this model encourages students to be more active, independent, and directly involved in the learning process, especially in the context of Arduino-based learning or other digital technologies. Thirdly, from a policy perspective, the results of this research highlight the importance of educational institutions providing training for teachers as well as adequate technological facilities. The implementation of innovative learning models such as RUDIE requires teachers to be prepared to effectively manage project-based and technology-based learning.

SUGGESTIONS

Based on the research findings, there are several suggestions that can be provided. First, for teachers, it is recommended to implement the RUDIE Model as an alternative learning method to enhance students' digital problem-solving skills. Teachers should also develop creativity in designing projects that are contextual and relevant to students' real-life situations. Second, for schools, it is necessary to provide support in the form of technological facilities and ongoing training for teachers so that the implementation of digital-based learning can run optimally. Third, for future researchers, it is recommended to expand this study with a broader scope, both in terms of sample size, educational levels, and integration with other variables such as creativity, collaboration, or digital literacy. In addition, future research can use a stronger experimental design or a mixed methods approach to obtain a more comprehensive picture.

REFERENCES

Aini, M., Aini, M., Yunitasari, I., & Ridianingsih, D. S. (2023). Implementasi Model Pembelajaran

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

Project Based Learningberbasis Stem Terhadap Keterampilan Pemecahan Masalah. *JPE (Jurnal Pendidikan Edutama*, *10*(2), 10.

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*.

Blanc, S., Peiro, A., Benlloch-Dualde, J.-V., Monteiro, A., & Grindei, L. (2025). Digital competence development in schools: a study on the association of problem-solving with autonomy and digital attitudes. *International Journal of STEM Education*, *12*. https://doi.org/10.1186/s40594-025-00534-6

Cassidy, B., & Fennimore, L. (2000). Learning and Instructional Theories. In *Nursing Education and Clinical Research for Evidence-Based Practice HUB*.

Csapó, B., & Funke, J. (2017). *The Nature of Problem Solving: Inspire 20th century*. OECD.

Dehghanzadeh, S., & Jafaraghaee, F. (2018). Comparing the effects of traditional lecture and flipped classroom on nursing students' critical thinking disposition: A quasi-experimental study. *Nurse Education Today*, *71*, 151–156. https://doi.org/10.1016/j.nedt.2018.09.027

Greiff, S., Scheiter, K., Scherer, R., Borgonovi, F., Graesser, A., Kitajima, M., & & Rouet, J.-F. (2017). Adaptive Problem Solving: Moving Towards a New Assessment Domain in the Second Cycle of PIAAC. *OECD Education Working Papers*, *156*.

Hargittai, E. (2002). Second-Level Digital Divide: Differences in People's Online Skills. *First Monday*, *7*(4). https://doi.org/10.5210/fm.v7i4.942

Ihwono, R., Cholily, Y., & Syaifuddin, M. (2025). PENGARUH MODEL RUDIE TERHADAP KEMNDIRIAN DIGITAL SISWA. *JS (JURNAL SEKOLAH)*, *10*, 330–342. https://doi.org/10.24114/js.v10i1.71748

Kretchmar, J. (2021). Constructivism. In *Educational Theory*. EBSCO.

Mu'ti, Y. (2023). Pemanfaatan platform digital dalam pembelajaran tingkat SMA. *AL-MIKRAJ Jurnal Studi Islam Dan Humaniora*, *3*(2), 104–113. https://doi.org/10.37680/almikraj.v3i2.2696

Murtiyasa, B., & Budiningsih. (2022). The Effectiveness of Project Based Learning in Improving Students '. *Jurnal Pendidikan Progresif*, *12*(2), 728–740. https://doi.org/10.23960/jpp.v12.i2.

na, R. F. R., Astuti, L. S., & Wardhani, I. S. (2025). Interactive Multimedia Learning Media Assisted by Wordwall to Improve Critical Thinking Skills of Elementary School. *Jurnal Penelitian Dan Pengembangan Pendidikan*, *9*(2), 275–284. https://doi.org/10.23887/jppp.v9i2.93458

Nourma, N. (2024). Perbandingan antara model pembelajaran berbasis proyek dan model

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

pembelajaran berbasis masalah dalam meningkatkan kemampuan kritis siswa. *Journal of Teaching in Elementary Education*. https://doi.org/10.30587/jtiee.v8i1.8199

Nur, J. (2025). The Impact of Digital Learning Tools on Students' Critical Thinking Development. *Asian Journal of Applied Education (AJAE)*, *4*, 635–648. https://doi.org/10.55927/ajae.v4i4.15615

nurul jubaedah. (2025). *peran guru dalam deep learning*. 18 Maret 2025. https://www.melintas.id/literasi/345779742/rahasia-guru-hebat-peran-guru-dalam-deep-learning-menjadi-kunci-pembelajaran-yang-bikin-murid-penasaran-dan-aktif#goog_rewarded

Orhan, A. (2024). Online or in-class problem based learning: Which one is more effective in enhancing learning outcomes and critical thinking in higher education EFL classroom? *Journal of Computer Assisted Learning*. https://doi.org/https://doi.org/10.1111/jcal.13033

Piaget, J. (1983). Piaget's theory. In *Handbook of Child Psychology. 4th edition.* Wiley.

Pratama, A. I., Yunus, M., & Agusniati, A. (2025). Perbandingan Model Project Based Learning dan Problem Based Learning dalam Meningkatkan Kemampuan Pemecahan Masalah IPAS Siswa UPT SPF SD Inpres Mandai Kota Makassar. *Bosowa Journal of Education*, *6*(1), 106–117. https://doi.org/10.35965/bje.v6i1.6230

Pratama, S., Ashari, M., Zulkarnain, S. A. B., & Sabrina, E. (2025). Pentingnya Literasi Digital dalam Dunia Pendidikan: Transformasi Pembelajaran di Era Digital. *Jurnal Kajian Ilmu Pendidikan (JKIP)*, *6*(2), 554–561. https://doi.org/10.55583/jkip.v6i2.1388

Prodani, R., Çobani, S., Andersons, A., & Bushati, J. (2022). Digital technologies integration in the classroom. A teacher's perspective. *Cypriot Journal of Educational Sciences*, *17*, 2823–2837. https://doi.org/10.18844/cjes.v17i8.7781

Redhana, I. W. (2024). *Pembelajaran Digital pada Abad ke-21*.

Rohmana, A. N., Shodiqin, A., & Prasetyowati, D. (2025). Efektivitas Model Problem Based Learning dan Project Based Learning Berbantuan GeoGebra Terhadap Kemampuan Pemecahan Masalah dimiliki siswa dengan penerapan dalam kehidupan mereka sehari-hari . Salah satu model yang diindikasi mampu meningkatkan kemampuan. *Al-Bahjah Journal of Mathematics Education*, *3*(1), 44–58.

Santos, D., & Miguel, L. (2019). Pre-Service Teachers' Professional Development Through Four-Step Problem-Solving Model: A Seminar Method. *International Journal of Education and Practice*, *7*(3), 146–157. https://doi.org/10.18488/journal.61.2019.73.146.157

Sari Dewi, O. (2025). *Transformasi Pendidikan Indonesia Menuju Era Digital: Tinjauan OECD,*

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License

UNESCO, dan World Bank terhadap Implementasi Merdeka Belajar.

Stephanie, C. G., Rina, V., & Yves, P. (2017). *DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples of use* (Issue KJ-NA-28558-EN-N (online),KJ-NA-28558-EN-C (print),KJ-NA-28558-EN-E (ePub)). Publications Office of the European Union. https://doi.org/10.2760/38842 (online),10.2760/836968 (print),10.2760/00963 (ePub)

UNESCO. (2024). *Digital Learning and Transformation of Education*. UNESCO. https://www.unesco.org

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The Digital Competence Framework for Citizens*. Publications Office of the European Union. https://doi.org/10.2760/115376

Vygotsky, L. S. (1979). Consciousness as a Problem in The Psychology of Behaviour. *Soviet Psychology*, *17*(3), 3–35.

Zakarya, M. A., & Suwadi, S. (2025). Optimalisasi Pendidikan Digital Nasional: Telaah Dan Rekomendasi Kebijakan Bagi Kemendikbud Dalam Bingkai Uu Sisdiknas Pasal 12 & 41. *PEMA/Pema*, *5*(2), 476–492. https://doi.org/10.56832/pema.v5i2.1110

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-Share Alike 4.0 International License