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Integration of PBL-Based E-Modules in Physics Education: Improving Problem-Solving Skills on Static Fluid Concept

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Abstract – *Developing students' problem-solving skills is a central aim of modern science education, yet many learners continue to struggle when applying physics concepts to authentic situations. In Indonesia, this challenge remains urgent, as national and international assessments consistently highlight gaps in higher-order thinking and reasoning. Responding to this need, the present study sought to investigate the effectiveness of a problem-based learning (PBL)–based electronic module (e-module) designed around Polya's four problem-solving stages in improving high school students' abilities in the static fluid topic. Using a pre-experimental one-group pretest–posttest design, the study involved 28 students who completed validated pretest and posttest instruments aligned with Polya's framework. Data were analyzed descriptively and inferentially through the Wilcoxon Signed-Rank Test, normalized gain (N-gain), and Cohen's d effect size. The results showed a clear increase in mean scores from 47.91 on the pretest to 73.11 on the posttest, with all four indicators: understanding the problem, planning solutions, implementing strategies, and evaluating outcomes. The Wilcoxon test confirmed statistically significant improvements for all participants, with an effect size of 1.971 indicating a very large practical impact. These findings demonstrate that integrating PBL with structured digital scaffolding can meaningfully enhance students' problem-solving skills. The novelty of this research lies in adapting Polya's classic model into an interactive e-module format and embedding it within PBL to promote inquiry and reflection. Overall, the study contributes to physics education by providing evidence that digital PBL resources can narrow performance gaps and foster deeper, more equitable learning outcomes in line with 21st-century educational demands.*

Keywords: *21st-century competencies; e-modules; problem-based learning; problem-solving skills; static fluid*

I. INTRODUCTION

Science education plays a pivotal role in equipping learners with the intellectual tools required to understand, interpret, and engage with the increasingly complex challenges of the modern world. Beyond the transmission of factual knowledge, science education fosters the development of cognitive and problem-solving abilities that are vital for navigating everyday situations and for participating in informed decision-making within society. In the twenty-first century, educational systems worldwide emphasize the cultivation of higher-order thinking skills, including critical thinking, creativity, and scientific reasoning, as indispensable outcomes of science instruction. These competencies are not only aligned with global trends in educational policy but also directly contribute to students' ability to address multifaceted issues, such as technological innovation, environmental sustainability, and public health challenges. Within this framework, physics education holds particular significance as it provides students with foundational knowledge of natural laws while simultaneously demanding the application of analytical, mathematical, and reasoning skills.

Recent research emphasizes that the effectiveness of science education is determined not merely by the mastery of content but by the extent to which learners are able to apply knowledge to problem contexts that require creativity and reasoning (OECD, 2019). In the Indonesian context, national curriculum reforms such as the "Merdeka Curriculum" have explicitly placed problem-solving, inquiry, and reasoning at the heart of science learning outcomes (Kemendikbud, 2022). Despite these efforts, data from international assessments reveal persistent gaps in the higher-order thinking skills of Indonesian students. The Programme for International Student Assessment (PISA) 2018 reported that Indonesian students' performance in science literacy remained significantly below the OECD average, indicating difficulties in applying conceptual understanding to solve authentic problems (OECD, 2019). Similarly, the Trends in International Mathematics and Science Study (TIMSS) has consistently shown that Indonesian learners struggle particularly with items that require reasoning, analysis, and problem-solving, rather than factual recall (Hadi & Novaliyosi, 2019). These results underscore the urgency of implementing innovative instructional strategies and resources that can effectively enhance problem-solving and reasoning skills in physics learning.

One of the central problems in Indonesian science education is the predominance of teacher-centered instructional practices that prioritize rote memorization and formula application over meaningful understanding and application. Traditional approaches to physics instruction often involve the passive transfer of knowledge, with students positioned as recipients rather than active participants in the learning process (Prayogi et al., 2024). This pattern limits students' opportunities to engage in exploration, inquiry, and reflective thinking, resulting in low motivation, minimal engagement, and weak problem-solving skills. Consequently, students frequently perceive physics as abstract, difficult, and disconnected from real-life contexts (Yulianti et al, 2020). The lack of student-centered pedagogical strategies has contributed to the observed stagnation in the performance of Indonesian students on both national and international assessments. Without explicit opportunities to practice and refine higher-order reasoning, students are unlikely to progress beyond procedural application toward genuine problem-solving competence.

To address these challenges, contemporary educational research and policy recommend the adoption of student-centered, active learning approaches. These include inquiry-based learning, project-based learning (PjBL), and problem-based learning (PBL), each of which positions students as central agents in their learning process (Hmelo-Silver, 2004; Bell, 2010). Among these, PBL has attracted particular attention for its potential to foster critical thinking, reasoning, and problem-solving abilities in science education. PBL engages students in authentic problem scenarios that require collaboration, hypothesis formulation, data analysis, and solution evaluation (Savery, 2006). In physics education, the integration of PBL has been shown to enhance not only students' conceptual understanding but also their scientific attitudes and motivation (Rahmawati et al., 2021). By situating learning in meaningful contexts and emphasizing inquiry, PBL provides opportunities for learners to develop competencies aligned with the demands of twenty-first-century science education.

Specifically, PBL has been recognized as an effective framework for developing problem-solving skills, a competency that is critical for success in physics learning. Problem-solving in physics requires more than algorithmic manipulation of formulas; it involves identifying relevant concepts, applying principles, and reasoning logically through multiple stages of problem analysis (Polya, 1957). The integration of Polya's four-step problem-solving model understanding the problem, devising a plan, carrying out the plan, and evaluating the solution provides a structured framework for scaffolding students' reasoning processes (Krulik & Rudnick, 1999). Studies have demonstrated that embedding Polya's model within PBL not only strengthens students' procedural fluency but also deepens their conceptual understanding and metacognitive awareness (Kapur, 2010; Wena, 2016). This synergy between PBL and Polya's model presents a promising approach for addressing the persistent challenges in Indonesian physics education, as it explicitly guides students through the problem-solving process while maintaining the inquiry-oriented principles of PBL.

In recent years, educational technology has emerged as a catalyst for transforming learning environments and supporting innovative pedagogies, such as PBL. The use of electronic modules (e-modules) has expanded in particular as a means of enhancing accessibility, interactivity, and student engagement. Unlike traditional textbooks, e-modules can integrate multimedia elements, simulations, and interactive exercises that make abstract physics concepts more concrete and relatable (Prastowo, 2019). Several studies have reported that e-modules improve learning outcomes, motivation, and independent learning skills by providing flexible and student-centered resources (Yuliana et al., 2020; Putra & Rachmawati, 2021). When integrated with PBL, e-modules serve as digital scaffolds that support students in navigating complex problem scenarios, accessing relevant information, and practicing reasoning through interactive exercises (Mahmudi et al., 2021). Thus, the combination of PBL and e-modules has the potential to address both the pedagogical and technological needs of contemporary physics education, offering a blended solution to enhance students' problem-solving competencies.

Although prior research has explored the effectiveness of PBL and e-modules separately, studies combining these two approaches in the specific context of physics problem-solving remain limited. Rahmawati et al. (2021) reported improvements in students' conceptual understanding of physics through PBL, while Prastowo (2019) highlighted the advantages of e-modules in fostering independent learning. However, there is a lack of empirical studies examining the integration of PBL with e-modules structured around Polya's problem-solving stages. Moreover, while previous investigations often focused on conceptual understanding or motivation, relatively few have explicitly addressed measurable gains in problem-solving ability, particularly within the Indonesian senior high school context. This gap is significant given the central role of problem-solving in physics education and the persistent challenges documented in international assessments.

The present study aims to address this gap by investigating the effectiveness of a PBL-based e-module, designed according to Polya's problem-solving steps, in enhancing the problem-solving abilities of high school students in physics. This study is novel in its dual contribution: first, by adapting Polya's classic problem-solving framework into a digital e-module format, and second, by embedding this framework within the PBL approach to foster inquiry and reasoning. By combining a structured problem-solving methodology with interactive technological tools and authentic problem contexts, this research offers an innovative instructional design that addresses both pedagogical needs and the realities of digital-era learning. The study contributes to the field of physics education by offering empirical evidence on how integrating PBL, e-modules, and Polya's stages can effectively strengthen students' problem-solving skills, with implications for curriculum design, instructional practice, and educational policy in Indonesia and beyond.

II. METHODS

This study employed a quantitative approach with a pre-experimental design, specifically using a one-group pretest–posttest model. Such a design is frequently used in educational research to measure changes in student outcomes before and after the implementation of an intervention, while controlling only minimally for extraneous variables (Creswell & Creswell, 2018). The design was chosen to evaluate the effectiveness of a problem-based learning (PBL)– based electronic module (e-module) structured around Polya's four problem-solving steps in improving students' physics problem-solving abilities. The one-group pretest–posttest design enables researchers to observe learning gains by comparing performance across two measurement points, thereby providing initial evidence of intervention impact (Fraenkel et al., 2015).

The study was conducted with students of class X at a public senior high school, where a total of 28 participants were purposively selected to represent the target population. The relatively small sample size reflects the class-based implementation of the intervention, which is typical in classroom-based educational research (Gay et al., 2012). All participants completed both the pretest and posttest assessments, ensuring the comparability of the data. The intervention consisted of integrating a PBL approach with a digital e-module specifically designed to align with Polya's problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and evaluating the solution (Polya, 1957; Krulik & Rudnick, 1999). These stages were embedded into the module to provide structured scaffolding, thereby allowing students to navigate problem-solving systematically while engaging with PBL activities.

The instruments used in this study comprised a set of problem-solving test items in physics that had been developed and validated by experts. The test items were designed to measure students' ability in accordance with the stages of Polya's problem-solving framework. The development process included expert judgment for content validity, ensuring that each item accurately reflected the targeted construct, as well as a pilot test to evaluate reliability. The reliability of the instrument was confirmed using Cronbach's alpha, a widely used measure of internal consistency in educational testing (Taber, 2018). The validity and reliability process ensured that the instrument could reliably measure the intended constructs and that the scores obtained were meaningful for subsequent statistical analysis.

Data collection was conducted in three phases: pretest administration, learning intervention, and posttest administration. At the outset, students completed a pretest to establish baseline measures of their problem-solving ability. During the learning phase, students engaged with the PBL-based e-module across a set number of sessions, which were integrated into the physics curriculum. The module included interactive explanations, guided problems, and opportunities for collaborative discussion, consistent with prior findings that technology-supported PBL environments improve engagement and learning outcomes (Hmelo-Silver, 2004; Mahmudi et al., 2021). Following the intervention, students completed a posttest containing items equivalent in structure and difficulty to the pretest, allowing for a valid comparison of scores.

The data analysis included both descriptive and inferential statistical techniques. Descriptive statistics were calculated to summarize mean scores, standard deviations, and performance distributions on the pretest and posttest. Inferential analysis was conducted using the Wilcoxon signed-rank test, a non-parametric method appropriate for paired data when assumptions of normality are not fully met (Sheskin, 2011). This test was chosen following normality checks on the score distribution, which indicated that parametric assumptions could not be satisfied. The Wilcoxon test, therefore, provided a robust method for evaluating whether there was a statistically significant difference between pretest and posttest results.

To further examine the magnitude of the observed differences, the normalized gain (N-gain) was calculated. The N-gain index is a measure widely used in educational research to assess the effectiveness of interventions in improving student learning outcomes (Hake, 1998). It compares the actual average gain with the maximum possible gain, thereby providing an interpretable metric of instructional effectiveness. The criteria for interpreting N-gain values are summarized in Table 1, which categorizes gain scores into high, medium, and low effectiveness.

Table 1. N-Gain criteria

No	N-Gain value	Category
1	$g \geq 0.70$	High
2	$0.30 \leq g < 0.70$	Medium
3	$g < 0.30$	Low

In addition, effect size was calculated using Cohen's d to determine the magnitude of the intervention's impact. Effect size provides valuable information on the practical significance of results, complementing statistical significance testing (Cohen, 1988). The interpretation of Cohen's d values is presented in Table 2.

Table 2. Effect size criteria (Cohen's d)

Cohen's d	Effect size	Interpretation
0.01 – 0.19	Very small	The effect is negligible or almost non-existent
0.20 – 0.49	Small	The effect exists, but is not strong
0.50 – 0.79	Medium	The effect is practically meaningful
0.80 – 1.29	Large	The effect is strong and clearly visible
≥ 1.30	Very large	The effect is very strong and highly significant

By combining Wilcoxon testing, N-gain, and effect size, the analysis provided a comprehensive picture of the intervention's effectiveness. While the Wilcoxon test established whether the differences between pretest and posttest scores were statistically significant, the N-gain index evaluated the relative effectiveness of the learning process, and the effect size indicated the magnitude of the educational impact. This triangulated approach ensured both statistical and practical perspectives were addressed in interpreting results. The design framework of the study is illustrated in Figure 1, which presents the stages of the research procedure from the initial planning to data collection and analysis.

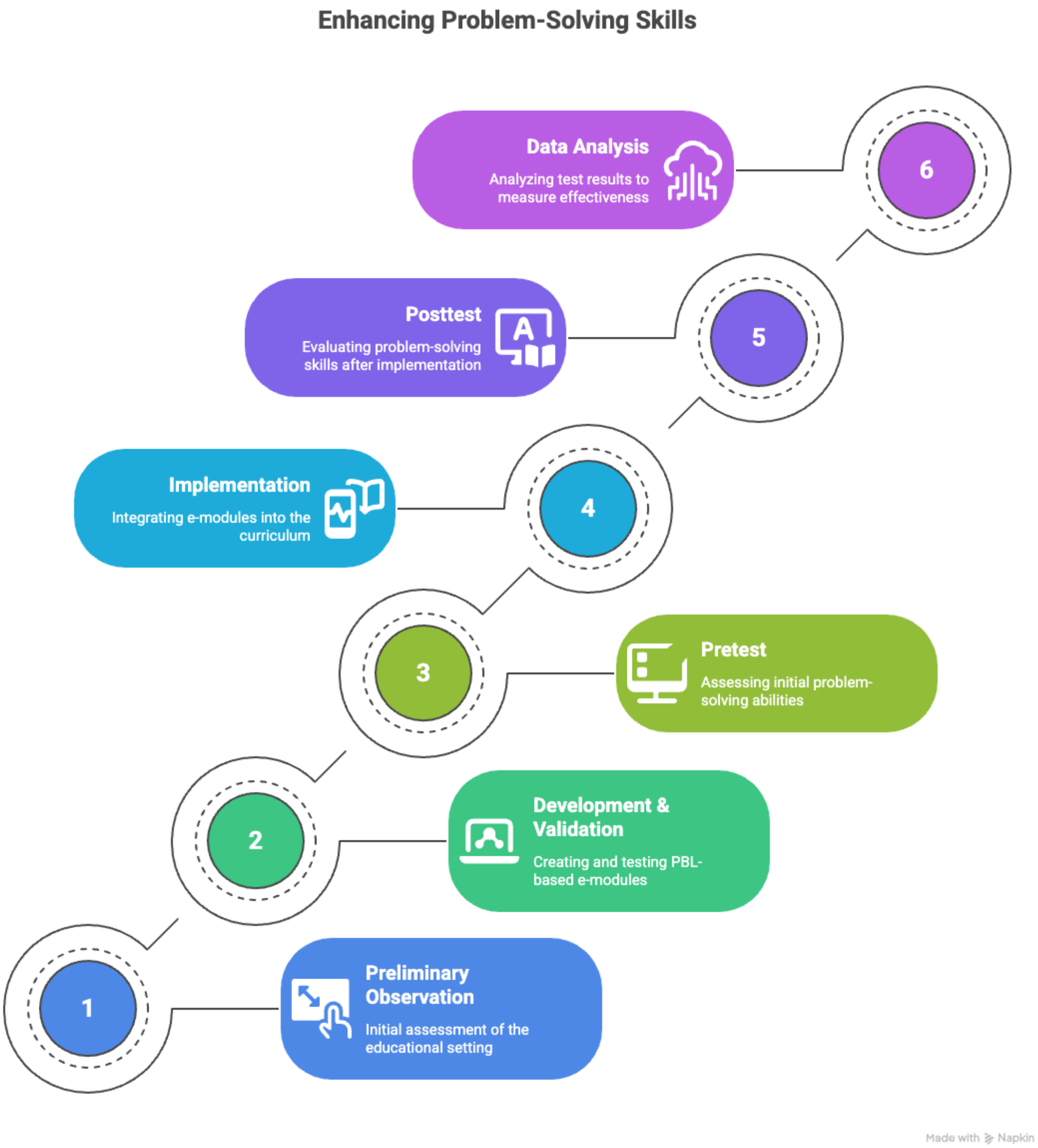

Figure 1. Flowchart of the data collection procedure

III. RESULTS AND DISCUSSION

3.1 Profile of students' problem-solving skills with PBL-based e-module integration

Students' problem-solving skills were analyzed based on the indicators proposed by Polya (1957). The results of the pretest, posttest, and N-gain values for each indicator are presented in Table 3.

Table 3. Analysis results of students' problem-solving skill indicators following the integration of PBL-based e-modules

No.	Indicator	Value			N-Gain Category
		Pretest	Post-test	N-Gain	
1	Understand the problem	61.68	81.00	0.504	Medium
2	Planning to solve the problem	36.82	63.00	0.414	Medium
3	Implementing the problem-solving plan	47.82	71.51	0.454	Medium
4	Evaluate the solution or conclude answer	50.15	80.40	0.607	Medium

Table 3 shows that improvements occurred across all four indicators of problem-solving skills. The highest N-gain was recorded in the indicator "evaluating the solution," with a value of 0.607 in the medium category. This indicates notable progress in students' ability to reflect on and assess the correctness of their answers. In contrast, the lowest N-gain value was found in the "planning to solve the problem" indicator (0.414), suggesting that strategy formulation remained relatively more challenging for students. The other two indicators, "understanding the problem" and "implementing the problem-solving plan," also showed moderate improvements with N-gain values of 0.504 and 0.454, respectively. These results demonstrate that the PBL-based e-module contributed to balanced improvements across all stages of the problem-solving process, though with varying degrees of gain.

3.2 Improved problem-solving with PBL-based e-module integration

The descriptive statistics of students' pretest and posttest scores are presented in Table 4. As shown in Table 4, the average performance of students improved considerably after the intervention. The mean score increased from 47.91 to 73.11, while the median rose from 44.75 to 76.50, indicating consistent progress across the majority of participants. The lowest score also improved from 18 to 46, suggesting that students with initially weak performance benefited substantially from the intervention. The maximum score showed a smaller increase, from 85 to 88, yet still demonstrated that high-achieving students were able to maintain and slightly enhance their outcomes. Furthermore, the decrease in standard deviation and variance values indicates that the score distribution became more homogeneous, reflecting a reduction in the performance gap among students.

Table 4. Pretest and posttest data on students' problem-solving skills following the integration of PBL-based e-modules in the static fluid concept

No	Statistic	Pretest	Posttest
1	Mean	47.91	73.11
2	Median	44.75	76.50
3	Standard deviation	14.23	11.15
4	Minimum	18	46
5	Maximum	85	88
6	Variance	202.57	124.36

To examine the assumptions for statistical testing, a normality test was performed. The results are summarized in Table 5.

Table 5. Normality test results for problem-solving skills with PBL-based e-module integration

	Shapiro-Wilk		
	Statistic	Df	Sig.
Pretest	.961	28	.378
Posttest	.877	28	.003

The results in Table 5 indicate that the pretest scores met the normality assumption, as shown by the significance value of 0.378, which is greater than 0.05. In contrast, the posttest data did not meet the assumption of normality, with a significance value of 0.003, which is below 0.05. These results suggest that the data distribution differed between the two test stages. Since the posttest scores were not normally distributed, a non-parametric statistical approach was applied for hypothesis testing to ensure accurate interpretation of the observed differences.

The difference between pretest and posttest results was further analyzed using the Wilcoxon Signed-Rank Test. The outcomes of this analysis are presented in Table 6.

Table 6. Wilcoxon test on problem-solving skills with PBL-based e-module integration on the concept of static fluid

Ranks				
		N	Mean Rank	Sum of Ranks
Posttest – Pretest	Negative Ranks	0^a	.00	.00
	Positive Ranks	28^b	14.50	406.00
	Ties	0^c		
	Total	28		

Table 6 shows that all 28 students experienced an increase in scores from pretest to posttest. There were no negative ranks, meaning none of the students' scores decreased, and there were no ties, indicating uniform improvement. The positive ranks recorded for all participants highlight the consistent effect of the intervention across the entire sample. The sum of ranks was 406.00, confirming that the posttest scores were systematically higher than the pretest scores.

The statistical results of the Wilcoxon Signed-Rank Test are shown in Table 7. As shown in Table 7, statistical confirmation indicates that the observed differences were highly significant. The Z value of -4.623 with a p-value of 0.000 ($p < 0.05$) indicates that the improvement between pretest and posttest was not due to random variation. The absence of negative ranks in Table 6, combined with the significance shown here, confirms that the intervention consistently produced positive outcomes. These results provide strong evidence that the implementation of the PBL-based e-module led to measurable improvements in students' problem-solving performance on the static fluid topic.

Table 7. Z Test Results on Problem-Solving Skills with PBL-Based E-Module Integration on the Concept of Static Fluid

Test Statistics[a]	
	Posttest – Pretest
Z	-4.623[b]
Asymp. Sig. (2-tailed)	.000

In addition to statistical significance, the effectiveness of the intervention was assessed using the normalized gain (N-gain). The summary of the N-gain results is shown in Table 8.

Table 8. Average values of pretest, posttest, and N-gain of problem-solving skills

Class	Pretest	Post-test	N-Gain	Interpretation
PBL-based physics e-module	47.91	73.11	0.48	Medium

As shown in Table 8, the N-gain value was 0.48, which falls within the medium category. This suggests that the intervention resulted in a moderate improvement in students' problem-solving skills. The increase from an average pretest score of 47.91 to a posttest score of 73.11 demonstrates that students achieved nearly half of the possible improvement relative to their initial performance. Although the gain was not classified as high, the medium category suggests that the intervention was effective and pedagogically meaningful. The results also reflect that the PBL-based e-module contributed to measurable learning progress that benefitted a wide range of students.

3.3 Effectiveness of PBL-based e-module in improving problem-solving skills

The effectiveness of the intervention was further evaluated by calculating the effect size using Cohen's d. This measure was applied to assess the magnitude of improvement between pretest and posttest scores, providing additional evidence beyond statistical significance. The results are presented in Table 9.

Table 9. Effect size values

Average		Standard deviation		D	Category
Pretest	**Post-test**	**Pretest**	**Post-test**		
47.91	73.11	14.23	11.15	1.97	High effect

Table 9 shows that the mean score increased from 47.91 in the pretest to 73.11 in the posttest, accompanied by standard deviations of 14.233 and 11.152, respectively. The effect size value obtained was 1.971, which is categorized as very high. This result indicates that the intervention had a strong and practically meaningful impact on students' problem-solving skills. The magnitude of the effect suggests that the observed improvement was not only statistically significant but also substantial in terms of its influence on students' actual learning outcomes. The large value of Cohen's d provides robust evidence that the integration of the PBL-based e-module was highly effective in supporting student achievement in the static fluid topic.

The findings of this study provide strong evidence that integrating PBL with an e-module designed according to Polya's problem-solving stages significantly improves students' performance on static fluid concepts. The descriptive analysis showed consistent increases across all four indicators of problem-solving skills, understanding problems, planning solutions, implementing strategies, and evaluating outcomes with N-gain values in the medium range. Among these, the greatest improvement was observed in the evaluation indicator, where students demonstrated enhanced ability to reflect upon and critically assess their solutions. This result aligns with Jonassen's (2000) perspective that problem-solving is a complex and iterative process that requires not only procedural execution but also reflective judgment. Similar patterns were observed in research on mathematics and medical education, where students developed reflective abilities more easily than strategic planning skills (Asad et al., 2015; Nisa et al., 2023). These findings suggest that reflective evaluation may be more naturally developed through structured inquiry, while the ability to plan solutions requires explicit scaffolding and repeated practice (Ali et al, 2019; Herawati & Wilujeng, 2023).

Although improvements were observed across all indicators, the lowest N-gain was recorded in the planning stage, reinforcing the notion that designing systematic solution strategies remains a persistent challenge for students. This difficulty aligns with previous studies, which highlight that students often struggle to structure problem-solving steps despite understanding the initial problem context (Ali et al, 2019). In the context of physics, this challenge is particularly pronounced because problems often require the coordination of multiple representations mathematical, conceptual, and graphical before an effective strategy can be implemented (Docktor & Mestre, 2014). Therefore, while the intervention successfully raised overall performance, future instructional designs should emphasize scaffolding strategies that specifically target the planning phase, perhaps through guided prompts or collaborative design tasks.

Beyond individual indicators, the comparison between pretest and posttest scores revealed statistically significant improvements across the entire sample. The Wilcoxon Signed-Rank Test confirmed that all students experienced gains, with no negative ranks, and the effect size analysis indicated a very large effect (d = 1.97). This magnitude of improvement demonstrates that the intervention was not only effective statistically but also meaningful in practical classroom contexts. Such strong results align with prior research showing the benefits of PBL in fostering higher-order thinking and problem-solving ability in science and mathematics education (Hmelo-Silver, 2004; Savery, 2006; Yew & Goh, 2016). Moreover, the integration of e-modules provided an interactive and flexible platform that supported student engagement, consistency of learning, and access to structured problem-solving guidance (Prastowo, 2019; Putra & Rachmawati, 2021). The synergy of PBL and digital media, therefore, appears to have contributed substantially to the effectiveness observed in this study.

The moderate N-gain value (0.48) observed in this study is consistent with previous investigations that reported similar levels of improvement in problem-solving ability through PBL-based interventions. For instance, Kadir et al. (2016) and Hasrawati et al. (2020) both found that PBL implementations generally resulted in medium learning gains, which they attributed to the gradual and cumulative nature of inquiry-based learning. These results reinforce the idea that PBL fosters steady progress rather than immediate large leaps, as students progressively build conceptual understanding through active engagement and collaboration. However, the large effect size observed in the present study suggests that, although average improvements fell within the medium category, the intervention still had a significant impact on individual student achievement and on the overall classroom learning environment.

The results also highlight important pedagogical implications for physics education. The significant improvement in evaluation skills suggests that students can develop reflective thinking when provided with structured opportunities to analyze and justify their solutions. This supports the argument by Belland et al. (2009) that PBL-based instructional designs integrated with digital resources promote deeper reasoning and conceptual mastery. Similarly, the reduction in score variance from pretest to posttest indicates that the intervention contributed to narrowing the performance gap among students, supporting weaker learners while also challenging stronger ones. This finding is particularly significant in the Indonesian context, where disparities in student achievement are often attributed to differences in access, prior knowledge, and motivation (Hadi

& Novaliyosi, 2019; Riau, 2023). By providing equitable access to structured problem-solving experiences, the e-module helped to level outcomes across the group.

Another key contribution of this study lies in demonstrating the practical applicability of combining Polya's problem-solving model with PBL principles in a digital format. While prior studies have examined PBL (Rahmawati et al., 2021) or e-modules independently (Yuliana et al., 2020), relatively few have explicitly integrated these approaches within physics education to target problem-solving competence. The novelty of this design lies in embedding the four systematic steps of Polya into interactive learning activities that are problem-centered, collaborative, and digitally accessible. The large effect size reported here provides empirical evidence that such integration can produce meaningful learning outcomes, bridging the gap between traditional instruction and the demands of 21st-century science education.

Finally, the findings emphasize the importance of aligning instructional innovations with the broader goals of national curriculum reforms. The Indonesian "Merdeka Curriculum" emphasizes inquiry, reasoning, and problem-solving as key competencies (Kemendikbud, 2022), yet challenges persist in implementing these at the classroom level. The present study contributes to addressing this gap by demonstrating that a carefully designed PBL-based e-module can effectively operationalize these competencies in the context of physics learning. By situating problem-solving tasks within digital platforms that guide students through structured reasoning processes, this study illustrates how curriculum aspirations can be translated into classroom practice

IV. CONCLUSION AND SUGGESTION

This study examined the effectiveness of a problem-based learning (PBL)–based electronic module (e-module) designed with Polya's problem-solving stages in improving high school students' problem-solving skills on the topic of static fluid. The results showed a clear increase in student performance, as reflected in the improvement of mean scores from pretest (47.91) to posttest (73.11). All four indicators of problem-solving skills understanding the problem, planning solutions, implementing strategies, and evaluating results showed gains, with N-gain values categorized as medium. The Wilcoxon Signed-Rank Test confirmed that all students achieved higher posttest scores, and the effect size analysis yielded a very large value ($d = 1.97$), indicating that the intervention produced not only statistically significant but also practically meaningful improvements in students' learning outcomes.

Despite these promising findings, the study has several limitations. The research was conducted with a relatively small sample size of 28 students from a single school, which may restrict the generalizability of the results. Additionally, the pre-experimental design, which lacked a control group, limited the ability to isolate the intervention's effect from other influencing factors. Future studies should expand the sample to multiple schools, include diverse student populations, and employ experimental or quasi-experimental designs with control groups to strengthen causal inferences. Longitudinal studies could also provide insights into the sustainability of improvements in problem-solving skills over time. Nevertheless, this study contributes to the field of physics education by demonstrating the potential of integrating PBL with Polya's structured problem-solving model in a digital module format. The findings highlight how combining inquiry-based pedagogy with interactive technology can enhance students' higher-order thinking skills, offering a practical instructional model for improving physics learning in line with 21st-century educational goals

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