

Enhancing Pre-service Science Teachers Physics Problem Solving Skills Through Problem Solving Innovative Situated Learning Instruction (PSISLI) Strategy

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Abstract - This study investigated the effectiveness of the Problem Solving Innovative Situated Learning Instruction (PSISLI) strategy in improving pre-service science teachers' physics problem-solving skills. Rooted in situated learning principles, PSISLI places learners in authentic, context-rich situations that strengthen the link between conceptual understanding and real-world application. The approach integrates guided inquiry and reflective dialogue to support analytical reasoning, enabling learners to engage meaningfully with complex, non-routine problem-solving tasks. It also emphasizes the development of higher-order thinking and metacognitive regulation by encouraging learners to articulate, monitor, and refine their reasoning processes. Through these experiences, pre-service teachers demonstrate growth not only in solving physics problems but also in explaining and evaluating their own thinking. Overall, the findings underscore the importance of authentic, learner-centered environments in cultivating scientifically literate and instructionally capable future teachers.

Keywords - Situated Learning Instruction, Fluid Mechanics Problem Solving, Authentic Rich Context Problems, Pre-Service Science Teachers,

I. INTRODUCTION AND LITERATURE REVIEW

Developing strong problem-solving skills among pre-service science teachers is essential, as many continue to struggle with applying physics concepts beyond rote procedures.

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Situated learning provides a meaningful pathway by immersing learners in authentic contexts that cultivate reasoning, adaptability, and cognitive apprenticeship. The Problem Solving Innovative Situated Learning Instruction (PSISLI) strategy builds on this foundation by embedding physics problems in realistic scenarios and guiding learners through structured steps that promote conceptual understanding, strategic thinking, and reflective practice. Given persistent challenges in physics problem solving and the need for practice-based teacher preparation, examining the effectiveness of PSISLI is both timely and necessary for strengthening future teachers' instructional competence.

Related Literature. The PSISLI strategy enhances pre-service teachers' physics problem-solving by integrating situated learning, cognitive apprenticeship, and structured heuristics into four aligned phases. Contextual anchoring situates problems in authentic scenarios to support problem representation (Lave & Wenger, 1991; Brown, Collins, & Duguid, 1989). Guided apprenticeship models expert reasoning through coaching and scaffolding (Collins, Brown, & Holum, 1991), while collaborative situated practice strengthens conceptual understanding through structured group work (Heller, Keith, & Anderson, 1992). Reflective abstraction develops metacognitive regulation by prompting learners to evaluate strategies and analyze errors, consistent with Schoenfeld's (1985, 1992) work. Together, these phases form a coherent, theory-based pathway that supports expected gains in problem-solving and metacognitive performance.

II. MAIN OBJECTIVES OF THE STUDY

The study aims to enhance pre-service science teachers' physics problem-solving competence by implementing the PSISLI strategy to strengthen conceptual application in authentic contexts, develop higher-order thinking and metacognitive skills and cultivate transferable, inquiry-driven problem-solving abilities for effective future classroom practice.

III. METHODOLOGY

The PSISLI was developed using the ADDIE model (Molenda, 2003), identifying key physics problem-solving domains, mapping them to Archimedes', Pascal's, and Bernoulli's principles, and creating validated situated tasks and rubrics. Implemented with pre-service teachers, the instrument measured cognitive and metacognitive competencies through standardized testing and student evaluation. A quasi-experimental pretest–posttest design captured PSISLI's impact, aligning with its phases of authentic context, guided apprenticeship, collaborative practice, and reflective abstraction. Cognitive gains were assessed through physics problem-solving tests, while metacognitive outcomes—planning, monitoring, and evaluation—were measured using awareness and self-regulation scales, consistent with Hmelo-Silver (2004) and Jonassen (2011).

A. Participants

The participants were preservice science teachers enrolled in a Physics content course in one of the state universities of Cebu, Philippines. They class was purposively selected through total enumeration to ensure full representation of the cohort. All participants had completed foundational coursework in General Physics and were concurrently taking methods courses in science education. Participation was voluntary, and informed consent was secured prior to data collection.

B. Instrument

The study used two primary instruments: a problem-solving performance test composed of non-routine, context-rich Physics problems on Archimedes', Pascal's, and Bernoulli's principles, and a metacognitive awareness inventory. Developed through the ADDIE model (Molenda, 2003), the instrument identified key competencies, mapped them to Fluid Mechanics concepts, and constructed situated problems with aligned scoring rubrics. Expert validation, clarity checks, and reliability analysis ensured that the tool accurately measured conceptual understanding, procedural fluency, analytical reasoning, critical thinking, and transfer of learning.

C. Procedure

Data collection was conducted during regular class hours to ensure accessibility and minimize disruption. Participants completed the profiling instrument individually within a predetermined time frame. Instructions were followed with no mobile phones or external references allowed to preserve the integrity of the problem-solving process. Completed responses were collected, anonymized, and coded for analysis. Expert validators reviewed the instrument prior to

administration to ensure content alignment, clarity, and cognitive appropriateness.

D. Data Analysis

Data analysis used the ADDIE-developed instruments and a quasi-experimental pretest–posttest design to evaluate the PSISLI strategy. Quantitative data from the problem-solving test and metacognitive awareness inventory were analyzed using descriptive statistics, paired-samples t-tests, and effect sizes to measure changes in conceptual understanding, procedural fluency, analytical reasoning, critical thinking, and transfer of learning. Metacognitive data were similarly examined through descriptive statistics and paired t-tests to assess gains in planning, monitoring, and evaluation. Together, these analyses provided a clear measure of PSISLI's impact on both cognitive and metacognitive dimensions of physics problem solving.

IV. DATA PRESENTATION, RESULTS AND DISCUSSION

The table below shows the data of the pre-post mean scores and index ratings of foundational physics problem solving skills and knowledge among pre-service science teachers.

TABLE I
PRE-POST MEAN SCORES AND INDEX RATINGS OF
FOUNDATIONAL PHYSICS PROBLEM SOLVING SKILLS AND
KNOWLEDGE AMONG PRE-SERVICE SCIENCE TEACHERS

Criteria	$\sum \bar{x}_w$	$\sum x_i$	Interp.
1. Useful description	2.02	0.67	S/H
2. Physics approach	1.54	0.52	F/M
3. Specific application of Physics	1.63	0.54	F/M
4. Physics equation	1.25	0.42	F/M
5. Foundational Knowledge and mathematical skills processes			
· Given identification	1.93	0.60	F/M
· Transposition	1.34	0.45	F/M
· Derivation formula	1.31	0.44	F/M
· Unit identification	1.53	0.51	F/M
· Unit cancellation and extraction	1.36	0.46	F/M
· Concept relation	1.07	0.47	F/M

·	Equation translation into words	2.22	0.66	F/M
·	Sign rule	1.70	0.53	F/M
·	Unit conversion	1.35	0.45	F/M
·	Scientific Notation	1.24	0.42	F/M
·	Simple Mathematical operation	1.47	0.49	F/M
6.	Logical progression	1.08	0.38	F/M
	Overall	1.03	0.49	F/M

The results indicate that learners demonstrate an overall Fair/Moderate (F/M) level of proficiency in physics problem-solving, with an overall index of 0.49. This suggests that while students possess emerging conceptual and representational skills, they struggle with deeper analytical reasoning, symbolic manipulation, and systematic mathematical execution—highlighting the need for targeted instructional support in equation formulation, mathematical fluency, and reflective problem-solving

TABLE II
PRE-POST TEST ITEM ANALYSIS TABLE: DIFFICULTY, DISCRIMINATION, AND RELIABILITY INDICATORS AMONG PRE SERVICE SCIENCE TEACHERS

Item	Description	Difficulty Index	
		$\sum x_i$	Interp.
1	Archimedes problem sketch formulation	52%	M
2	Archimedes concepts and principles involve in the problem	56%	M
3	Archimedes principle resolving the problem with the known and unknown identification	42%	M
4	Archimedes formulation of Physics Equation	52%	M
5	Archimedes correct translation of equation into words	78%	E
6	Archimedes mathematical procedure using the equation	31%	M
7	Archimedes mathematical procedure using the equation	67%	M
8	Archimedes mathematical procedure using the equation	38%	M
9	Archimedes mathematical procedure using the equation	32%	M
10	Archimedes mathematical procedure using the equation	9%	D
11	Pascal principle problem sketch formulation	24%	D
12	Pascal's concepts and principles involve in the problem	18%	D
13	Pascal's principle resolving the problem with the known and unknown identification	39%	M

14	Pascal's formulation of Physics Equation	13%	D
15	Pascal's principle correct translation of equation into words	28%	D
16	Pascal's mathematical procedure using the equation	36%	M
17	Pascal's mathematical procedure using the equation	12%	D
18	Pascal's mathematical procedure using the equation	53%	M
19	Pascal's mathematical procedure using the equation	58%	M
20	Pascal's logical progression	6%	D
21	Bernoulli's principle problem sketch formulation	45%	M
22	Bernoulli's concepts and principles involve in the problem	24%	D
23	Bernoulli's principle resolving the problem with the known and unknown identification	40%	M
24	Bernoulli's principle in formulation of Physics Equation	31%	D
25	Bernoulli's principle correct translation of equation into words	29%	D
26	Bernoulli's mathematical procedure using the equation	34%	M
27	Bernoulli's mathematical procedure using the equation	34%	M
28	Bernoulli's mathematical procedure using the equation	29%	D
29	Bernoulli's mathematical procedure using the equation	30%	D
30	Bernoulli's principle logical progression	7%	D
	Total	35%	M

Table 2 tabulates pre-posttest item analysis. The overall difficulty index of 35% (Moderate) indicates that students found the test moderately challenging. Items related to Archimedes' principle mostly fall within the moderate range, except for the translation of equations into words, which students found easy, and one mathematical item that was difficult. In contrast, most items under Pascal's principle were rated difficult, suggesting significant learner struggle with conceptual understanding, equation formulation, and procedural application. Similarly, Bernoulli's principle shows a pattern of difficulty in conceptual and procedural items, with only a few falling into the moderate range. Overall, students demonstrated better performance in Archimedes-related tasks, while Pascal and Bernoulli concepts posed greater difficulty, particularly in higher-order reasoning and mathematical procedures.

TABLE III
PRE-POSTTEST RATINGS OF PROBLEM SOLVING INNOVATIVE
SITUATED LEARNING INSTRUCTION AMONG THE PRE SERVICE
SCIENCE TEACHERS

Respo ndents	Pre- test Mean	Post Test Mean	Mean Diffe rence	SD EV. P	t _{df} at < p=0 .025	Cohen d
Pre- Serv ice Scie nce Teac hers	7.89	13	4.97	4.2	0	1.18

Interpretation Guide (Cohen, 1988)

0.2 small 0.5 medium 0.8 large 1+ very large

Table 3 presents the pre-posttest ratings of problem solving innovative situated learning instruction among the pre service science teachers. The pre-service science teachers showed a substantial improvement from the pre-test mean of 7.89 to the post-test mean of 12.86, yielding a mean gain of 4.97. With a standard deviation of 4.23 and a t-value significant at $p < 0.025$, the increase is statistically meaningful. The computed Cohen's $d = 1.18$ indicates a very large effect size, demonstrating that the intervention produced a strong and educationally significant impact on learners' performance.

V. DISCUSSION

Novice learners often rely on surface features rather than deep structural reasoning (Larkin, McDermott, Simon, & Simon, 1980; McDermott, 1991), show fragmented conceptual understanding (Heller & Reif, 1984; McDermott & Shaffer, 1992), and struggle with planning multi-step solutions (Reif & Heller, 1982). Difficulties in selecting and applying equations (Maloney, 1994) and in mathematical modeling, symbolic manipulation, and unit analysis (Tuminaro & Redish, 2007) mirror the weak analytical and computational performance observed. Similar patterns reported by Loverude et al. (2003), Planinic et al. (2006), Meltzer (2002), and Docktor & Heller (2009, 2014) show that students typically excel in descriptive representation but falter in execution and evaluation. Collectively, these studies confirm that pre-service teachers demonstrate emerging representational skills but persistent challenges in analytical reasoning, mathematical fluency, and systematic problem-solving.

V. CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

The implementation of the Problem-Solving Innovative Situated Learning Instruction (PSISLI) strategy demonstrates that pre-service science teachers' problem-solving skills in Physics can be significantly strengthened when instruction is

anchored in authentic, context-rich learning environments. By situating Physics tasks in meaningful scenarios, PSISLI enables learners to connect conceptual understanding with real-world application—an approach consistent with Lave and Wenger's (1991) assertion that learning becomes more powerful when embedded in genuine practice. This alignment between context and cognition supports the development of flexible reasoning and deeper conceptual insight.

The strategy's emphasis on guided inquiry and reflective dialogue echoes the work of Hmelo-Silver (2004), who highlights that structured problem-based learning environments enhance learners' ability to analyze conditions, evaluate assumptions, and construct evidence-based solutions. Similarly, Jonassen (2011) argues that complex, ill-structured problems promote higher-order thinking and metacognitive regulation—both of which are central features of the PSISLI design. Through these processes, pre-service teachers not only learn how to solve Physics problems but also how to articulate, monitor, and refine their reasoning.

A. Implications

1. Strengthening teacher education and classroom practice. Teacher education programs should adopt authentic, context-rich, and inquiry-oriented approaches like PSISLI to prepare future teachers to model real-world reasoning and implement learner-centered, problem-based instruction in their own classrooms.
2. Guiding curriculum and instructional design in physics. The success of PSISLI—grounded in situated learning (Lave & Wenger, 1991), guided inquiry (Hmelo-Silver, 2004), and complex problem-solving frameworks (Jonassen, 2011)—highlights the need for curricula and materials that embed authentic contexts, reflective dialogue, and ill-structured problems to build deeper conceptual understanding and flexible reasoning.
3. Improving assessment and problem-solving competence. Since PSISLI develops analytical reasoning, metacognitive regulation, and transferable problem-solving skills, assessment practices should move beyond multiple-choice formats toward performance-based tasks and reflective explanations that capture learners' thinking processes more accurately.

B. Recommendations

1. Integrate PSISLI into teacher education coursework. Teacher education institutions should formally embed the PSISLI framework into Physics content courses and methods classes. This ensures that pre-service teachers consistently experience authentic, context-rich, inquiry-driven learning, rather than traditional formula-based instruction.
2. Redesign physics learning activities around real-world contexts. Faculty should revise laboratory tasks, problem sets, and classroom activities to include situated scenarios, complex problems, and real-life applications. This supports deeper conceptual understanding and mirrors the cognitive demands of actual scientific practice.

3. Strengthen guided inquiry and reflective dialogue in instruction. Instructors should incorporate structured questioning, collaborative reasoning tasks, and reflective discussions to help learners articulate their thinking. These practices reinforce metacognitive awareness, a key outcome of PSISLI.

4. Conduct continuous evaluation and refinement of PSISLI implementation. Institutions should regularly assess the effectiveness of PSISLI through student performance data, classroom observations, and feedback from pre-service teachers. This ensures ongoing improvement and sustainability of the strategy.

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