



ENHANCING STUDENTS' INTENTIONALITY AND PROBLEM-SOLVING SKILLS THROUGH EXPERIENTIAL LEARNING USING 3-D VECTOR APPARATUS

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ABSTRACT

Researchers in science education are constantly developing strategies to improve students' skills. This study evaluates whether the Experiential Learning Environment (ELE), aided by the 3-D Vector apparatus, affects students' problem-solving skills and Intentionality in learning Physics at Bukidnon National High School of Home Industries, Maramag, Bukidnon, during the first semester of the school year 2024-2025. A quasi-experimental research design was used in the study, with 87 grade 12 STEM students from two intact class sections as participants; there were forty-seven (47) students in the ELE group, and forty (40) students in the non-ELE group. Two research instruments were used in the study. The researcher developed a 5-item Physics test to assess problem-solving skills, which was validated by Physics experts using Heller's Problem-Solving Framework and the Intentional Learning Questionnaire (ILQ), which was adapted to assess students' intentionality in Physics. The data were analyzed using descriptive statistics and Analysis of Covariance (ANCOVA). The results showed that students exposed to ELE scored higher on the posttest in problem-solving skills than those exposed to non-ELE. It also revealed that the ELE group shows significant improvements in intentionality, particularly in their motivation and learning strategies, compared to the non-ELE group. Both tests obtained p-values below the accepted significance level of 0.05, thereby rejecting the null hypothesis. These findings indicate that the Experiential Learning Environment is an effective instructional approach in enhancing students' problem-solving skills and intentionality compared to traditional methods.

Keywords: *Students' Intentionality, problem-solving skills, 3D Vector Apparatus, Heller's Problem-solving framework.*

INTRODUCTION

For a long time, Philippine science education has been facing difficulties in improving students' problem-solving skills and performance. These international and national assessment results still challenge science education in the Philippines, despite its notable vision to equip learners with scientific skills and attitudes, which makes students more capable of doing things on their own and more competent for future careers to meet job market demands. According to the 2022 Program for International Student Assessment (PISA), published in 2023, about 23% of Filipino students are unable to identify and explain common scientific phenomena or rationally support conclusions. Hence, the Philippines' performance in problem-solving skills continues to rank lowest internationally (OECD, 2023). Moreover, the National Achievement Test (NAT) shows that students' problem-solving skills in science were generally low from 2004 to 2018 (Lumboy & Mangansat, 2022).

The struggle to develop these vital skills is particularly evident in physics. Problem-solving skills are an important part of learning physics that students need to develop, enabling them to tackle difficulties and identify which problems require logical thinking, rational analysis, and decision-making. However, a study by Foroughi et al. (2016) found that problem-solving skills are plagued by methodological problems. For this reason, a great deal of research and instructional development has focused on strengthening the emphasis on problem-solving skills in physics courses (Amrizaldi et al., 2024; Mikula & Heckler, 2017). Locally, problem-solving research found that, while students initially performed satisfactorily in carrying out the plan, they were poor at understanding the problem, devising a plan, and executing and reflecting on the solution (Gulam & Arenas, 2024). This is especially true for abstract topics like vectors, where students likely rely on rote memorization and "plug-and-chug" formulas rather than authentic problem-solving.

One psychological factor that complicates this reliance on rote memorization is student intentionality. In a conventional setting, students often struggle to see the realness or relatedness of a physics concept. When learning is confined to abstract symbols, students fail to recognize the value of the task. This leads to passive intentionality, where students may want to pass the exam but lack the intrinsic drive to master the concept. Without a tangible connection, motivation remains stagnant. Conversely, intentional learners take an active role and accountability for their own learning, including how they learn and what they need to learn (Bucayong, 2019; Bucayong & Bee, 2018). They also stated that motivation and preferred learning strategy are factors that affect student intentionality. Focusing on how students learn rather than what to learn can be emphasized through problem-solving activities (Tanjung & Nasution, 2022).

To effectively channel student intentionality into actionable skills, structured cognitive frameworks are necessary. One useful technique for helping students with physics problem-solving is the five-step process described by Heller et al. (2010) as cited by Tanjung et al. (2024). These steps include focusing on the problem, describing the problem in terms of Physics, planning a solution, executing the plan, and evaluating the

results. However, Shimizu (2022) argues that this does not guarantee the solution of problems; it is simply how one thinks when solving them. Therefore, for Heller's steps to be effective, students must possess the active intentionality needed to engage cognitively with each stage, especially the planning and evaluation phases, where local students traditionally struggle.

Experiential learning solves the crisis above by shifting the focus away from getting the right answer and onto the process of discovery. It teaches students that making a mistake isn't a failure but rather a necessary step toward their next attempt. The experiential learning strategy is a learning approach that encompasses all the key aspects of active learning. Specifically, the layout of the Experiential Learning Environment might enhance students' problem-solving skills and their intentionality when using a tangible 3-D vector apparatus, thereby sparking motivational drive and influencing the development of learning strategies and adherence to Heller's problem-solving framework.

While the quest to address the gap in the literature on problem-solving skills continues, a specific need remains. Although many studies support enhancing problem-solving skills, few focus on experiential factors that are highly correlated with studying physics topics. The gap presented above poses a challenge for the researcher to enhance students' problem-solving skills and intentionality by using experiential learning. Hence, the present study needs to be developed to examine how the Experiential Learning Environment affects students' problem-solving skills and their intentionality in Physics when solving vector problems. The study's findings could spark further research on teaching and learning in other parts of science and physics.

Research Questions

This study aimed to assess the effect of the Experiential Learning Environment (ELE) with the 3-D vector apparatus and Heller's Problem-Solving Framework on students' problem-solving skills and intentionality in Grade 12 STEM at Bukidnon National School of Home Industries. Specifically, this study sought to answer the following questions:

1. What is the level of students' intentionality before and after the intervention of those exposed to ELE and those exposed to non-ELE in terms of:
 - 1.1 Motivation; and
 - 1.2 Learning Strategy?
2. What is the level of students' problem-solving skills in Vectors when exposed to ELE and to non-ELE in terms of:
 - 2.1 Pretest; and
 - 2.2 Posttest?
3. Is there a significant difference in the students' intentionality before and after the intervention of those exposed to ELE and those exposed to non-ELE?
4. Is there a significant difference in the level of students' problem-solving skills in Vectors when exposed to ELE and to non-ELE?

METHODOLOGY

Research Design and Locale

The study employed a quasi-experimental design, specifically a pretest-posttest control group design. This approach involved selecting two groups of students: an experimental group was exposed to an Experiential Learning Environment, including the 3-D Vector Apparatus, during their learning process, and a control group was exposed to a non-Experiential Learning Environment. Both groups will undergo a pretest to establish baseline levels of intentionality and problem-solving skills, followed by a post-test after the ELE group's interaction with the 3-D Vector Apparatus. This post-intervention assessment will measure changes in the dependent variables, enabling a comparative analysis between the ELE and non-ELE groups. Pretest and posttest scores were gathered to assess the students' problem-solving skills and intentionality

Additionally, the study was conducted at the Bukidnon National School of Home Industries, located in Maramag, Bukidnon. BNSHI is a Secondary Education headed by a principal under the supervision of the Department of Education (DepEd). The school has laboratories and equipment, including the 3D vector apparatus. During the delivery of the apparatus, the inventor conducted an orientation on how to use it. Accidentally, including those students who are chosen to be the participants of the study.

Research Participants and Sampling

For the study, the participants consist of 87 students from two intact classes within an educational institution. These participants were carefully selected based on criteria designed to ensure a representative sample of the broader student population. The ELE group engaged with the 3-D Vector Apparatus eight (8) times, excluding the session where the inventor provided an orientation on how to use the apparatus and Heller's problem-solving steps as part of their learning process. This allowed the study to assess the effect of this technological tool on their intentionality and problem-solving skills. In contrast, the non-ELE group continued with the standard curriculum without incorporating the 3-D Vector Apparatus, serving as a benchmark against which the effectiveness of the experimental intervention can be measured.

In summary, the participants in this study were carefully selected to provide a balanced and comprehensive analysis of the effect of the 3-D Vector Apparatus on student learning outcomes, with a focus on enhancing student intentionality and problem-solving skills.

Research Instruments

The study utilized academic and non-academic assessments.

The first instrument was intended to determine the student's problem-solving skills. The researcher constructed a test that covers the content presented, Vectors. The instrument consists of five (5) word problems. Each set includes questions designed to

measure the student's problem-solving skills using Heller's Problem-solving framework. This test includes a series of problems that require the application of concepts taught using the 3-D Vector Apparatus.

This test aimed to quantitatively measure the improvement in the students' problem-solving skills resulting from interaction with the apparatus. The test was reviewed by experts in physics. Two physics experts from BNSHI and one from CMU Laboratory High School served as content validators. This validation process comprises expert review by three validators, who assess the questionnaire for clarity and relevance, followed by a refinement phase to adjust questions based on their feedback.

Subsequently, students' answers were rated using the following rubric, adapted from Docktor et al. (2016). Data on test results measuring students' problem-solving skills were reflected in scores based on a special grading rubric. The scores obtained were then calculated, analyzed, and converted into qualitative data to determine the percentage level of students' physics problem-solving skills.

The second research instrument is intended to determine the student's intentionality; an intentional learning questionnaire (ILQ) adapted from Bucayong and Bee (2018) from their study Direct Current Electric Circuits. It was validated and reliability-tested, with Cronbach's alpha of 0.789 for the motivation construct and 0.874 for the learning strategy construct.

The questionnaire included structured items to assess students' intentionality, motivation, and learning strategies during learning activities. It consisted of a 40-item Likert-scale type of survey with 2 factors. This instrument serves not merely as a measure of academic engagement but as a reflection of students' intentionality in their learning process. By linking numerical ratings to qualitative descriptors such as Extreme High Intentionality (EHI) or Very Low Intentionality (VLI), the scale enables a more human-centered interpretation of students' motivation and strategies. It acknowledges that learning is a dynamic process influenced by personal effort, reflection, and persistence, rather than a static measure of performance alone.

Data Gathering Procedure

A systematic procedure was followed to collect data for the study. The process began with obtaining the necessary permissions, including approval to conduct research among Grade 12 STEM students under the K to 12 Curriculum. This request was submitted to the Superintendent of the Schools Division of Bukidnon for the school year 2024-2025. Additionally, permission and approval from the principal of Bukidnon National School of Home Industries (BNSHI) were obtained prior to the study. Approval from the Institutional Ethics Review Committee (IERC) was also secured to ensure that the research adhered to institutional and ethical standards before any data collection commenced.

After receiving the necessary approvals, the research instruments were validated and pilot tested to ensure their reliability and content validity. This phase included an

expert evaluation of the researcher-developed tools designed to assess students' problem-solving skills using a specific rubric. The refinement process confirmed that the instruments were appropriate for measuring the intended constructs, particularly problem-solving skills and student intentionality, which were also adapted and validated by experts.

Participants were selected based on predefined inclusion criteria that aligned with the study's design. Since Grade 12 STEM students cover vector topics during the semester, they were specifically chosen for this study. Care was taken to ensure that the participants accurately represented the target population, and the sampling procedures were designed to uphold the integrity of the research outcomes.

Ethical considerations were addressed throughout the study, including informed consent, confidentiality, and voluntary participation. These measures safeguarded the participants' rights and maintained the ethical rigor of the research process.

Before implementing the Experiential Learning Environment (ELE), both groups underwent pretests using the standardized test to establish baseline problem-solving abilities. They completed questionnaires to gauge initial levels of student intentionality. During the intervention phase, the ELE group engaged with the 3-D Vector Apparatus and utilized Heller's Problem-Solving Steps as part of their learning process, while the non-ELE group continued with the standard curriculum. Throughout this period, interactions with the 3-D Vector Apparatus and the use of Heller's Problem-Solving Steps were closely observed, focusing on usage patterns and students' engagement with the apparatus.

After the intervention, both groups were administered posttests identical to the pretests to measure any changes in problem-solving skills. The same questionnaires were also redistributed to assess shifts in student intentionality. All collected data, including tests and questionnaire responses, were systematically organized for analysis. This analysis used statistical methods to compare pretest and posttest results between the ELE and non-ELE groups, aiming to evaluate the effects of the 3-D Vector Apparatus and Heller's Problem-Solving Steps on students' problem-solving skills and intentionality.

After implementation, data analysis was conducted using appropriate statistical techniques, such as descriptive statistics and analysis of covariance (ANCOVA), to compare relationships and differences between groups. The results were interpreted in alignment with the study's objectives and theoretical framework.

Finally, the data interpretation provided meaningful insights into how experiential learning with the 3-D Vector Apparatus and direct instructional approaches influenced students' learning behaviors and problem-solving proficiency. This stage synthesized quantitative findings with qualitative interpretations to draw conclusions relevant to educational practice and theory.

Data Analysis

A series of statistical techniques was deployed to address the research objectives. The study employed descriptive statistics to assess the level of student intentionality and problem-solving skills in the Experiential Learning Environment with 3-D Vector Apparatus and Heller's problem-solving framework, and the non-Experiential Learning Environment. Frequency, mean, and standard deviations were used to describe the pretest and post-test results. This analytical approach provided insights into students' levels of intentionality and problem-solving skills.

Furthermore, the study aimed to determine whether there was a significant difference in students' intentionality and problem-solving skills before and after using the 3-D Vector apparatus and Heller's Problem-solving steps. To accomplish this, Analysis of Covariance (ANCOVA) was employed to determine whether there was a significant difference in students' problem-solving skills and intentionality between the two groups.

To effectively evaluate the survey and exam data, this research blended these methods, providing insights into how the Experiential Learning Environment with 3-D Vector Apparatus and Heller's problem-solving framework influenced students' intentionality and problem-solving skills. By employing a combination of descriptive and inferential statistics, the study yielded an accurate description of the data and facilitated generalizations about the entire population from the sample.

RESULTS AND DISCUSSION

Students' Intentionality

Table 1 clearly shows how students' motivation and learning strategies shifted over time. The Experiential Learning Environment (ELE) with 3D Vector Apparatus and Heller's Problem-Solving Framework group shows accelerated progress in intentional learning when the intervention is implemented. The group's motivation pretest mean is 3.35, the same as the learning strategy, which falls under Moderately Low Intentionality (MLI). By contrast, a non-Experiential Learning Environment (Non-ELE) group obtained the highest mean score of 4.85 in their Learning Strategy, indicating High Intentionality, followed by motivation, with a mean of 4.53.

The ELE group in the pretest perceived intentional learning as "somewhat not true" of them. This baseline indicates a significant "intentionality gap," where students may have lacked clear goals or effective mental frameworks for learning. This was evident in their output, as they did not know where to start when it came to solving the problem. However, although non-ELE also shows a lack of prior knowledge in solving the problems, this group already possessed a strong foundation in motivation and learning strategies prior to the study, as evidenced by a mean interpreted as high intentionality. This indicates that these students were likely already high-achievers or had prior exposure to learning environments that fostered a "somewhat true of me" attitude toward intentionality.

Table 1: Students' Level of Intentionality in Senior High School Physics in Experiential Learning and Non-Experiential Learning Environment in terms of Pretest and Posttest

	GROUP							
	ELE				Non-ELE			
Intentional Learning	Pretest		Posttest		Pretest		Posttest	
	Mean	QD	Mean	QD	Mean	QD	Mean	QD
Motivation	3.35	MLI	5.35	HI	4.53	HI	5.14	HI
Learning Strategy	3.35	MLI	5.56	VHI	4.85	HI	5.06	HI
Overall Mean	3.35	MLI	5.46	HI	4.69	HI	5.10	HI

Legend:

<u>Scale</u>	<u>Descriptive Rating</u>	<u>Qualitative Description</u>
6.50-7.00	Very true of me	Extreme High Intentionality (EHI)
5.50-6.49	True of me	Very High Intentionality (VHI)
4.50-5.49	Somewhat true of me	High Intentionality (HI)
3.50-4.49	Neutral	Moderate Intentionality (MI)
2.50-3.49	Somewhat not true of me	Moderate Low Intentionality (MLI)
1.50-2.49	Not true of me	Low Intentionality (LI)
1.00-1.49	Not all true of me	Very Low Intentionality

The overall mean on the pretest for both groups shows gaps in intentional learning. The ELE group obtained an overall mean score of 3.35, indicating Moderately Low Intentionality. However, the non-ELE group obtained an overall mean score of 4.69, indicating a High Intentionality Level. This implies that the students assigned to the ELE group were initially at a disadvantage. A mean of 3.35 suggests that, prior to using the 3D vector apparatus, these students perceived intentional learning behaviors, such as setting goals or employing specific study methods, as "somewhat not true" of themselves. In contrast, the non-ELE group already possessed a well-established sense of responsibility for their own learning. From a pedagogical standpoint, the pretest data suggested that the ELE group would require a much more intensive and engaging intervention to achieve outcomes comparable to those of the non-ELE group. The lower baseline in the ELE group suggests a lack of prior exposure to active learning environments or an earlier dependence on passive learning techniques.

Table 1 also presents the students' level of intentionality when exposed to ELE and non-ELE in Senior High School Physics, as measured by the posttest. The ELE group obtained a high mean score of 5.56 for Learning Strategy, indicating Very High Intentionality, followed by a Motivation mean of 5.35, indicating High Intentionality. A level of High Intentionality was indicated by the total mean score of 5.46. It also indicates that throughout the intervention, the ELE group was highly involved with the 3D Vector

Apparatus and demonstrated strong participation. This suggests that with concrete models like the apparatus, students felt motivated and developed their own learning strategies to make the most of their time with the 3D Vector Apparatus.

Then again, non-ELE sustained a level of High Intentionality in the posttest mean score. The group obtained a mean Motivation score of 5.14, indicating High Intentionality, followed by a Learning Strategy mean of 5.06, also indicating High Intentionality. The students' overall mean score for intentional learning when exposed to non-ELE was 5.10, indicating High Intentionality.

The findings show that the ELE group outperformed the non-ELE group in the posttest. This suggests that while conventional teaching (non-ELE) can support a high level of intentionality, it may not be as effective as an experiential learning environment. The 3D apparatus likely provided a stronger cognitive framework, allowing the experimental group to exceed the natural growth of their peers. The non-ELE group showed a slight increase from 4.69 to 5.10. This implies that conventional teaching provides a stable environment that maintains high intentionality but lacks the accelerant quality needed to produce transformative shifts. The growth in this group is likely due to standard academic progression rather than a fundamental change in how they approach learning.

From a pedagogical perspective, these posttest results imply that experiential tools are powerful equalizers. The ELE intervention, using the 3D Vector Apparatus and Heller's Problem-Solving Framework, was successful not only in closing a significant pre-existing intentionality gap but also in elevating a previously lower-performing group to a superior standing. It is an effective accelerative tool for intentional learning. It effectively transitions students from a state of low engagement to a state of high strategic and motivational intentionality, eventually surpassing the outcomes of conventional instructional designs

The findings of this study suggest that high levels of intentionality, particularly in the domain of motivation, are realized when students recognize the inherent value and importance of their learning tasks. The data indicate that an experiential learning environment (ELE) utilizing a 3D vector apparatus provides unique opportunities to enhance student motivation far beyond what is attainable in a conventional setting. Specifically, the ELE group's progression from Moderate Low intentionality to High Intentionality suggests that hands-on, 3D interaction is the motivational force behind the change.

Additionally, when students take accountability for their learning in this experiential environment, they appear highly self-aware, strive to meet rigorous standards, and derive self-esteem from achieving objectives through persistent effort. This result aligns with Cholbi (2007, as cited in Kheng (2023), who posited that students who attain high standards and self-esteem are more likely to become observant of their surroundings and evolve into effective problem solvers. This enhanced engagement is further explained by the "realness" of the 3D apparatus; the problem's relatedness to students' everyday experiences makes the learning process more meaningful, rendering students more

attentive, active, and self-motivated (Lee et al., 2014, as cited in Kheng, 2023). Consequently, students who reach these high levels of motivational intentionality tend to adopt an optimistic outlook, exhibiting greater accountability and control over their learning processes (Mollman & Candela, 2018).

This increase in motivation directly informs the development of refined learning strategies. As students become more driven, they tend to refine their time management skills, setting clear priorities and monitoring their own growth in knowledge acquisition. These findings support the conclusions of Jadraque (2023) and Anthonysamy et al. (2020), which state that when students possess the agency to manage their learning progression, academic success follows. Notably, the ELE group achieved the study's highest strategic mean (Very high intentionality), suggesting that ELE encourages novices to exert greater effort and creativity when solving complex problems Lee et al., 2014, cited in (Kheng, 2023).

By actively engaging with the 3D vector apparatus and self-regulating their learning, students in the ELE group developed more objective and rational academic purposes. This strategic growth was characterized by improved preparation habits and the use of "self-checklist" reasoning to attain specific objectives. Furthermore, this clarification of concepts was not limited to teacher-centered instruction; students frequently utilized peer collaboration to deepen their understanding, a collaborative dynamic observed in several previous studies (Bucayong & Bee, 2018; Chee, 2014, as cited in Wei, 2023).

Lastly, the results demonstrate that the ELE is a superior instructional method to non-ELE for fostering deeper understanding compared to a conventional setting. Beyond individual growth, the ELE group showed greater performance consistency than the non-ELE group. While the non-ELE group displayed greater instability, relying on established, perhaps less adaptive habits (Lee et al., 2014, as cited in Kheng, 2023), the ELE group moved toward a more responsible and independent learning model.

The experiential learning environment acts as a holistic bridge. It not only fuels the "will" to learn through increased self-esteem and motivation but also provides the "way" to learn by forcing the adoption of high-level learning strategies.

Students' Problem-Solving Skills

Table 2 presents the problem-solving skills of students who were exposed to ELE and non-ELE. The pretest reveals that among the 47 students exposed to Experiential Learning Environment (ELE), there were 2 (4.3%) who obtained a percentage score ranging from 80-84, which is interpreted as being in the middle level of problem-solving skills, and 45 (95.7%) who obtained a very low problem-solving score. On the other hand, 40 (100%) students in the Non-Experiential Learning Environment (Non-ELE) achieved scores below 75%, indicating very low problem-solving skills.

Table 2. Students' Level of Problem-solving Skills in Physics under an Experiential Learning Environment and Non-Experiential Learning Environment.

Percentage equivalent	GROUP								QD
	ELE				Non-ELE				
	Pretest		Posttest		Pretest		Posttest		
f	%	f	%	f	%	f	%		
90-100	0	0	31	66.00	0	0	7	17.50	EP
85-89	0	0	1	2.10	0	0	4	10.00	PP
80-84	2	4.3	5	10.60	0	0	2	5.00	CP
75-79	0	0	3	6.49	0	0	1	2.50	BP
Below 75	45	95.7	7	14.90	40	100	26	65.00	NP
Total	47	100	47	100	40	100	40	100	
MPS	43.49		90		39.23		64		
QD	NP		EP		NP		NP		

Legend:

<u>Percentage Equivalent</u>	<u>Problem-solving Skill level</u>	<u>Qualitative Description</u>
90-100	Very High (VH)	Expert in problem-solving stages (EP)
85-89	High (H)	Proficient in problem-solving stages (PP)
80-84	Middle (M)	Competent in problem-solving stages (CP)
75-79	Low (L)	Beginner in problem-solving stages (BP)
Below 75	Very Low (VL)	Novice in problem-solving stages (NP)

The mean percentage score for students in the ELE group is 43.49, while students in the non-ELE group have a mean score of 39.23. Both groups scored below 75%, indicating they are still in the novice stage of problem-solving skills. These findings suggest that the students' prior knowledge provides a limited foundation in Physics, particularly in Vector topics. Additionally, it appears that the students are unfamiliar with Heller's Problem-Solving Framework, which may explain their poor performance on the pretest.

Additionally, the posttest indicates that students in ELE outperformed those in non-ELE. The data presented an increase of MPS (90.00%) when exposed to ELE. The distribution of results is as follows: about 31 (66.00%) students achieved very high-level problem-solving skills, 1 (2.10%) student got high problem-solving skills, 5 (10.6%) students achieved middle level of problem-solving skills, 3 (6.49%) students in low level of problem-solving skills, and 7 (14.90%) students obtained a very low level of problem-solving skills. The overall mean percentage of 90.00% suggests a very high level of problem-solving skill. On the other hand, out of 40 students exposed to non-ELE, 7 (17.50%) achieved very high-level problem-solving skills, 4 (10.00%) students obtained

a high level of problem-solving skills, 2 (5.00%) students attained a middle level of problem-solving skills, 1 (2.50%) student got a low level in problem-solving skills, and 26 (65.00%) obtained a very low level of problem-solving skills. The overall mean was 64.00%, suggesting a very low level of problem-solving skills.

The data reveal improvements in students' physics problem-solving skills in the Experiential Learning Environment (ELE) with 3-D Vector Apparatus and Heller's Problem-Solving Framework compared to the Non-Experiential Learning Environment (Non-ELE). These results demonstrate knowledge gains after implementing ELE and non-ELE. Non-ELE students showed progress, with a higher mean percentage score, but not as much as those exposed to ELE. The ELE's transition from novice to expert-level problem-solving skills demonstrates that an experiential learning environment effectively enhances students' skills and suggests that active engagement, experimentation, and reflection indicate that students are motivated and accountable for their learning. Motivation serves as the inner drive, energizing students to engage deeply, while learning strategies are the behavioral expression of that motivation. It is the concrete ways in which students plan, organize, and apply their learning to solve problems. In contrast, the non-ELE modest gains suggest that traditional, passive instruction may not sufficiently develop problem-solving skills.

The results also indicate that when students are exposed to contemporary teaching methods, especially sub-predictors such as the 3-D Vector apparatus and Heller's problem-solving framework, which address gaps in prior knowledge and skills related to experiential learning environments, they demonstrate improved skill transfer and apply these skills to real-world contexts. In this regard, the ELE group parallels previous research on problem-solving skills. Using a problem-solving skill-based test instrument, such as Heller's Problem-Solving Steps, can help students to refine their problem-solving skills and improve their higher-order thinking skills when solving physics problems (Kusuma & Setyarsih, 2021).

Concrete experiences energize students' inner drive to participate in classroom activities and improve their performance. These experiences turn into knowledge, making the learning long-lasting and hard to forget. The improvements shown in ELE's mean percentage score, from a Very Low Level of Problem-Solving Skills to a Very High Level of Problem-Solving, signify that hands-on experiences in solving problems using Heller's Problem-Solving Steps, together with students' interaction with the apparatus, improved knowledge and skills, boosting their level of performance. Physical models enable students to solve problems more effectively and promote meaningful learning through hands-on experimentation. This was supported by Fleischfresser et al. (2012, as cited in Kinzli, 2017), which showed that problem-solving skills improved and that it is preferable to interact with concrete materials, such as physical models, including the 3-D Vector apparatus. Similarly, in Bucayong's (2023) study, which developed a 3D vector apparatus, it was evident that the device enhances students' problem-solving skills in vector topics. The experiential learning facilitated by this apparatus closely aligns with the results of traditional mathematical approaches, making it a far more engaging and experimental form of vector analysis. Additionally, students who apply concepts directly to experimentation or to real-world situations solidify the link between theory and practice.

Analysis of Covariance (ANCOVA) of Students' Intentionality

Table 3: Analysis of Covariance (ANCOVA) of Students' Intentionality between the group exposed to the Experiential Learning Environment and the Non-Experiential Learning Environment

Indicator	Group	Mean	SD	F-value	Sig	Partial Eta Squared
Intentional Learning	ELE	5.46	.61	153.34	.000	.785
	Non-ELE	5.10	.80			

Legend:**-significance at 0.05 level

Table 3 compares posttest scores for students exposed to the Experiential Learning Environment (ELE) with those of the non-ELE group. Accordingly, the table shows that the ELE group had a higher mean score of 5.50, indicating Very High Intentionality, with a standard deviation of 0.61. In contrast, the non-ELE group obtained a mean score of 5.16, indicating High Intentionality, with a standard deviation of 0.80.

The ANCOVA results show a significant group effect after the treatment, with a p-value of 0.000, which is below the accepted significance level of $p < 0.05$. This means the difference in intentionality between the ELE and Non-ELE groups is statistically significant. More importantly, the partial eta squared of .785 indicates a very large effect size, meaning that roughly 78.5% of the variance in intentional learning is explained by the learning environment itself. The covariate pretest results, with a p-value of 0.667, were not significant, suggesting that the initial differences in students' intentionality did not influence the posttest results. Instead, the instructional method itself explained the observed variation.

In other words, students who participated in ELE showed more intent in their learning behaviors than those in a traditional classroom setting. The ELE group had a higher mean score, indicating a more careful and steady approach to learning. The non-ELE group also showed a high level of intent but fell a bit short. The lack of significant pretest effects suggests that the improvement was not solely due to preexisting differences but was also influenced by the educational environment. This finding emphasizes the value of an experiential learning environment, enhancing intentional learning. Students in ELE settings appear to be more engaged, focused, and purposeful in their study habits, which supports the overall goal of developing self-directed learners.

This suggests that the observed improvements in students' intentionality are primarily due to the Experiential Learning Environment rather than students' pretest scores. As a result, the null hypothesis that there is no significant difference in students' level of intentionality when exposed to the Experiential Learning Environment and the Non-Experiential Learning Environment is rejected, suggesting that the instructional strategy used had a meaningful effect on students' posttest scores.

The results also indicate that the Experiential Learning Environment has a noticeable improvement in students' intentionality. They became more motivated and held accountable for their learning, as their learning strategies show progress compared to their initial test. They set their own learning timeline, attain specific goals, and assess the purpose and function of their knowledge acquisition, especially in Vector topics. This is also parallel to the study by Lee (2014, as cited in Kheng, 2023), which argues that the concept of intentional learning primarily denotes the possession of specific mental states, such as objectives, purposes, and convictions, that serve to inspire and steer the educational process towards achieving the targeted learning objectives.

The ELE group is proactive in their learning, which aligns with Lee's (2014) findings cited in Mollman and Candela (2018), who found that intentional learners actively construct knowledge, monitor, and regulate their learning. They understand that learning is not something that just happens to them, but also, it's something they do for themselves, deliberately and purposefully.

Though non-ELE shows a higher level of intentionality in its initial score, it tends to maintain that level, showing little progress as the study progresses. This is also evident in the study by Walsh et al. (2021), whose results reveal that when students interact with intentional content, their engagement is inconsistent, leading to an overall lack of sustained engagement. Initially, students show more consistent engagement, but their interaction with the content noticeably declines as the term advances

Hence, with the help of ELE, a 3D Vector Apparatus, and Heller's Problem-Solving Framework, students can improve their intentionality in learning practices and develop a deeper awareness of their own thinking and learning processes (Chee, 2014, as cited in Wei, 2023), leading to greater self-confidence and mastery orientation.

Analysis of Covariance (ANCOVA) of Students' Problem-Solving Skills

Table 4 indicates that the Experiential Learning Environment (ELE) shows a statistically significant effect on problem-solving skills. Students exposed to ELE score higher, with a mean percentage score of 90.00, indicating Very High Problem-Solving Skills, and a standard deviation of 12.09.

On the other hand, students in the non-ELE group had a mean of 63.64, indicating Very Low Problem-Solving Skills, with a standard deviation of 25.45. This difference of more than 26 points shows that ELE-based instruction helped students improve their problem-solving skills and understand Vector topics better. It also helped them apply what they learned more effectively when solving problems. Additionally, students in the ELE group performed better on the posttest than those in the non-ELE group. The higher standard deviation in the non-ELE group (25.45) compared to the ELE group (12.09) suggests that student performance was much more inconsistent in the traditional setting.

Table 4: Analysis of Covariance (ANCOVA) of Posttest Results in Problem-Solving between the group exposed to the Experiential Learning Environment and the Non-Experiential Learning Environment.

Group	N	Mean	SD
Instruction using Experiential Learning Environment (ELE)	47	90.00	12.09
Non-Instruction using Experiential Learning Environment (non-ELE)	40	64.00	25.45
TOTAL	87	77.79	23.33

Source	SS	Df	MS	F-value	Sig	Partial Eta Squared
Model	541434.24	3	180478.08	475.38	.000	.944
Group	61183.088	2	30591.544	80.578	.000	.657
Pre-problem-solving skills	99.022	1	99.022	.261	.611	.003
Error	31890.565	84	379.650			
Total	573324.800	87				

Legend: **-significance at 0.05 level

The p-values in the table show the likelihood that the observed effects happened by chance. In this analysis, the p-value of 0.00 between the groups was below the accepted significance level of $p < 0.05$. The table also presents the effect size (.657), which is considered large. It indicates that 65.7% of the variance in students' final scores is explained by the instructional group they were in. This provides strong evidence that the type of instructional strategy truly impacts students' problem-solving skills, rather than the differences being due to random variation. In contrast, the p-value of 0.611 for the pretest was above the significance level, indicating that initial differences in students' problem-solving skills did not significantly influence the posttest scores for the problem-solving skills tested in the study.

This suggests that the observed improvements in problem-solving skills are primarily due to the Experiential Learning Environment rather than students' pretest scores. As a result, the null hypothesis that there is no significant difference in the level of students' problem-solving skills when exposed to the Experiential Learning Environment and to the Non-Experiential Learning Environment is rejected, suggesting that the instructional strategy used had a meaningful effect on students' posttest scores.

The results also revealed that when students are fully immersed in ELE, they tend to perform well in problem-solving, which aligns with the studies by Akben (2018) and Ulla (2018). Accordingly, mathematics and science education have been focal points for enhancing problem-solving skills; both fields share objectives and methodologies, such as the Experiential Learning Environment, which truly enhances problem-solving skills compared to the group that uses conventional teaching. Though both groups use Heller's

problem-solving steps, they do not guarantee a solution; they are only techniques that guide problem-solving (Shimizu, 2022).

Conventional teaching, such as non-ELE, which is teacher-centered, creates barriers that hinder students' problem-solving skills. This result aligns with the studies by Docktor et al. (2015), and Khateeb (2018); students' ability to solve physics problems is influenced by the typical teacher-centered problem-solving approach. Because of this, students' physics problem-solving skills remain very limited or even poor (Saka et. al., 2024).

To conclude, the Experiential Learning Environment (ELE) is a highly effective instructional strategy, particularly in enhancing problem-solving skills. Not only is the improvement statistically significant, but the large effect size indicates it is practically significant, meaning it makes a major difference in a real-world classroom setting, independent of students' prior skills.

Conclusions

The conclusions presented in this study are grounded in empirical evidence gathered through the systematic implementation of the Experiential Learning Environment (ELE). These findings reflect the authentic learning experiences of students who are exposed to the 3-D Vector Apparatus and Heller's Problem-Solving Framework within the 7E instructional cycle. The results highlight how experiential learning fosters not only problem-solving skills but also intentionality in learning strategies and motivation.

The findings of the study have brought about the following conclusions:

1. The ELE greatly affects problem-solving skills in Vectors. It is a more effective instructional strategy for supporting students' understanding and problem-solving skills, enabling them to achieve a reasonable, satisfactory grasp of the subject matter and apply the essential knowledge acquired.
2. The experiential learning environment appears to be highly intentional, promoting higher levels of student intentionality across the two domains: Intentionality in Motivation and Intentionality in Learning Strategies. This suggests that the ELE not only supports learning but also enhances motivation, holds students accountable for their learning strategies, and promotes active participation in the learning process.
3. The improvements in problem-solving can be attributed to the use of ELE, aided by the 3D Vector apparatus and Heller's Problem-Solving Steps, rather than to students' initial pretest scores. This highlights the effect of these instructional strategies (ELE) in enhancing students' problem-solving skills.
4. The significant difference in students' intentionality between the ELE and Non-ELE groups has a measurable effect.

Recommendations

Based on the conclusions drawn from the study, the following recommendations are proposed:

1. To strengthen problem-solving skills, students are advised to practice intentional learning behaviors: setting clear goals, monitoring their progress, and reflecting on strategies that work best for them. Collaboration with peers, consultation with teachers, and consistent participation in hands-on exercises can further enhance comprehension and confidence.
2. Curriculum designers and teachers are encouraged to explicitly incorporate engaging and experiential prompts at the beginning of a lesson. This approach is designed to capture students' attention and activate their prior knowledge, targeting emotional aspects such as motivation and learning strategies, which are proven drivers of intentional learning. Since engaging learning experiences enhance motivation, teachers should consider utilizing experiential learning environments (ELE) with a three-dimensional vector apparatus and Heller's problem-solving framework. Additionally, linking problem-solving tasks to relevant applications—such as engineering, technology, or everyday scenarios—demonstrates that science is practical and valuable, rather than merely abstract.
3. Teachers should design lessons that reward persistence and curiosity. The ELE encourages students to set personal learning goals and reflect on their progress. It helps build accountability and improve motivational learning habits, making them independent learners and mastering their problem-solving skills.
4. School administrators are encouraged to support the creation of instructional models that help students improve their skills, particularly in problem-solving. Incorporating these models into ELE will greatly improve students' participation in class, elevate their motivation to learn, and develop additional learning strategies to help students bridge the gap between abstract theoretical concepts and practical, real-world applications in science.
5. Future researchers should expand upon these findings by exploring the long-term effects of incorporating structured self-regulation tools, like note-taking frameworks and self-assessment rubrics. This study establishes that the Experiential Learning Environment (ELE) transforms the notion of intentionality from a theoretical idea into tangible learning behaviors. However, further data is necessary to identify which specific reflection activities, including self-checklists or peer feedback, most effectively maintain student motivation and learning strategies over time.

Compliance with Ethical Standards

Prior to the implementation of the study, a provisional notice was secured from the Institutional Ethics Review Committee to strictly allow the conduct of the research.

Obtaining consent from the school's division superintendent, principal, and cooperating teachers' agreement for the study's conduct, as well as students' and parents' approval for their participation, was also secured. Ethical standards were rigorously maintained throughout the data-gathering process, ensuring informed consent, voluntary participation, and confidentiality of participants' information. This structured approach to data gathering was designed to ensure that the study produced reliable, valid, and ethically sound results, thereby contributing significant insights into the effectiveness of educational technology in learning environments.

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