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ORIGINAL

Simulation-Based Learning Packet Embedded with Metacognitive Scaffolding in Teaching Projectile Motion

Paquete de aprendizaje basado en simulación con andamiaje metacognitivo integrado para la enseñanza del movimiento de proyectiles

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ABSTRACT

This study addresses the challenges that Grade 9 students' face with projectile motion due to its abstract nature and mathematical complexity. Traditional teaching methods often fall short in addressing misconceptions and fostering deep conceptual understanding, underscoring the importance of innovative strategies in teaching. To bridge this gap, an innovative learning packet was developed and evaluated, incorporating a virtual guided-inquiry laboratory activity via the Physics Education Technology (PhET) platform with embedded metacognitive scaffolding. The learning packet underwent iterative refinement using the Successive Approximation Model (SAM) and was structured following the 7E Learning Cycle, a guided inquiry framework, and was validated by 16 experienced physics educators. The study was implemented with 41 Grade 9 students in a quasi-experimental one-group pretest-posttest design. A needs assessment of 35 DepEd teachers confirmed projectile motion as the most challenging topic (Kendall's W = 0,37). Experts rated the packet "*Very Satisfactory*" in terms of content, format, presentation, and accuracy. The results showed a significant improvement in achievement from pretest (M = 7,07) to posttest (M = 14,34), t(40) = 23,41, p < 0,001, reflecting a very large effect size (d = 3,66) and a moderate average normalized gaing= 0,56). Metacognitive analysis revealed frequent evaluation (34,63 %) and monitoring (27,64 %), whereas planning (8,46 %) was the least evident. The results suggest that simulation-based guided inquiry with embedded metacognitive prompts enhances conceptual understanding and reflective thinking among students. Such approaches are recommended for physics instruction to improve problem-solving skills and support inclusive quality education in line with SDG 4.

Keywords: Conceptual Understanding; Metacognitive Development; Physics Education; Projectile Motion; Simulation-Based Learning.

RESUMEN

Este estudio aborda los retos que enfrentan los estudiantes de grado 9 con movimiento proyectil debido a su naturaleza abstracta y complejidad matemática. Los métodos tradicionales de enseñanza suelen ser escasos para abordar las concepciones erróneas y fomentar una profunda comprensión conceptual, subrayando la importancia de las estrategias innovadoras en la enseñanza. Para colmar esta brecha, se desarrolló y evaluó un paquete de aprendizaje innovador, que incorpora una actividad de laboratorio virtual de investigación guiada a través de la plataforma de Tecnología de la Educación Física (PheT) con andamios metacognitivos incorporados. El paquete de aprendizaje fue objeto de refinamiento iterativo utilizando el modelo de aproximación sucesiva (SAM) y se estructuraba a raíz del ciclo de aprendizaje 7E, marco de investigación guiado, y fue validado por 16 educadores de física experimentados. El estudio se llevó a cabo con 41 estudiantes de grado 9 en un diseño cuasi-experimental de un grupo anterior a un test. Una evaluación de las necesidades de 35 maestros de DepEd confirmó el movimiento de proyectiles como el tema más difícil (Kendall's W = 0,37). Los expertos calificaron el paquete "Muy satisfactorio" en términos de contenido, formato, presentación y precisión. Los resultados mostraron una mejora significativa en el logro desde el pretest (M = 7,07) hasta el postest (M = 14,34), t(40) = -23,41, p < 0,001, lo que refleja un tamaño de efecto muy grande (d = 3,66) y un aumento medio normalizado moderadog= 0,56). El análisis metacognitivo reveló frecuentes evaluaciones (34,63 %) y monitoreo (27,64 %), mientras que la planificación (8,46 %) era la menos evidente. Los resultados sugieren que la investigación guiada basada en simulaciones con incrustaciones metacognitivas mejora la comprensión conceptual y el pensamiento reflexivo entre los estudiantes. Se recomiendan estos enfoques para la instrucción de física a fin de mejorar las aptitudes para resolver problemas y apoyar la educación de calidad inclusiva en consonancia con el ODS 4.

Palabras clave: Comprensión Conceptual; Desarrollo Metacognitivo; Educación Física; Movimiento de Proyectiles; Aprendizaje Basado en Simulación.

INTRODUCTION

Projectile motion, a fundamental concept in classical mechanics, captivates and challenges students because of its engaging nature and real-world applications, from baseball to orbiting satellites. It serves as a crucial foundation for advanced physics, connecting theoretical knowledge with practical experience, particularly for Grade 9 students.[1,2] However, many students struggle with persistent misconceptions and difficulty in applying projectile motion principles to new problems.[3,4] These challenges often stem from difficulties in understanding the independent horizontal and vertical components of motion and integrating algebra and trigonometry for two-dimensional problems.[5,6] The abstractness of the topic, combined with traditional, decontextualized teaching methods that emphasize rote memorization, further exacerbates learning difficulties.[7] The need for well-crafted tools to tackle these misconceptions is also indicated by newer interventions, including computer-based instructional packages.[8]

The majority of teachers continue to use the old approach of lecture delivery, where students listen and move on to apply predetermined formulae to problem-solving. From the constructivist perspective, this method restricts action in the construction of conceptual knowledge. Cognitive load theory also elucidates that the presentation of formulas in a context free of meaning may congest working memory such that new ideas will not be assimilated. As a result, learners can solve equations but fail to understand the physics of projectile motion.[7] Students come to class with incorrect ideas about how things work, and these teaching methods do not fix those misconceptions. They also do not help students build real understanding or learn how to think about their own learning processes.[9] Because of these issues, this study attempts to help students understand concepts better by creating a learning packet that uses computer simulations and teaches students how to think about their thinking. The structure of this packet was based on the 7E model of instruction created by Eisenkraft and expanded upon the 5E cycle by adding elicit and extend stages. This framework was chosen because it promotes guided inquiry: students' prior knowledge is made visible, they experiment with their ideas in simulations, and they consider strategies and practice newly learned ideas. The pedagogical model of the 7E model was used to implement simulation-based activities and reflection cues.[10]

Computer simulations can make difficult concepts easier to understand and engage students.[11,12] But even with simulations, students still struggle. They do not know how to organize all the information they are receiving, cannot figure out what steps to take next, and do not dig deep enough into the material without someone guiding them. This shows why students need metacognitive scaffolding, which gives them structured questions and reflection activities to help them watch and regulate their own thinking.[13,14] Current teaching methods rarely combine simulations with organized support for thinking about thinking to help students organize information and engage deeply in their learning. Physics learning issues are found globally, and they are the same in the Philippine context. In science, Filipino students ranked 78th out of 79 countries in the TIMSS 2019 testing, highlighting the structural deficits in their understanding of concepts and problem solving.[15] Local science education reports also highlight the challenges in mastering physics concepts such as projectile motion, which provide reasons why the country overall underperforms in STEM.[16] This long-lasting challenge underscores the necessity of novel teaching methods that not only neutralize erroneous beliefs but also develop more profound theoretical knowledge and thinking, that is, a problem that this study aims to solve. In this study, a needs assessment was conducted on 35 science teachers in the Department of Education. Findings revealed that projectile motion is considered the hardest Grade 9 physics topic. Teachers pointed out the problems of conceptual knowledge, poor mathematical abilities, and common mistakes in operations with vectors and choices of formulae made by students. Moreover, several stated that students do not have proper access to textbooks, learning modules, and online access, which makes specific instructional support particularly acute.

This study aims to develop, and measure how well a Simulation-Based Guided Inquiry Learning Packet with embedded Metacognitive Scaffolding (SBGILP-MS) helps Grade 9 students learn projectile motion better. The study goals are to develop a learning packet that aligned the K-12 curriculum for Grade 9 projectile motion, find out how well this packet improves students' understanding of projectile motion, and investigate the metacognitive strategies students use. Besides helping students learn better, this study wants to improve STEM teaching by encouraging inquiry skills and metacognition. It also supports Sustainable Development Goal 4 by promoting fair quality education and building students' lifelong learning abilities. This study provides useful ideas for teachers and education leaders who want to improve science teaching in schools with limited resources.[17]

METHOD

Type of the Study

This study is a non-observational, quasi-experimental study that employed the Successive Approximation Model (SAM) to carefully design, develop, and test the SBGILP-MS. SAM works through iterative cycles and involves collaboration, which allowed the team to keep improving the teaching materials based on helpful feedback from experts in physics education

To rigorously assess the efficacy of the SBGILP-MS, a one-group pretest-posttest quasi-experimental design ($O_1 \times O_2$) was implemented. This design enabled measurement of students' conceptual mastery of projectile motion before and after intervention. Employing a mixed-methods approach, the quantitative component analyzed pretest and posttest results using normalized gain scores (Hake's gain) to quantify improvements in conceptual understanding. A paired t-test was conducted to statistically evaluate the difference in conceptual understanding between pretest and posttest scores. Additionally, Cohen's d was calculated to determine the effect size of the intervention. Concurrently, qualitative data from students' reflective responses embedded within the learning packet underwent content analysis. This analysis explored learners' metacognitive development across five critical dimensions: planning, monitoring, evaluation, action, and transfer.

Sampling

The needs assessment used a purposive sample of 35 science teachers in the Philippines, while the quasi-experimental implementation was conducted with 41 Grade 9 students in a public school in Iligan City. The achievement test was validated through a pilot test with 108 grade 10 students.

Data Gathering Procedure

The development of the SBGILP-MS followed the SAM, a systematic and iterative instructional design framework consisting of three main phases: Preparation, Iterative Design, and Iterative Development. Figure 1 shows the step-by-step process of SAM.

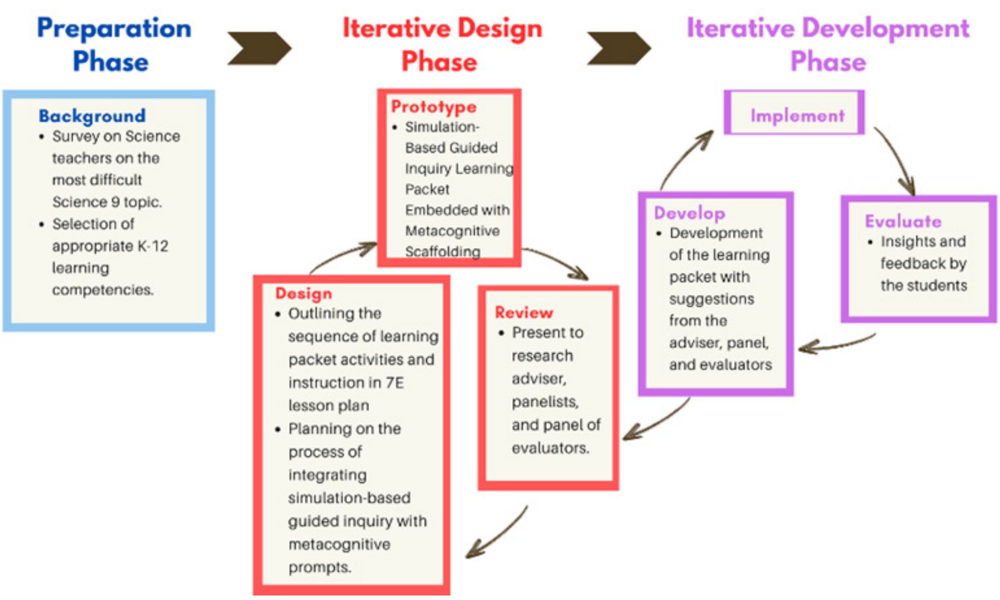

Figure 1. Step by step process of the Successive Approximation Model

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In the Preparation Phase, the authors did a thorough needs assessment by asking 35 Grade 9 Science teachers from different public secondary schools to fill out a survey. This survey showed that projectile motion was the hardest topic in Grade 9 physics, so it made sense to focus the intervention on this area. At the same time, the K-12 curriculum was carefully aligned to make sure the learning packet's goals aligned with the national standards so it would be relevant and meet educational requirements. These basic activities helped figure out teaching goals and guided how everything that followed was designed.

The Iterative Design Phase had three important steps: Design, Prototype, and Review. First, the authors planned the teaching sequence and activities using the 7E Instructional Model, combining computer simulation-based guided inquiry with built-in thinking prompts to encourage students to actively learn and monitor themselves. They then created a prototype of the learning packet that included PhET interactive simulations and reflection questions to help students with their thinking processes. This prototype was reviewed several times by 16 expert evaluators - physics teachers and curriculum specialists - who checked whether the content was accurate, the teaching was effective, and whether it was easy to use. They used the Department of Education's Learning Resources Management and Development System (LRMDS) rubric for their evaluation. The evaluators provided feedback that was systematically included, with changes made repeatedly until everyone agreed, ensuring the quality and effectiveness of the learning packet.

To test the 30-item achievement test aimed at assessing projectile motion conceptual knowledge in students, a pilot test was conducted on 108 Grade 10 students in public schools. The reliability test produced a Cronbach's alpha of 0,91, indicating good internal consistency of the items. The items were also analyzed using the difficulty index and discrimination index to determine the suitability of each question. Easy and difficult items and those that did not discriminate between high- and low-performing students were modified or removed. Moreover, the physics education teachers were also involved in the feedback of expert reviewers to ensure that the content was valid and met the desired outcome of the learning. The achievement test achieved as a result of such processes was then implemented in the quasi-experimental stage.

In the Iterative Development Phase, the completed packet (Version 4) was a six-guided inquiry activity with PhET simulation, three series of metacognitive reflections (15 questions total), sample problems, problem sets, and a 7E lesson plan. One intact Grade 9 science lesson that involved 41 students in a public secondary school was used as the study group in a controlled quasi-experimental design. It was implemented over 10 school days, with informed consent from the students and their guardians obtained beforehand.

Pre- and post-tests were given at the beginning and end of the intervention, and the instructional sequence developed progressively assigned the projectile motion concepts: Day 1 included basic definitions and understanding; Day 2 explored the independence of horizontal and vertical motion; Days 3–4 explored projectile motion problem-solving using equations of uniformly accelerated motion; Day 5 examined the comparisons between the theoretical and experimental findings through simulations; and Days 7 and 8 covered problem-solving further.

The guided inquiry activities provided in PhET presented visual interaction and served the purpose of learning objectives. Since the constraints of the 45-minute class period were included, students were mainly asked to do their metacognitive reflections as homework, and they were given feedback on the topic in the following classes to facilitate constant monitoring and participation. As a solution to the connection constraints, mobile-accessible PhET simulations were used in a way that enabled offline use on the smartphone, and 41 scientific calculators were borrowed from the school laboratory to assist in the computational processes. The researcher-implementer conducted the intervention in a teacher-led manner, and classroom observations were undertaken to check the fidelity of implementation, participation of students, and challenges faced. The observations made, together with student responses, informed usability and learning assumptions, thus ensuring that systematic validation of the process was achieved.

Variables

The SBGILP-MS intervention was the independent variable and the students understanding and performance in projectile motion was the dependent variable which was measured using pretests, posttests and reflective responses.

Data Analysis

Pretests, posttests and reflective responses that were incorporated within the learning packet were used in the collection of data. Quantitative data were examined by means of normalized gain scores, paired t-test and Cohen's *d* and the qualitative data were examined by content analysis to investigate how students developed in terms of metacognition. All of the phases were guided by SAM towards refinement.

Ethical Considerations

The authors made sure to follow ethical rules to protect everyone who participated in the study. They got permission from students and their parents or guardians after explaining what the study was about, what would happen, and any possible risks. Students didn't have to participate if they didn't want to, and they could stop being part of the study anytime without getting in trouble. The authors kept all information private by using codes instead of real names. They also tried to reduce any problems, like students feeling uncomfortable when answering open-ended questions, by writing the questions carefully and talking with students afterward.

Ethical Approval

The authors followed ethical rules to protect everyone in the study. They got approval from the proper authorities before collecting any data to make sure they followed both school and national guidelines.

Informed Consent

The authors got permission from all participants before starting the study. For students under 18, they also got permission from parents or guardians. Everyone was told about the study's purpose, what would happen, possible risks, and that they could quit anytime without any problems.

Statement Regarding Research Involving Human Participants and/or Animals

This study involved human participants - specifically Grade 9 students from Hinaplanon National High School in Iligan City, Philippines. No animals were part of this study. Everything was done following ethical guidelines for research with people.

Consent to Participate

Students chose to be part of the study after getting detailed information about what the research was trying to do and what procedures would be used. The authors documented their permission to make sure students made informed choices.

Consent to Publish

The authors got permission from participants to use their anonymous data for publication. All answers and personal information were removed to keep everything confidential and protect data.

RESULTS AND DISCUSSION

Preparation Phase

The authors began by conducting a needs analysis through a survey of 35 DepEd science teachers. Results consistently identified projectile motion as the most challenging Grade 9 physics topic, causing significant comprehension difficulties. This consensus, supported by a Kendall's W of 0,37, indicated moderate agreement and validated projectile motion as a critical problem area. The finding aligns with prior studies of Celestino-Salcedo et al. and San Juan that documented persistent misconceptions in projectile motion, confirming that the issue is systemic and widespread.

Teacher responses revealed several reasons for these difficulties. Students often held misconceptions about the independence of horizontal and vertical motion, believing horizontal velocity changes over time rather than remaining constant while gravity affects vertical velocity. They also struggled with recalling and applying formulas, had weak skills in trigonometry and word problems, and faced limited access to learning resources. These gaps in prior knowledge and resources further reduced engagement and problem-solving ability. Collectively, these findings highlight the need for interventions that target both conceptual understanding and mathematical application, echoing earlier research on barriers in physics learning.[18]

To guide development, the authors mapped the intervention to the DepEd Grade 9 Science K–12 Curriculum. For the 4th Quarter, the content standard emphasizes "projectile motion," with a performance standard requiring learners to "propose ways to enhance sports related to projectile motion." The packet was anchored on the Most Essential Learning Competencies (MELCs): *Describe the horizontal and vertical motions of a projectile* (S9FE-IVa-34) for Week 1, and *Investigate the relationship between the angle of release and the height and range of the projectile* (S9FE-IVa-35) for Weeks 1–2. By selecting these MELCs, the authors directly addressed misconceptions identified in the needs assessment while ensuring alignment with national standards. Such alignment not only strengthened relevance but also increased the likelihood of meaningful learning transfer, consistent with instructional design literature.[19]

Iterative Design Phase: Preliminary Evaluation of Prototype

The authors wrote the learning packet's content to match the Department of Education's K-12 curriculum standards. The packet underwent four rounds of revisions based on feedback from 16 panel evaluators to strengthen alignment with objectives, improve teaching content, refine thinking prompts, and enhance guided inquiry activities.

The initial version was praised for its engaging design but revealed issues in visual clarity, terminology, formatting, question design, and instructional flow. Problems included pixelated figures, inconsistent symbols, unclear abbreviations, and formatting gaps. Evaluators also noted that many questions were yes/no or too broad, limiting critical thinking. Suggestions included using open-ended prompts, clearer derivations, standardized formatting, and visual aids. The second version received positive feedback on challenge level and content quality, with recommendations to clarify learning objectives, label activities, enlarge QR codes, revise culturally neutral language, format equations professionally, and ensure balanced multimedia. Inclusivity in language, real-world relevance, and improved readability through layout adjustments and simpler instructions were emphasized.

By the third version, feedback was minimal, focusing on clarity and consistency. Suggestions included boxing final answers, adding answer keys, refining challenge directions, and standardizing units, symbols, and references. Layout refinements reduced clutter, used more readable fonts, and separated worked solutions with subtle design elements. These final revisions produced Version 4, a polished packet that reflected the value of iterative design. The progressive improvements demonstrated how repeated feedback cycles enhanced usability and alignment with objectives, consistent with findings from other SAM-based studies.[20]

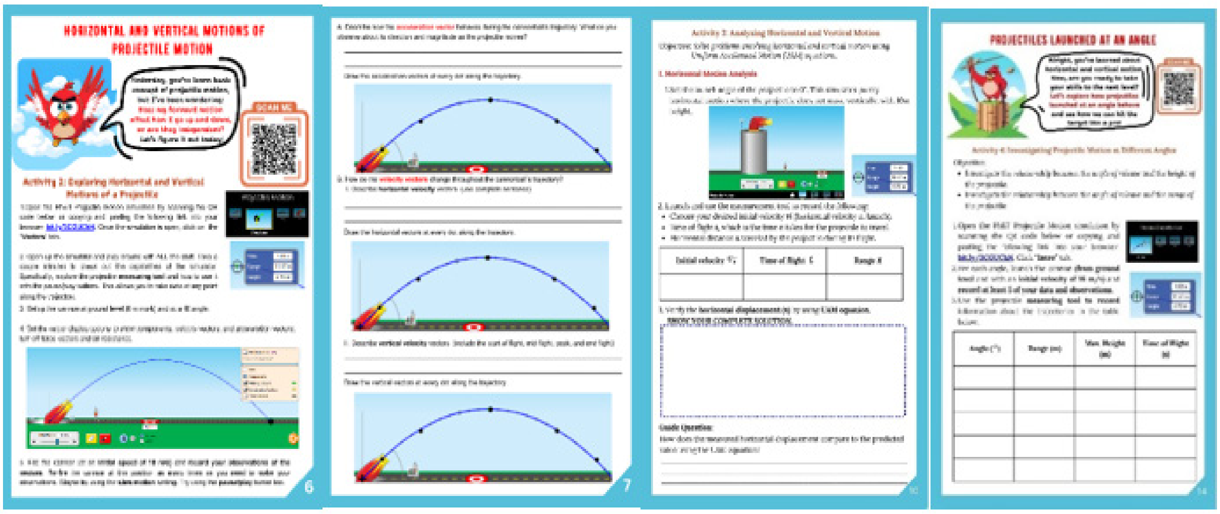

Figure 2. Sample page from Developed Learning Packet on Projectile Motion (V4)

Iterative Development Phase

The review of the simulation-based guided inquiry learning packet by sixteen (16) working teachers showed that it met all needed standards, getting a "PASSED" rating in four main areas. The best score (4,00) was for being correct and accurate, showing the material was reliable and had no mistakes, while the lowest score (3,44) was for building good values and character, which means this area needs work. Teachers liked how the packet looked and was set up, but gave small suggestions to use simpler words and better pictures. These results show that the packet works well as a teaching tool, but future versions could be better with stronger pictures and activities that help build character to make learning even better for students. These findings suggest that the learning packet not only meets content accuracy standards but also demonstrates practical usability in classroom settings. The high accuracy rating aligns with literature emphasizing the importance of error-free content in supporting student conceptual gains in physics.[19,21] The relatively lower score for values and traits highlights an opportunity to embed affective and character-building elements in future iterations, promoting more holistic learning outcomes.[22,23]

Table 1. Overall Rating of the Learning Packet

Factor	Mean	Interpretation
Content	3,73	Very Satisfactory
Format	3,78	Very Satisfactory
Presentation and Organization	3,75	Very Satisfactory
Accuracy and up-to-dateness of Information	4	Very Satisfactory
Overall Mean	3,82	Very Satisfactory

The overall ratings show consistently positive feedback across all evaluation areas. Content earned an average score of 3,73, interpreted as "Very Satisfactory," meaning it was relevant and comprehensive. Format (3,78) and organization (3,75) also fell in the "Very Satisfactory" range, indicating that layout and structure supported effective learning. Accuracy and up-to-dateness received the highest score (4,00), reinforcing the reliability and correctness of the packet's information. The overall mean rating of 3,82, likewise "Very Satisfactory," confirms strong evaluator consensus regarding the packet's quality and effectiveness.

Taken together, these results validate the success of the iterative design and development process. Guided by expert evaluation and repeated refinement, the packet emerged as a high-quality instructional resource. Similar studies on guided inquiry and PhET-based interventions have likewise reported that iterative development enhances both usability and instructional effectiveness.(12,24,25)

Normalized Gain

The analysis of pretest and posttest findings indicated significant individual gain scores, demonstrating a marked change in scores after using the learning package. The intervention lasted for two weeks. Figure 3 demonstrates the individual performance of the students, out of 41 students, 31 students (75,6 %) achieved an average normalized gain ($0,3 \le g < 0,70$), while 10 students (24,4 %) attained a high normalized gain ($g \ge 0,7$). No students fell into the low-gain category, showing all participants had a positive learning impact and made some progress. This distribution of gains demonstrates that the learning packet effectively facilitated conceptual understanding for the majority of students, with most achieving at least moderate improvement. The absence of low-gain participants suggests that the intervention was generally successful in engaging all learners, which is consistent with findings from other PhET-assisted guided inquiry interventions.(26,27)

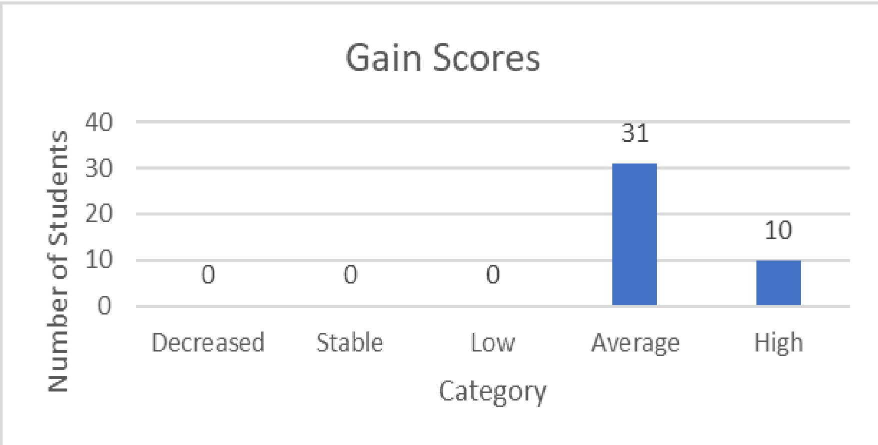

Figure 3. Individualized Gain Scores of Students

The data from table 2 further supports the positive impact of the learning packet, showing a significant improvement in student achievement test scores from pretest to posttest. The average score nearly doubled, rising from 7,07 to 14,34, which indicates a substantial enhancement in students' understanding of projectile motion following the instructional intervention. The paired sample t-test result ($t(40) = 23,41$, $p = 0,001$) confirms that this improvement is statistically significant, that the learning gains observed were not due to chance, underscoring the efficacy of the instructional intervention. Additionally, the average normalized gain score provides insight into the magnitude of improvement, with 0,56 falling into the "Average" category, reflecting a moderate level of improvement. Complementing this, Cohen's d_z was calculated as 3,66, indicating a very large effect size and highlighting that the improvement was both substantial and consistent across students. This outcome demonstrates the efficacy of the developed SBGILP-MS in improving students' conceptual grasp of projectile motion. The significant gains indicate that the intervention successfully facilitated learning improvements. However, the "Average" gain suggests that the learning packet led to moderate learning gain, indicating that while progress was made, there is still room for optimization, perhaps by providing more practice, more scaffolds, or reinforcers. The results are consistent with previous studies on guided inquiry interventions in physics, where even brief interventions can result in large gains but they may still need follow-up support to achieve optimal conceptual mastery.(28,29)

Table 2. Summary of Students' Achievement and Learning Gain

Achievement Test	Mean	Mean Dif.	T-test	P-value	Average Gain Score	Cohen's d_z	Interpretation
Pretest	7,07	7,27	23,41	<0,001	0,56	3,66	Significant
Posttest	14,34						

Metacognitive Development

This section shows what the study found about how students developed their thinking skills based on their written reflections. The researchers used a coding system that Stratman and Diefes-Dux [30] had already created, which was based on Flavell's [31] theories about thinking. They sorted students' responses into five different types of thinking: planning, monitoring, evaluating, action, and transfer. They looked at 615 reflection responses from 41 students by analyzing the content of what students wrote. These responses came from 15 reflection questions that were built into the learning packet, which gave them 615 individual answers to examine. The analysis of 615 student reflection responses revealed varying frequencies of the five metacognitive strategies examined: Planning, Monitoring, Evaluation, Action, and Transfer. Table 3 summarizes the frequency and percentage of each strategy observed.

Table 3. Frequency and Percentage of Students' Use of Metacognitive Strategies

Metacognitive Strategy	Frequency	Sample Students Responses
Planning	52	"Before starting, I identified the key variables affecting projectile motion, such as angle and velocity, to predict the outcome accurately."
Monitoring	170	"My predictions were close, but small errors happened. Air resistance and measurement mistakes may have caused differences."
Evaluation	213	"I realized my prediction was incorrect because I didn't consider the impact of air resistance, which changed the projectile's range."
Action	84	"I adjusted my calculations after noticing a mistake in my initial velocity estimation, which helped me get a more accurate result."
Transfer	96	"This experiment reminded me of a previous lesson on free fall, where we also ignored air resistance in theoretical calculations."
Total	615	

As shown in table 3 and illustrated in figure 4, Evaluation was the most frequently used strategy (34,63 %), suggesting that students actively assessed their predictions and identified misconceptions. Monitoring (27,64 %) followed, indicating that students recognized their learning progress and identified potential sources of errors. Transfer (15,61 %) responses demonstrated students' ability to connect prior and new knowledge, while Action (13,66 %) showed students adjusting strategies based on observations. Planning (8,46 %) was the least utilized strategy, suggesting a need for stronger pre-task structuring.

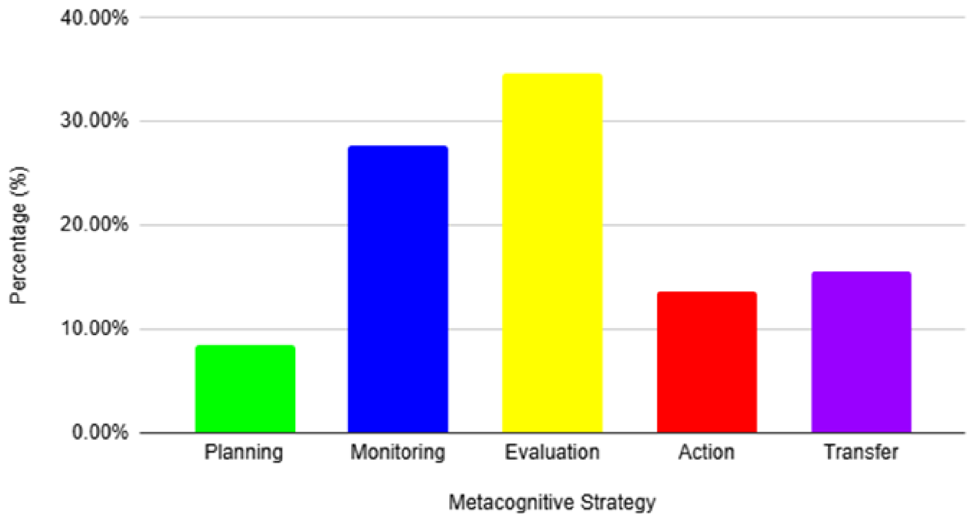

Figure 4. Distribution of Metacognitive Strategies

Evaluation's prominence aligns with the learning packet's design, incorporating structured reflection prompts after each simulation. These prompts, such as *"How did your prediction compare to the actual outcome? What factors might explain any differences?"* explicitly guided students to compare their predicted outcomes with the simulation results and to analyze the reasons for any discrepancies. The fact that the Evaluation responses are high shows that the packet is successful in encouraging reactive metacognition, which enables students to detect and rectify misconceptions. This is in line with the studies that found out that embedded reflection prompts facilitate more evaluative skills and strengthen conceptual learning.

The way the researchers set up the learning activities explains why students gave so many evaluation-type responses. When students evaluate their own thinking, it helps them understand concepts better because they spot gaps in what they know and try to fill them. Andrade[32] found something similar - when teachers build reflection questions right into assignments, students get much better at evaluating their own learning. The fact that students focused so much on evaluation also shows that the simulation worked well at creating what Festinger[33] called "cognitive dissonance" - basically, it made students uncomfortable when they realized their ideas were wrong, which pushed them to fix their understanding of how projectile motion works. One student said: *"I thought the angle would be the only thing that mattered, but I saw that the velocity made a big difference too. I did not expect that."* This shows exactly how the simulation made students question what they thought they knew.

Students also did a lot of monitoring, which means they were paying attention to how well they were learning and could tell when they might be making mistakes. Students often attributed discrepancies between their predictions and the simulation results to factors such as air resistance or measurement errors, demonstrating an awareness of the limitations of their models. Monitoring responses are rather high, which can be attributed to the fact that students are becoming aware of learning processes that happen to them rather than planning them proactively. This is in line with the above-mentioned prior research that guided inquiry simulations are more likely to focus on reflection assessment rather than pre-task preparation.[34] However, the fact that Monitoring was less frequent than Evaluation suggests that students may have been more focused on identifying errors after they occurred rather than actively monitoring their thinking during the simulation. As a result, the instructional design may have better supported reactive metacognition (evaluating after the event) than proactive metacognition (monitoring progress during the event).

The relatively lower frequency of Planning (8,46 %) is a noteworthy finding. Several factors could have contributed to this. One possibility is that the simulation environment, while effective at promoting Evaluation and Monitoring, inadvertently reduced the perceived need for independent Planning. The simulation's explicit visual representations, guided inquiry approach, and step-by-step structure may have led students to believe that explicit Planning was unnecessary or that the "correct" approach was self-evident. Another possibility is that students lacked the knowledge or skills to plan their approach to the simulation effectively. One student said, *"I did not know how to plan, so I just started experimenting to see what would happen."* This tells us that students probably need clearer instruction on how to plan their work - like figuring out what variables matter most, making educated guesses about what will happen, and testing those guesses in an organized way.[35] Also, some students didn't think the planning part was as important or interesting as actually running the simulation.

The few Planning responses demonstrate a possible area to be improved. Proactive metacognition skills that are relevant in solving physics problems might be enhanced by the incorporation of explicit scaffolds or prompts of pre-task planning. Students did show they could adjust their approach and connect new learning to things they already knew, though not as much as we hoped. The way they described taking action shows they could change their calculations or tweak the simulation settings after they noticed problems with earlier attempts. One student explained it like this: *"I kept changing the angle until I got closer to the target."* The Transfer responses suggest that students could relate the concepts learned in the simulation to real-world scenarios or previous lessons. For example, a student wrote, *"This is like when we learned about free fall, but now we have to think about horizontal movement too."*

Action and Transfer responses being present demonstrate students to be starting to bring learning to bear on problem solving and relating new information to previous experiences, a desired outcome in guided inquiry strategies.[36] The learning packet effectively promotes evaluative and monitoring metacognitive processes, which likely supported an increased conceptual understanding of projectile motion. However, the relatively low frequency of Planning suggests a need for additional instructional strategies to strengthen students' ability to anticipate challenges.

In general, the metacognitive analysis shows that the learning packet is able not only to improve content knowledge but also higher-order thinking processes. The next stages might be to improve proactive planning abilities and retain high levels of the evaluative and monitoring elements to optimize cognitive and metacognitive benefits. It is important to acknowledge several limitations of this analysis; the data is based solely on written reflection responses, which may not fully capture the range of metacognitive strategies students employed during the learning activities. Students may have engaged in metacognitive processes that they did not explicitly articulate in their written responses.

CONCLUSIONS

The topic of projectile motion among Grade 9 students is still a challenging one based on conceptual, mathematical and resource based issues. Guided inquiry learning packet is a simulation based learning packet with the metacognitive scaffolding, which is in line with the DepEd curriculum standards, and was successfully used in improving the student engagement, understanding and reflection. Teacher assessments stated that the content, format, and accuracy of the packets met the educational quality standards, and the results of assessments indicated that there were meaningful learning gains. Students, especially those who made a significant progress in assessing and tracking their learning, also need additional instructional support in planning skills. Teachers are advised to combine simulations, guided inquiry and structured reflection exercises, whereas the future materials must focus on more graphic illustrations and tasks that would promote a proactive thinking. Future studies are needed to address interventions to enhance planning ability, evaluate long-term memory, and investigate the intervention effectiveness with various learners with different data collection tools.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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