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Article

The Effectiveness of Discovery Learning Integrated with Google Sites (DL-GS) to Enhance Students' Problem-Solving and Scientific Literacy Abilities

Agus Budiyono[1*], Arin Wildani[2], Rowena A. Pila[3], Syaifiyatul H.[4]

[1,2]Universitas Islam Madura, Indonesia
[3]Rizal Technological University, Philipines
[4]Kyoto University, Japan

**Corresponding Address: agusbudiyono@uim.ac.id*

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ABSTRACT

Learning parabolic motion requires students to connect mathematical problem-solving with scientific explanations and evidence interpretation. These demands highlight the need for guided investigations supported by accessible digital resources that address problem-solving and scientific literacy together. This study investigated the effectiveness of Discovery Learning integrated with Google Sites (DL-GS) in enhancing these competencies in parabolic motion. A quasi-experimental study employed a non-equivalent control group design. Participants were 60 tenth-grade students from two intact classes selected through simple random sampling at the class level from four classes comprising 120 students. The experimental group received DL-GS instruction incorporating 3D animations, PhET virtual laboratories, and interactive quizzes, whereas the control group received conventional PowerPoint-supported instruction. The intervention comprised two sessions over two weeks. Data were collected using five essay items scored with separate rubrics for problem-solving and scientific literacy and analyzed using MANOVA, normalized gains, and effect sizes. The groups differed significantly in the combined outcomes ($p < .001$). The experimental group achieved higher normalized gains in problem-solving (0.78 versus 0.44) and scientific literacy (0.77 versus 0.46), with large effect sizes (Cohen's $f = 1.50$ and 1.05, respectively). These findings support DL-GS as a promising instructional approach for developing both competencies in parabolic motion. However, the short intervention and single-topic focus limit conclusions about long-term retention and applicability to other physics topics.

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INTRODUCTION

Problem-solving and scientific literacy abilities have an important role in forming student competencies. Problem-solving abilities enable students to identify, analyze, and find solutions to various problems encountered in academic environments and everyday life (Acquandoh et al., 2022; Adeoye & Jimoh, 2023; Hidayati, Idris, & Handayani, 2022; Wang, Peng, & Li, 2022). Meanwhile,

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scientific literacy abilities play a role in understanding scientific concepts and applying knowledge in evaluating information, making decisions based on evidence, and thinking critically. (Adawiyah & Chastanti, 2023; Davidsone & Silkane, 2023; Fatmawati & Khotimah, 2023; Kelp, McCartney, Sarvary, Shaffer, & Wolyniak, 2023; Syarifuddin, Hasnawati, Lasaima, & Saranani, 2023). Good scientific literacy abilities can also develop students' collaboration and communication skills (Anggraeni, Permanasari, & Heliawati, 2022; Mutasam, Ibrohim, & Susilo, 2021; Odell, Dyer, & Klett, 2023). Low scientific literacy skills can hinder students' abilites to develop creativity and innovation, which are necessary to face global challenges (Aunur, 2023; Irawan, Adawiyah, Zubaidah, & Arsih, 2023). In the physics learning process, problem-solving skills and scientific literacy are very important for students to be able to understand concepts correctly and solve complex physics problems.

Research on students' problem-solving abilities in physics has been widely conducted, exploring various aspects such as knowledge organization, cognitive load, metacognition, problem-solving heuristics, and differences between expert and novice problem solvers (Maries & Singh, 2023; Riantoni & Yelianti, 2023; Sari, Jatmiko, & Suprapto, 2023). Tools such as PhysPross-CAT have been developed to assess students' problem-solving skills. Research has shown that although some students demonstrate high problem-solving abilities in physics, other students struggle with certain indicators such as mathematical processes and logical development (A'yuni, Kurniawan, Suelsy, Nugraha, & Wibowo, 2023; Pelobillo, 2022). Other research has integrated real-life contexts to evaluate students' application of physics concepts in everyday situations and was found to increase the practical dimension of students' problem-solving abilities. (Fabby, 2015; Hernández-Suarez, Paz-Montes, & Castro, 2022). Additionally, exploration of virtual laboratories has shown how technology can enhance students' problem-solving skills by providing interactive and immersive learning experiences (Gunawan, Suranti, Nisrina, & Herayanti, 2018). The systematic review has also highlighted effective strategies and common challenges in teaching problem-solving skills in physics, emphasizing the importance of methods that encourage critical thinking and adaptive learning (Singh, Maries, Heller, & Heller, 2023). Additionally, integrating local wisdom and contextual examples has been proven to increase student engagement and problem-solving abilities, thereby contributing to a more effective learning experience (Pakpahan, 2022; Riantoni & Yelianti, 2023).

Recent studies on students' scientific literacy in physics highlight persistent challenges in their ability to understand and apply scientific concepts effectively. While socio-scientific worksheets have been shown to enhance scientific literacy (Effendi, Sinensis, & Firdaus, 2023), and STEM-based digital teaching materials support conceptual understanding (Ambaryani, Sarwanto, & Budiawanti, 2022; Asrizal, Annisa, Festiyed, Ashel, & Amnah, 2023), many students still struggle with key competencies. These include explaining scientific phenomena, designing investigations, and interpreting data and evidence (Sholikah & Pertiwi, 2021). Furthermore, assessments reveal limitations in students' abilities to reason scientifically and evaluate information, often linked to weak self-concept and underdeveloped scientific reasoning skills (Fitriana, Hardianti, & Syahwin, 2023; Siswanto et al., 2023; Vizbarienė, Emeljanovas, & Miežienė, 2023). Both internal factors (such as students' understanding of scientific processes) and external ones (such as teachers' STEM literacy and classroom environments) contribute to these difficulties. Despite the growing body of research, few studies examine the integration of digital platforms with inquiry-based learning models to simultaneously foster both scientific literacy and problem-solving skills. This gap underlines the need for innovative, technology-integrated instructional approaches that holistically address these competencies within physics education.

Discovery Learning requires organized access to learning resources that support students in formulating hypotheses, conducting investigations, and interpreting evidence. Google Sites was therefore integrated with Discovery Learning to organize animated stimuli, worksheets, PhET simulations, and quizzes within the six discovery-learning phases, enabling students to remain actively involved in virtual experimentation and evidence-based reasoning. Discovery Learning, as proven in various studies (Martaida, Bukit, & Ginting, 2017; Wijaya, Sukroyanti, & Herayanti, 2023; Zulaiha, Latifah, & Puspitasari, 2023), fosters active involvement in seeking and discovering knowledge independently, thus increasing analytical and critical thinking skills. Research on Google Sites-based learning media has also reported improvements in learning outcomes and student engagement (Lindra et al., 2025), as well as information literacy (Wahyuningsih & Lidyasari, 2025). These findings provide a rationale for combining the investigative structure of Discovery Learning with the resource-organizing role of Google Sites to support problem-solving and scientific literacy in parabolic motion. By

combining Discovery Learning's interactive, student-centered approach with Google Sites' innovative platform, students are encouraged to explore, analyze, and apply knowledge, leading to improved problem-solving abilities and a deeper understanding of scientific concepts, ultimately contributing to increased literacy science.

This research aims to investigate the implementation of DL-GS in improving students' problem-solving abilities and scientific literacy. Through this research, we aim to fill the gap in the literature by investigating the potential integration between DL and GS, which could make an important contribution to the development of innovative and relevant learning methods. Apart from that, this research also aims to expand our understanding of the potential use of Google Sites media in supporting the implementation of DL in the physics education environment. The significance of this research lies in its ability to provide concrete and applicable solutions to improve the quality of learning in schools, as well as providing a strong theoretical foundation for further development in the fields of physics education and learning technology.

METHODS

Research Design

This research used a quasi-experimental type with a non-equivalent control group design (Leavy, 2022). The research was carried out with a research design as shown in Table 1. The research used two classes that were given different treatment. One class as an experimental class was given Application of DL-GS treatment and one class as a control class was given Physics teaching using PPT. Before being given treatment, both classes were given a pre-test, and after the treatment they were given a post-test. Other things such as subject matter, curriculum, number of meetings, class hours, and teachers, have the same design. The subject used in this study is parabolic motion.

Table 1. Research Design

Group	Pre-test		Treatment	Post- test	
	Y1	Y2		Y1	Y2
Experimental Class	T1	T1	X1	T2	T2
Control Class	T1	T1	X2	T2	T2

Two classes were purposively selected to serve as the experimental and control groups. Both groups received a pretest (T1) to measure their initial levels of problem-solving abilities (Y1) and scientific literacy abilities (Y2). Following the pretest, the experimental group was taught using the DL-GS (X1), while the control group received conventional instruction through PowerPoint-based teaching (X2). After the intervention, both groups were administered a posttest (T2) to assess the improvement in Y1 and Y2. The instructional design and materials were kept consistent between the two groups in terms of subject matter, duration, class hours, and instructor, ensuring that the only variable differentiating the two groups was the learning model. The intervention focused on the topic of parabolic motion, and the assessments were aligned with the learning objectives and competencies targeted in the study.

Working Group

The problem-solving and scientific literacy tests were piloted with 180 students from two senior high schools in Pamekasan Regency to evaluate their validity and reliability. Neither school participated in the main study, and all pilot participants had previously studied parabolic motion. The main study population comprised 120 tenth-grade students distributed across four intact classes of 30 students each at another senior high school in the same regency. Cluster random sampling was employed, with two intact classes selected through simple random sampling from the four classes. The four classes were considered eligible for random selection because they had comparable academic ability. Selecting intact classes also preserved the existing classroom organization during the intervention. The resulting sample comprised 60 students, with one class serving as the experimental group and the other as the control group, each consisting of 30 students. Participants included male and female students aged 15–16

years. The intervention lasted two weeks and consisted of two instructional sessions, with a pretest administered before the intervention and a posttest afterward.

Data Collection Tools

The data collection instrument consisted of five essay questions on parabolic motion, with separate scoring rubrics for problem-solving and scientific literacy. Problem-solving was assessed using the five-component ACCES rubric implemented by Prahani et al. (2022): assessing the problem, creating a drawing, conceptualizing the strategy, executing the solution, and scrutinizing the results. Scientific literacy assessment focused on the scientific knowledge dimension through three indicators: explaining scientific facts, presenting hypotheses, and answering questions related to scientific information. Comparable indicators were used by Sumantara et al. (2021). Table 2 presents the indicators and their operational descriptions in the context of parabolic motion.

Table 2. Indicators for Assessing Problem-Solving and the Scientific Knowledge Dimension of Scientific Literacy

Assessed variable	Indicator	Operational description in parabolic motion
Problem-solving	Assess the problem	Identifies the given information, quantities to be determined, and relevant physical principles.
Problem-solving	Create a drawing	Represents the projectile trajectory and relevant physical quantities using a labeled diagram.
Problem-solving	Conceptualize the strategy	Develops a solution strategy by selecting appropriate physical principles and equations.
Problem-solving	Execute the solution	Applies the selected equations and performs the calculations required to obtain a solution.
Problem-solving	Scrutinize the results	Checks the units, consistency, and physical plausibility of the solution.
Scientific literacy	Explain scientific facts	Explains projectile-motion phenomena using relevant scientific facts and concepts.
Scientific literacy	Present hypotheses	Proposes hypotheses concerning relationships between physical quantities in parabolic motion.
Scientific literacy	Answer questions related to scientific information	Uses relevant scientific knowledge to answer questions about the parabolic-motion information presented.

Responses for both variables were evaluated according to three criteria: correctness, logical reasoning, and systematic presentation, adapting the scoring approach used by Prahani et al. (2022). Each indicator was scored from 0 to 3: a score of 3 indicated that all three criteria were met, 2 indicated that two criteria were met, 1 indicated that one criterion was met, and 0 indicated that none of the criteria were met. Raw scores were summed separately for problem-solving and scientific literacy across the five questions and converted to a 0–100 scale before analysis. Pretest and posttest scores were reported on this scale, and normalized gains were calculated from the converted scores.

Data Analysis

Analysis of question items to see improvements in problem-solving abilities and scientific literacy abilities was carried out using equations (Meltzer, 2002).

$$gain\ score\ (g) = \frac{\bar{x}_{posttest} - \bar{x}_{pretest}}{x_{Maks} - \bar{x}_{pretest}} \qquad (1)$$

The results were adjusted using Hake's criteria, as shown in Table 2 (Hake, 1999). Next, reveal the effectiveness of using DL-GS using statistical analysis using the MANOVA test using IBM SPSS. First the decision is made based on the SPSS output in Hotelling Trace. The higher the score on the Hotelling Trace the greater the media influence. Revealing the magnitude of the influence of DL-GS on improving students' problem-solving abilities and scientific literacy was carried out through effect size analysis using multivariate GLM (General Linear Model). The GLM output in the form of eta squared is converted into Cohen's f value to produce an effect size. The value of the effect size can be calculated with the equation (Cohen, 1988).

$$f = \sqrt{\frac{\eta^2}{1-\eta^2}} \quad (2)$$

However, before carrying out MANOVA statistical analysis, it is necessary to have statistical prerequisite analysis. The prerequisite analysis consists of multivariate normality analysis using Shapiro-Wilk, correlation analysis using Pearson Correlation, and homogeneity analysis using the Box's M test. The validity of the DL-GS model is determined using the average expert score from the assessment results. After that, the average assessment results are adjusted according to the criteria in Table 3. Meanwhile, the reliability of the instrument is assessed using Cronbach's Alpha coefficient value, namely if the value is greater than 0.7 then the instrument can be said to be reliable (Taber, 2018).

Table 3. The Category of Learning Instrument Validity Criteria, Hake's N-gain, and Cohen's Value

Validity Criteria		Cohen's value		Hake's N-gain	
Average Score	**Validity Criteria**	**Cohen's f**	**Category**	**N-gain**	**Category**
$3.25 < N \leq 4.00$	Very Valid	$0.10 \leq f < 0.25$	Small Effect Size	$g < 0.3$	Low
$2.50 < N \leq 3.25$	Valid	$0.25 \leq f < 0.40$	Medium Effect Size	$0.3 \leq g < 0.7$	Middle
$1.75 < N \leq 2.50$	Less Valid	$f \geq 0.40$	Large Effect Size	$g \geq 0.7$	High
$1.00 \leq N \leq 1.75$	Invalid				

Experimental Process

The instruments used in this research consisted of teaching instruments and data collection instruments. The teaching instruments in this research include lesson plans, DL-GS models, and PPT. The lesson plan consists of several components, namely syllabus, lesson plan, and assessment. The learning syllabus in both classes is adjusted to the curriculum that applies at school, however, the RPP in the two classes has differences in its learning approach. The experimental class uses DL-GS with six syntaxes, namely: 1) stimulation; 2) problem statement; 3) data collection; 4) data processing; 5) verification; and 6) generalization; Learning activities can be seen in Table 3 (Ramsden, 2003). The complete syntax cannot be separated from the Google Sites which is filled with 3D animated video learning media, PheT, and Quiziz. In the control class, learning is carried out conventionally, consisting of observing the phenomenon of parabolic motion, listening to written lessons about theories, concepts, and examples of phenomena, working on questions, and discussing them with class members. Students' problem-solving abilities were assessed directly against the three indicators described earlier (correct, logical, systematic), while scientific literacy abilities were assessed using three sub-rubrics: 1) the ability to explain facts, 2) the ability to present hypotheses, and 3) the ability to answer (Lau, 2009), each scored against the same three indicators. The learning activities carried out in the experimental class were organized based on the integration of Discovery Learning and Google Sites. These activities were designed to enhance students' engagement, problem-solving abilities, and scientific literacy. Table 4 presented the sequence of learning activities implemented during the intervention.

Table 4. Learning Activities in the Experimental Class

Syntax	Activity	
	Teacher	**Student**
Stimulation	• Prepare the learning instruments, especially the Google Sites which already contain 3D animated videos, PheT virtual labs, and e-modules • Introduce the parabolic motion and its significance in learning. • Orientation to parabolic motion problems through 3D animation videos on the Google Sites. • The teacher asks to pay attention to the shape of	• Open the Google Sites link given by the teacher • Listen to the teacher's explanation of the subject parabolic motion. • Observe and answer stimulus questions from the teacher

Syntax	Activity	
	Teacher	**Student**
	the trajectory and the way the ball is kicked and thrown and then asks whether there is a difference between this movement and a straight, uniform movement or a straight, uniform movement.	
Problem Statement	• Teacher divides students into 4-5 groups heterogeneously • Teacher asks students to watch a video that contains problems with parabolic motion in everyday life	• Students sit with their respective groups • Students discuss with groups to identify problems and answers to problems found on the Google Sites • Students make temporary hypotheses regarding existing problems
Data Collection	• The teacher asks students to open the LKPD on the Google Sites and carry out a virtual PheT experiment like the one on the Google Sites • The teacher guides students to search for or collect information from an experiment that is already on the LKPD • The teacher asks students to look for information from parabolic motion material on the Google Sites	• The teacher asks students to open the LKPD on the Google Sites and carry out a virtual PheT experiment like the one on the Google Sites • The teacher guides students to search for or collect information from an experiment that is already on the LKPD • The teacher asks students to look for information from parabolic motion material on the Google Sites
Data Processing	• The teacher asks the students together to make a scientific report in the form of a ppt for presentation • The teacher guides students in making group ppt	• Students record information obtained from experiments, materials, or discussions with groups and write it in PPT form to present in front of the class.
Verification	• The teacher asks student representatives from the group to present the results of the discussion	• Students present the results of the discussion
Generalization	• The teacher concludes the learning activities	• Students listen to the teacher's explanation and make conclusions

The complete procedure for this research is shown in Figure 1.

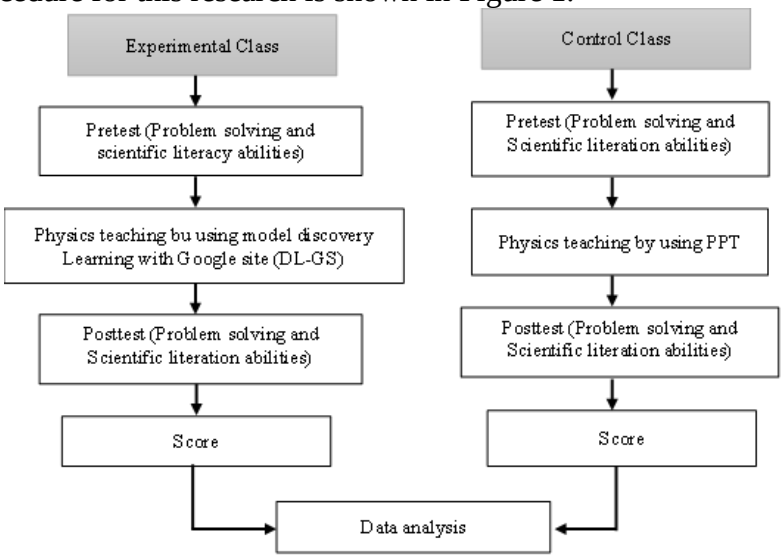


Figure 1. Procedure Research

RESULTS AND DISCUSSION

Reliability And Validity Of Problem-Solving And Scientific Literacy Abilities Test

Three physics education experts assessed the validity of the DL-GS model. The instruments assessed were the content and construct of the lesson plan, Google Sites (appearance and content), and test instruments as shown in Table 5. The validation results show that all aspects have valid criteria. Just like the reliability value, all aspects can be relied on.

Table 5. The Results of the Assessment of the Validity of the Instruments by the Expert

Component	Validity and reability of DL-GS			
	Score	Validity	α	Reliability
Content Validity				
1. Lesson plan	3.37	Very valid	0.73	Reliable
2. Google Sites	3.55	Very valid	0.83	Reliable
3. Test Instruments	3.41	Very valid	0.80	Reliable
Construct Validity				
1. Lesson plan	3.51	Very valid	0.75	Reliable
2. Google Sites	3.61	Very valid	0.73	Reliable
3. Test instrument	3.35	Very valid	0.78	Reliable

Improvement In Problem-Solving And Scientific Literacy Abilities

Before testing the hypothesis, the data were screened against the statistical prerequisites. All conditions were met (Table 6): scores in both classes were normally distributed, variances were homogeneous, and problem-solving and scientific literacy abilities were strongly and significantly correlated, confirming that the two constructs develop together rather than independently.

Table 6. Summary of the Statistical Prerequisite and MANOVA Tests (n = 30 per class)

Test	Statistic	Value	Sig.	Decision
Normality	Shapiro-Wilk W	0.938–0.988	0.081–0.975	Normal
Homogeneity	Box's M (F)	2.815 (0.903)	0.439	Homogeneous
Correlation	Pearson r	0.850	<0.001	Strong
Multivariate effect	Hotelling's Trace	2.272	<0.001	Significant

With the prerequisites satisfied, the MANOVA test on Hotelling's Trace confirms the effect itself (Table 6): the combined gain in problem-solving and scientific literacy differs significantly between the DL-GS class and the conventional (PPT) class. Because both groups began the parabolic-motion unit with no prior instruction, the gap that opens after treatment is attributable to the model rather than to pre-existing knowledge.

Table 7. Improvement and Effect Size of Problem-Solving and Scientific Literacy Abilities (Pre/Post = mean scores; ⟨g⟩ = normalised gain; f = Cohen's f)

Variable	Class	Pre	Post	⟨g⟩	Category	η²	f	Effect
Problem-solving	Experimental	34.23	85.80	0.78	High	0.693	1.50	Large
	Control	32.30	62.10	0.44	Medium	–	–	–
Scientific literacy	Experimental	32.00	84.60	0.77	High	0.529	1.05	Large
	Control	32.35	63.50	0.46	Medium	–	–	–

Table 7 shows how large that gap is. The experimental class reaches the high category of normalised gain on both abilities, while the control class stays in the medium category, and the effect sizes for both variables fall in the large category. DL-GS therefore did not merely outperform conventional instruction statistically — it changed the size of the gain. In line with several research results, the use of Discovery Learning can improve their learning outcomes (Rahman, 2017; Rahmawati et al., 2023)

Discussion

The findings indicate that students receiving DL-GS instruction achieved greater improvements in problem-solving and scientific literacy scores than those receiving conventional PowerPoint-supported instruction. The normalized gains for problem-solving and scientific literacy were 0.78 and 0.77 in the experimental group, compared with 0.44 and 0.46 in the control group, respectively. The corresponding effect sizes were large for both outcomes.

These results suggest that the instructional package supported the assessed competencies within the parabolic-motion unit. The scientific literacy findings should, however, be interpreted within the scientific knowledge dimension represented by the instrument, rather than as evidence of improvement across all dimensions of scientific literacy.

The advantage of DL-GS is best explained by what the two classes actually did. The experimental class solved problems through discovery learning hosted on a Google Sites, while the control class relied on conventional, teacher-centred delivery; this difference in strategy, not in ability, accounts for the difference in outcomes. Discovery learning consistently produces positive effects on student motivation, creative thinking, and learning outcomes (Maladerita, Ananda, & Montesori, 2023; Murtiyasa & Al Karomah, 2020; Nehe, Gusnedi, Hufri, & Sari, 2023; Rosmala, Rahman, & Sukmayadi, 2023). Similarly, active-learning strategies built around a science-literacy approach have been shown to significantly outperform conventional instruction on related competencies such as scientific argumentation (Susilo & Hadi, 2025). Recent evidence sharpens this pattern for physics specifically: systematic reviews confirm that inquiry- and discovery-based strategies remain the most effective route to stronger problem-solving performance (Musengimana et al., 2025) and meta-analyses place discovery learning among the highest-yielding models for scientific literacy (Fajar et al., 2025). By actively involving students in the learning process, this model encourages independent exploration and discovery of new knowledge, fostering reasoning and systematic thinking skills (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011; Rosmala et al., 2023). Hands-on tasks push students to analyze, infer, and apply information on their own rather than passively receive it from the teacher, a shift that also deepens conceptual mastery of physics, since students construct understanding through direct discovery instead of memorising it. This same mechanism trains the problem-solving and creativity skills that complex physics topics demand (Bokingo, Supartin, & Odja, 2022; Subekhi, Fakhruddin, & Sulistyorini, 2022; Zulaiha et al., 2023). A 2026 systematic review of guided-discovery models reaches the same conclusion, linking discovery learning directly to gains in science process skills and critical thinking, the twin engines of scientific literacy (Salsabila et al., 2026).

Google Sites and PhET contributed complementary forms of support to the discovery-learning sequence. Google Sites coordinated access to animated stimuli, worksheets, learning materials, simulations, and quizzes, allowing students to move between investigation instructions and relevant resources within the same learning environment. This organizational role provides a plausible explanation for how the platform supported the activities; related research has reported improvements in learning outcomes and engagement following the use of Google Sites-based media (Lindra et al., 2025). PhET provided a different contribution by allowing students to manipulate projectile-motion parameters and examine the resulting trajectories, turning predictions into relationships that could be investigated. Such interaction is consistent with the inquiry and conceptual-learning affordances identified by Ramaila (2024). In the specific context of projectile motion, Suherman et al. (2025) also reported improved conceptual understanding following PhET-based instruction, although their one-group design limits causal interpretation. When linked to worksheet prompts and teacher guidance, these opportunities may help students connect diagrams, physical quantities, and mathematical relationships, thereby engaging the representation, strategy development, execution, and evaluation components of ACCES (Prahani et al., 2022). The proposed advantage therefore lies in aligning resource organization with guided experimentation, rather than in digital access alone; however, the present design cannot isolate the contribution of either tool.

Interactive quizzes on Quizizz complemented the virtual investigations by providing opportunities for students to retrieve and apply their knowledge of parabolic motion. This potential learning function is supported by classroom research showing that retrieval practice benefits learning across educational levels and subject areas (Agarwal et al., 2021). When quiz questions address predictions or conceptual relationships explored through PhET, reviewing

responses and feedback may help students identify discrepancies between their understanding and the scientific explanation. However, this benefit depends on students' engagement with the feedback: Le & Tran (2024) found that engagement with Quizizz feedback was moderate and complex, indicating that access to feedback does not necessarily ensure its productive use. In physics education, Humairah et al. (2025) reported improved learning outcomes for contextual instruction integrated with Quizizz, providing supporting evidence for its use within a structured instructional approach. Compared with the PowerPoint-supported activities implemented in the present control group, DL-GS offered additional opportunities for variable manipulation and interactive questioning. These differences provide a plausible explanation for the observed gains, although neither conceptual change attributable to the quizzes nor the independent contribution of Quizizz was measured.

The observed advantage of DL-GS is therefore best interpreted as an outcome associated with the combined instructional arrangement. Discovery Learning structured the investigation, Google Sites coordinated the resources, and PhET supported experimentation, while quizzes complemented the learning activities. Previous studies have reported improvements in learning outcomes and engagement with Google Sites-based media (Lindra et al., 2025), and in information literacy with Google Sites-based interactive multimedia (Wahyuningsih & Lidyasari, 2025). These findings support the educational potential of the platform, although they do not directly establish its effect on the outcomes assessed here. Because the present study compared two instructional packages, it cannot determine whether the observed differences arose primarily from Discovery Learning, Google Sites, PhET, Quizizz, or their combination.

Several limitations constrain the interpretation of these findings. First, the intervention comprised only two sessions over two weeks, and the posttest assessed outcomes following this brief implementation. Without a delayed assessment, the study cannot establish whether the gains were retained over time. Second, the intervention addressed only parabolic motion, so transfer to other physics topics remains untested. Third, the sample consisted of 60 students from two intact classes at one school. Although the classes were randomly selected from four classes with comparable academic ability, using one class per condition limits the separation of intervention effects from class-specific influences. Finally, the scientific literacy instrument addressed selected indicators within the scientific knowledge dimension. Future research should involve more classes and schools, longer interventions, delayed assessments, additional physics topics, and broader measures of scientific literacy.

CONCLUSION

This study found that DL-GS instruction was associated with greater improvements in students' problem-solving and assessed scientific literacy scores than conventional PowerPoint-supported instruction in parabolic motion. The experimental group achieved higher normalized gains in both outcomes, with large effect sizes. The findings support the use of structured discovery activities coordinated through Google Sites and supported by virtual investigations as a promising approach for this topic. This implication is limited to the brief intervention, participating classes, and competencies assessed.

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