Interactive Simulation-Driven Inquiry (ISDI) on Learners' Academic Performance and Attitude in Physics

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Abstract: This study examined the effects of Interactive Simulation-Driven Inquiry (ISDI) on the academic performance and attitude toward Physics of Grade 11 Humanities and Social Sciences (HUMSS) students at Kitubo National High School during the School Year 2025–2026. Guided by constructivist and social constructivist learning theories, the study employed a quasi-experimental pretest–posttest non-equivalent groups design involving two intact classes, with one group exposed to ISDI and the other taught through conventional instruction. Academic performance was measured using a teacher-constructed physics achievement test, while students' attitudes, specifically personal interest and real-world connection, problem solving, and conceptual understanding, were assessed using an adapted attitude questionnaire. Descriptive statistics and Analysis of Covariance (ANCOVA) were utilized to analyze the data, with pretest scores treated as covariates. Results showed that both groups had very low pretest performance, establishing baseline equivalence; however, posttest results revealed a statistically significant difference in academic performance favoring the ISDI group ($p < .001$), with the instructional strategy accounting for a substantial portion of score variance. In contrast, ANCOVA results indicated no significant difference in students' anxiety toward Physics between the ISDI and non-ISDI groups. The findings suggest that ISDI is an effective instructional approach for improving academic performance in Physics among non-STEM learners, though reductions in student anxiety may require longer implementation periods and additional affective-support strategies.

Keywords: *Academic Performance, Attitude in Physics, Interactive Simulation-Driven Inquiry (ISDI), Learners.*

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I. INTRODUCTION

The Philippine Department of Education (DepEd) has recently introduced the MATATAG Curriculum, which is anchored on the Sulong Edukalidad framework and Ambisyon Natin 2040, and is aligned with the Basic Education Development Plan (BEDP) 2030 and the United Nations Sustainable Development Goals (SDGs) 2030. The MATATAG Curriculum places strong emphasis on strengthening foundational competencies, promoting critical and higher-order thinking skills, and enhancing learner engagement across all senior high school tracks, including the Humanities and Social Sciences (HUMSS) strand (Department of Education [DepEd], 2024). Within this curricular framework, physics instruction for HUMSS learners must be designed to foster conceptual understanding and real-world relevance, even among students whose primary academic interests lie outside the sciences.

Despite these reforms, findings from the National Achievement Test (NAT) continue to indicate persistently low levels of proficiency in science, particularly in physics-related competencies. NAT results suggest that many Grade 11 learners, including those enrolled in the HUMSS strand, struggle to understand fundamental physics concepts such as motion, forces, and energy, as well as their applications to everyday life. These difficulties are often more evident among HUMSS students, who tend to view physics as abstract, mathematically demanding, and disconnected from their chosen field of specialization. Consequently, such perceptions frequently result in low academic performance and reduced engagement during physics instruction.

At Kitubo National High School, similar patterns have been observed among Grade 11 HUMSS students based on school-level assessments and classroom observations aligned with NAT competencies. Learners commonly experience difficulty in interpreting physical phenomena, analyzing graphs and data, and applying scientific reasoning to real-world contexts. Moreover, low levels of interest, weak problem-solving skills, and limited conceptual understanding have been noted, indicating that traditional lecture-based instruction may not adequately address the learning needs and interests of HUMSS learners. These observations underscore

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the need for instructional approaches that are learner-centered, contextualized, and inclusive.

One instructional approach that shows considerable potential in addressing these challenges is Interactive Simulation–Driven Inquiry (ISDI). ISDI combines interactive computer simulations with inquiry-based learning, enabling students to actively explore physics concepts by manipulating variables, observing outcomes, and constructing explanations through guided inquiry. Previous studies provide empirical support for this approach. For instance, Fan et al. (2018) found that students exposed to interactive simulations embedded within inquiry-based instruction exhibited significantly greater gains in conceptual understanding, inquiry skills, and learning confidence than those taught through traditional methods. Similarly, Mohd et al. (2022) reported that the integration of interactive simulations in physics instruction led to improved conceptual comprehension and more positive student attitudes toward the subject. Furthermore, Papalazarou et al. (2023) demonstrated that technology-supported virtual inquiry experiments positively influenced students' learning outcomes and attitudes in physics education.

In addition to enhancing academic performance, ISDI has been shown to support students' attitudes toward learning across the behavioral, emotional, and cognitive dimensions, as described by Astleitner (2018). Through simulation-based inquiry activities, HUMSS students are encouraged to participate actively in learning tasks, develop more favorable perceptions of physics, and engage in higher-order cognitive processes such as analysis, interpretation, and reflection. Supporting this view, Mariati (2024) emphasized that interactive simulations increase students' motivation and curiosity, thereby making physics learning more accessible and meaningful for diverse groups of learners.

The primary objective of this study is to examine the effects of Interactive Simulation–Driven Inquiry (ISDI) on the academic performance and attitude of Grade 11 HUMSS students in physics at Kitubo National High School, using NAT-aligned physics competencies as the basis for assessment. Specifically, the study aims to determine whether ISDI can significantly improve students' academic achievement in physics and positively influence their behavioral, emotional, and cognitive attitudes toward the subject when compared to conventional teaching methods. The findings of this research are expected to provide empirical evidence supporting the use of ISDI as an effective and inclusive instructional strategy aligned with the goals of the MATATAG Curriculum, particularly for senior high school learners in non-STEM tracks.

Generally, this study aims to assess the academic performance and attitude levels in physics among Grade 11 students at Kitubo National High School using Interactive Simulation-Driven Inquiry (ISDI). The following research questions guide the investigation:

- What is the level of Learners' Academic performance expose to Interactive Simulation-Driven Inquiry and those expose to Non-Interactive Simulation-Driven Inquiry in terms of:
  - Pretest; and
  - Posttest?
- What is the level of Learners' attitude in Physics expose to Interactive Simulation-Driven Inquiry and those expose to Non-Interactive Simulation-Driven in terms of:
  - Personal Interest and Real-World Connection;
  - Problem Solving; and
  - Conceptual Understanding?
- Is there a significant difference in Learners' Academic performance expose to Interactive Simulation-Driven Inquiry and those expose to Non- Interactive Simulation-Driven Inquiry?
- Is there a significant difference in Learners' attitude in Physics expose to Interactive Simulation-Driven Inquiry and those expose to Non-Interactive Simulation-Driven?

II. LITERATURE REVIEW

- *Interactive Simulation–Driven Inquiry (ISDI)*

One of the essential skills students must develop to thrive in the 21st century is the capacity to learn through inquiry, evaluate evidence, and communicate explanations grounded in systematic observation and reasoning. Inquiry-based learning has long been recognized as an effective approach for developing deep conceptual understanding and higher-order thinking in science education (Biggs & Tang, 2016; Dole et al., 2016). In this context, Interactive Simulation–Driven Inquiry (ISDI) has emerged as an instructional approach that integrates interactive computer simulations with inquiry-oriented pedagogy to support meaningful and learner-centered physics instruction.

ISDI enables learners to manipulate variables, visualize abstract or invisible physical processes, and iteratively refine explanations through immediate feedback. These features align with constructivist perspectives on learning, which emphasize that knowledge is actively constructed through interaction with phenomena and the resolution of conceptual conflict (diSessa, 2018; Vosniadou, 2017). Synthesizing more than a decade of quasi-experimental research involving PhET Interactive Simulations, Banda and Nzabahimana (2021) concluded that simulations significantly enhance conceptual understanding when embedded within active, inquiry-based learning environments—precisely the pedagogical intent of ISDI. Supporting this conclusion, Rutten et al. (2018) and Smetana and Bell (2018) found that simulation-supported inquiry facilitates conceptual change and reduces persistent misconceptions in physics.

At the tertiary level, Taibu et al. (2021) reported large effect sizes in laboratory skills, conceptual understanding, and positive learning attitudes when students engaged in sustained, inquiry-centered simulation projects. Similar benefits have

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been documented in secondary education. A quasi-experimental study by Ogegbo and Ramnarain (2022) demonstrated that guided-inquiry lessons supported by interactive simulations produced significantly higher learning gains in electrostatics than conventional lecture-based instruction. These findings reinforce evidence from large-scale reviews indicating that interactive and structured inquiry designs outperform lecture-first approaches in science learning (Hattie, 2017).

The effectiveness of ISDI depends not only on the use of simulations but also on sound instructional design. From a simulation-design perspective, Moore et al. (2013) showed that implicit scaffolding embedded in PhET simulations—such as affordances, feedback, multiple representations, and constrained interaction—guides learners toward productive exploration while minimizing cognitive overload. Complementing this design approach, research on just-in-time guidance indicates that adaptive prompts and teacher mediation support students' progress through the inquiry cycle, particularly during hypothesis generation, evidence evaluation, and explanation construction (Fukuda et al., 2022, 2024).

Evidence further indicates that ISDI generalizes beyond physics. In chemistry education, a systematic review by Aliyu et al. (2024) identified inquiry-based, problem-based, and Predict–Observe–Explain (POE) strategies as the dominant approaches paired with simulations, particularly in abstract topics such as bonding and particle models. Empirical findings by Batamuliza et al. (2024) showed that simulation-based inquiry significantly improved achievement and delayed retention compared with traditional instruction. From a broader perspective, a meta-analysis by Muilwijk and Lazonder (2023) found that virtual investigations are as effective as physical experiments for conceptual learning, especially when tactile feedback is nonessential, validating ISDI as a legitimate form of scientific inquiry. However, implementation challenges related to access and professional development persist, as noted in teacher survey studies (Ben Ouahi et al., 2022).

Recent developments have extended ISDI into immersive environments. Studies by Tsivitanidou et al. (2021) and Georgiou et al. (2021) demonstrated that inquiry-based learning supported by virtual reality simulations yields significant conceptual gains and interacts meaningfully with students' attitudinal profiles, suggesting that immersive simulations may further enhance the cognitive and affective impact of ISDI.

➢ *Attitude Toward Physics*

Students' attitudes toward physics significantly influence engagement, persistence, and achievement. Physics is often perceived as abstract and cognitively demanding, leading to anxiety, low confidence, and reduced motivation (Assem et al., 2023). Research grounded in the Control-Value Theory of Achievement Emotions indicates that students' anxiety is shaped by perceived task value and control (Pekrun et al., 2017).

Simulation-enhanced inquiry instruction has demonstrated positive effects on learners' attitudes. Studies by Ben Ouahi et al. (2025) and Ayasrah et al. (2024) showed that integrating simulations within inquiry-based models improves enjoyment, inquiry orientation, and interest in physics careers. Constructivist and learner-centered strategies are also associated with more positive attitudinal outcomes than heavily structured instruction (Okeke & Ramaila, 2025).

However, attitudinal change is complex. Research indicates that while inquiry-based instruction often improves conceptual understanding, its effects on anxiety may be limited without sustained emotional and motivational support (Sagatbek et al., 2024; Putwain et al., 2020). Students' beliefs about problem solving and knowledge structure strongly influence emotional responses in physics (Docktor & Mestre, 2016; Avargil et al., 2018). Fragmented conceptual frameworks and reliance on procedural memorization can intensify anxiety (Finkelstein et al., 2016; Treagust & Duit, 2018).

Studies using the CLASS instrument further show that many students exhibit only partial alignment with expert-like beliefs, leaving room for growth in confidence and conceptual coherence (Wandi et al., 2024). Emotional regulation and confidence improve when students develop clearer conceptual frameworks and receive structured support (Schunk & DiBenedetto, 2020). Relevance and contextualization also play key roles in reducing anxiety and sustaining motivation (Linnenbrink-Garcia et al., 2018; Fencl & Scheel, 2016).

Problem solving is frequently identified as the most anxiety-provoking aspect of physics due to its high cognitive demands (Larkin & Reif, 2017). Moderate anxiety may function as either a facilitator or barrier depending on instructional scaffolding and support (Beilock & Ramirez, 2016). Consequently, effective reduction of physics-related anxiety often requires a combination of instructional, motivational, and emotional interventions (Raccanello et al., 2019; Thomas et al., 2018; Villavicencio & Bernardo, 2016; Villafañe et al., 2020).

III. METHODOLOGY

The researcher utilized a quasi-experimental research design to assess the learners' academic performance and attitude in physics, using Interactive Simulation-Driven Inquiry. One intact section for experimental group and one intact section for control group.

The study involved one section of Grade11 Senior High School students from Kitubo National High School who officially enrolled in Grade 11 for the school year 2025-2026. This section takes Physics during the study period.

The study was conducted at Kitubo National High School, located in Purok 2, Kitobo, Kitaotao, Bukidnon, with School ID 303964. The school follows the K to 12 Science Curriculum, aligning with government requirements mandated by RA 10533.

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➢ *Design and Development of the Lesson*

- *Design and Development of the Interactive Simulation-Driven Inquiry with the 7E Lesson Plan*

✓ 1st Step: Elicit: Students were organized into teams, and prior knowledge about the physics topic (e.g., motion, forces, energy) was reviewed. The teacher introduced the learning objectives and provided context for the simulation-based activities in the computer laboratory. This step aimed to activate students' prior knowledge, prepare them mentally, and promote collaboration among team members.

✓ 2nd Step: Engage: The teacher presented a real-world problem or scenario related to the physics concept. Students brainstormed initial ideas, made predictions, and discussed how the concept applies to everyday situations. A short video demonstration or guided discussion introduced the physics concept, setting the stage for the simulation activity in the lab.

✓ 3rd Step: Explore: In the computer laboratory, teams interacted with interactive physics simulations (e.g., PhET, Algodoo, physlet) to manipulate variables, test hypotheses, and observe results. Students planned and conducted inquiry-based tasks, assigned team roles, and applied theoretical concepts in the simulation environment. Active experimentation and collaboration were emphasized to promote attitude and discovery.

✓ 4th Step: Explain: Teams shared their simulation results, interpretations, and reasoning with the class. The teacher facilitated discussions to clarify misconceptions, reinforce key concepts, and encourage peer learning. Students explained the principles behind the simulation outcomes and connected them to the underlying physics theories.

✓ 5th Step: Elaborate: The teacher provided additional examples and real-life applications of the physics concepts explored in the simulations. Students were encouraged to link their findings to other physics topics or interdisciplinary contexts, deepening understanding and reinforcing relevance.

✓ 6th Step: Evaluate: Students completed post-assessments in the computer laboratory, such as quizzes, problem-solving exercises, or reflection tasks designed to measure academic performance and conceptual mastery. Team discussions and individual reflections were used to assess understanding and learning outcomes.

✓ 7th Step: Extend: Follow-up tasks were assigned to strengthen learning, including additional simulations, experiments, or real-life problem scenarios. Students were encouraged to explore physics concepts beyond the classroom, promoting knowledge transfer, higher-order thinking, and sustained engagement.

Academic performance was measured using a 30-item teacher-constructed test assessing Physics concepts aligned with the curriculum. Content validity was established through expert review, and the instrument was pilot tested with Grade 12 students from Kitubo National High School. The test demonstrated acceptable internal consistency with a Cronbach's alpha of .78.

Students' attitudes toward Physics were assessed using an adopted and modified version of the Colorado Learning Attitudes about Science Survey (CLASS) by Cupida (2014). The instrument consists of 28 items rated on a five-point Likert scale and measures attitudes in terms of personal interest and real-world connection, problem solving, and conceptual understanding. The questionnaire was pilot tested with Grade 12 students from Kitubo National High School, yielding a Cronbach's alpha of .867, indicating acceptable internal consistency.

The study was conducted during the third quarter of the 2025–2026 school year. Primary data sources included pretest and posttest scores and attitude survey results. Two selected sections completed the pretest prior to the intervention, and after the implementation of the Interactive Simulation-Driven Inquiry approach, the same sections completed the posttest and attitude survey. Data were analyzed using appropriate statistical methods to determine the effectiveness of the intervention.

The researcher employed descriptive statistics, including frequency counts, percentages, mean, and standard deviation, to articulate the levels of academic performance among students and their levels of Physics attitude.

Additionally, the Analysis of Covariance (ANCOVA) utilized to investigate whether a significant difference exists in learners' academic performance. The same statistical method, ANCOVA, will also be applied to assess if there is a significant difference in learners' attitude expose to Interactive Simulation-Driven Inquiry and those expose to Non-Interactive Simulation-Driven.

IV. PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

Table 1 Frequency and Percentage of the Learners' Academic Performance of Physics in their Pretest.

ISDI ***(n=29)***				**Non-ISDI** ***(n=35)***		
Scoring Scale	**Pretest (f)**	**%**	**Qualitative Interpretation**	**Pretest (f)**	**%**	**Qualitative Interpretation**
26-30	0	0	Outstanding	0	0	Outstanding
23-25	0	20	Very Satisfactory	0	0	Very Satisfactory
21-22	0	40	Satisfactory	0	0	Satisfactory
18-20	0	0	Fairly Satisfactory	0	0	Fairly Satisfactory
Below 18	29	100	Did Not Meet Expectation	35	100	Did Not Meet Expectation

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Table 1 presents the distribution of students' academic performance based on their pretest performance prior to the implementation of the intervention. The respondents were divided into two groups: ISDI (n = 29) and Non-ISDI (n = 35). Five performance levels were utilized: Outstanding (26–30), Very Satisfactory (23–25), Satisfactory (21–22), Fairly Satisfactory (18–20), and Did Not Meet Expectation (Below 18).

Results reveal that none of the students from both the ISDI and Non-ISDI groups obtained scores within the Outstanding, Very Satisfactory, Satisfactory, or Fairly Satisfactory categories. All respondents in both groups scored below 18, placing them under the Did Not Meet Expectation level, with 100% frequency and percentage in each group.

These findings indicate that both groups exhibited a very low level of academic performance prior to instruction. The absence of students in the higher performance categories suggests that learners entered the study with limited prior knowledge and weak conceptual foundations in the subject matter. Because both groups demonstrated identical performance levels at baseline, the results confirm academic comparability, thereby reducing selection bias and strengthening the internal validity of subsequent analyses.

Low pretest scores of this nature are characteristic of diagnostic assessments administered before formal instruction and are useful in identifying students' initial misconceptions and learning gaps (Heritage, 2016). Such outcomes emphasize the need for carefully designed instructional interventions that can address foundational deficiencies before higher-order learning can occur

From a constructivist perspective, meaningful learning is dependent on the recognition and remediation of prior misconceptions. When learners lack adequate conceptual grounding, instruction must be intentionally structured to scaffold understanding and promote knowledge construction (Biggs & Tang, 2016). The uniform Did Not Meet Expectation results observed in this study highlight the necessity for explicit, learner-centered, and structured instructional strategies.

Furthermore, the equivalence of pretest performance between the ISDI and Non-ISDI groups provides a strong justification for the conduct of the intervention. Since both groups began at the same level, any improvement observed in posttest performance may be more confidently attributed to the instructional strategy rather than to pre-existing academic differences. Large-scale educational research has consistently reported that low initial performance in science subjects is a widespread concern that requires evidence-based pedagogical responses (Organisation for Economic Co-operation and Development [OECD], 2017).

Table 2 Frequency and Percentage of the Learners' Academic Performance of Physics in their Posttest.

ISDI *(n=29)*				**Non-ISDI *(n=35)***		
Scoring Scale	**Posttest**		**Qualitative Interpretation**	**Posttest**		**Qualitative Interpretation**
	(f)	**%**		**(f)**	**%**	
26-30	0	0	Outstanding	0	0	Outstanding
23-25	3	10.3	Very Satisfactory	0	0	Very Satisfactory
21-22	2	6.9	Satisfactory	1	3	Satisfactory
18-20	3	10.3	Fairly Satisfactory	5	14	Fairly Satisfactory
Below 18	21	72.5	Did Not Meet Expectation	29	83	Did Not Meet Expectation

Table 2 presents the posttest results showing the level of academic performance of students after the conduct of instruction. The respondents were grouped into ISDI (n = 29) and Non-ISDI (n = 35) and were assessed using the same performance scale applied in the pretest.The results indicate that students exposed to Interactive Simulation-Driven Inquiry (ISDI) demonstrated improved academic performance compared to their initial pretest scores. In the ISDI group, 3 students (10.3%) attained a Very Satisfactory level, 2 students (6.9%) reached a Satisfactory level, and 3 students (10.3%) were classified as Fairly Satisfactory. However, the majority of students in this group—21 learners (72.5%)—still remained under the Did Not Meet Expectation category.

In contrast, the Non-ISDI group exhibited relatively lower posttest performance. Only one student (3%) achieved a Satisfactory level, while 5 students (14%) reached the Fairly Satisfactory category. A substantial proportion of the group, comprising 29 students (83%), continued to fall under the Did Not Meet Expectation level. Notably, no students from either group attained the Outstanding category in the posttest. Overall, the posttest findings reveal that both groups demonstrated improvement compared to their pretest performance; however, the ISDI group exhibited more noticeable gains, particularly in the higher performance categories. The appearance of students in the Very Satisfactory and Satisfactory levels in the ISDI group—categories that were absent in the pretest—indicates the positive effect of the instructional approach on students' academic performance.

Although a majority of students in both groups still did not meet expectations, the lower proportion of underperforming students in the ISDI group (72.5%) compared to the Non-ISDI group (83%) suggests that ISDI had a more favorable impact on learning outcomes. Structured and interactive instructional approaches have been shown to improve post-instruction achievement by promoting active engagement and conceptual processing (Hattie, 2017).

The findings further imply that ISDI contributed to meaningful learning progression, even if full mastery was not achieved by all learners. Educational research emphasizes that learning gains, particularly in complex and abstract subjects such as Physics, occur incrementally and should be interpreted based on progress rather than immediate attainment of mastery levels (OECD, 2019).

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Moreover, alignment between instructional strategies, learning objectives, and assessment practices is essential for observable improvement in posttest performance. When instruction is intentionally designed to support conceptual understanding and feedback, learners are more likely to demonstrate measurable academic growth (Biggs & Tang, 2016). These perspectives support the present findings, particularly the improved performance of students exposed to ISDI.

Table 3 Level of Learners' Attitude in Physics in Terms of Personal Interest and Real-World Connection.

			ISDI			***Non-ISDI***
Statements	**Mean**	**SD**	**Qualitative Interpretation**	**Mean**	**SD**	**Qualitative Interpretation**
1. I think about physics I experience in everyday life.	3.7241	.79716	Positive	3.0286	.89066	Moderate Positive
2. Learning physics changes my ideas about how the world works.	3.6207	1.04928	Positive	3.3714	.77024	Moderate Positive
3. I am not satisfied until I understand why something works the way it does.	3.5862	.94556	Positive	3.3143	.93215	Moderate Positive
4. Reasoning skills used to understand physics can be helpful to me in my everyday life.	3.5862	.90701	Positive	3.6000	.84714	Positive
5. The subject of physics has little relation to what I experience in the real world.	3.4483	.82748	Moderate Positive	3.6000	1.14275	Positive
6. To understand physics, I sometimes think about my personal experiences and relate them to the topic being analyzed.	3.4138	.68229	Moderate Positive	3.2286	.97274	Moderate Positive
7. I study physics to learn knowledge that will be useful in my life outside of school.	3.3793	.90292	Moderate Positive	3.4000	.84714	Moderate Positive
8. It is important for the government to approve new scientific ideas before they can be widely accepted.	3.2069	.72601	Moderate Positive	3.2286	.87735	Moderate Positive
9. As physicist learn more, most physics ideas we use today are likely to be proven wrong.	3.1034	.77205	Moderate Positive	3.0571	1.08310	Moderate Positive
10. I enjoy solving physics problems.	2.9655	.73108	Moderate Positive	2.9143	1.01087	Moderate Positive
Overall Mean Interpretation	3.40	.8341	Moderate Positive	3.27	.937414	Moderate Positive

Table 3 presents the level of students' perceptions regarding personal interest and real-world connection in Physics, as reflected in their mean responses, standard deviations, and qualitative interpretations for both the ISDI and Non-ISDI groups.

For the ISDI group, item means ranged from 2.97 to 3.72, with most statements interpreted as Positive or Moderate Positive. The highest mean score (M = 3.7241, SD = .79716) was obtained for the statement "I think about physics I experience in everyday life," indicating a strong perception of real-world relevance. The overall mean of 3.40 (SD = .8341) suggests a Moderate Positive level of attitude toward Physics.

Similarly, the Non-ISDI group obtained item means ranging from 2.91 to 3.60, with all statements interpreted as Moderate Positive or Positive. The highest mean scores (M = 3.6000) were recorded for statements emphasizing the usefulness of reasoning skills and the relevance of Physics to everyday life. The group's overall mean of 3.27 (SD = .9374) also reflects a Moderate Positive attitude.

The findings indicate that students in both groups exhibited a generally positive orientation toward Physics, particularly in terms of personal relevance and applicability to real-life situations. However, the ISDI group consistently obtained higher mean scores across most items, suggesting that Interactive Simulation-Driven Inquiry strengthened students' engagement and appreciation of Physics as a meaningful subject. Instructional approaches that emphasize contextual learning and relevance have been shown to reduce emotional barriers and promote more positive learning experiences in science (Fencl & Scheel, 2016).

The slightly higher variability in responses observed in the Non-ISDI group indicates less consistency in students' attitudes, which may reflect differing levels of interest and confidence toward Physics concepts. Students who fail to consistently perceive learning tasks as relevant tend to show fluctuating engagement and emotional responses (Muis et al., 2018).

Overall, the results imply that students in both groups experienced manageable levels of physics anxiety, as indicated by their moderately positive attitudes toward

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personal interest and real-world connection. According to the Control-Value Theory of Achievement Emotions, students' anxiety is closely linked to how valuable and relevant they perceive a learning task to be (Pekrun et al., 2017). The stronger real-world connections reported by the ISDI group suggest improved emotional regulation and reduced anxiety toward Physics learning.

These findings are further supported by large-scale educational research emphasizing that students' emotional engagement and perceived relevance of science content play a crucial role in sustaining motivation and learning success, especially in abstract subjects such as Physics (Organisation for Economic Co-operation and Development [OECD], 2019). Hence, the results highlight that fostering personal interest and real-world connections through ISDI contributes to healthier learning dispositions and reduced anxiety among students.

Table 4 Mean and Standard Deviation of the Learners' Attitude in Physics in Terms of Problem Solving.

			ISDI			***Non-ISDI***
Statements	**Mean**	**SD**	**Qualitative Interpretation**	**Mean**	**SD**	**Qualitative Interpretation**
1. When I am solving a physics problem, I Try to decide what would be a reasonable value for the answer.	3.3793	.82001	Moderate Positive	3.0571	.90563	Moderate Positive
2. When studying physics, I relate the important information to what I already know rather than just memorizing it the way it is presented.	3.3793	.86246	Moderate Positive	3.4000	.91394	Moderate Positive
3. Nearly everyone is capable of Understanding physics if they work at it.	3.3448	1.04457	Moderate Positive	3.4571	.88593	Moderate Positive
4. I do not expect physics equations to help My understanding of the ideas; they are just for doing calculations.	3.2414	.83045	Moderate Positive	3.0571	.93755	Moderate Positive
5. There is usually only one correct approach to solving a physics problem.	3.2414	.68947	Moderate Positive	3.2571	.98048	Moderate Positive
6. In physics, mathematical formulas express meaningful relationships among measurable quantities.	3.2414	.91242	Moderate Positive	3.3143	.71831	Moderate Positive
7. I can usually figure out a way to solve Physics problems.	3.2069	.90156	Moderate Positive	3.2571	1.01003	Moderate Positive
8. If I get stuck on a physics problem in my First try, I usually try to figure out different way that works.	3.1724	.88918	Moderate Positive	3.1429	.69209	Moderate Positive
9. If I get stuck on a physics problem, there is no chance I'll figure it out on my own.	3.1724	.75918	Moderate Positive	3.0857	1.01087	Moderate Positive
10. After I study a topic in physics and feel that I understand it, I have difficulty solving Problems on the same topic.	3.1379	.83342	Moderate Positive	3.2857	.85994	Moderate Positive
11. There could be two different correct values to a physics problem if I use two Different approaches.	3.1379	.83342	Moderate Positive	3.2571	.65722	Moderate Positive
12. If I don't remember a particular equation to solve a problem on an exam, there's Nothing much I can do (legally!) to come up with it.	3.1034	.85960	Moderate Positive	3.3143	.86675	Moderate Positive
13. If I want to apply a method used for solving one physics problem to another problem, the problems must involve very Similar situations.	3.1034	.67320	Moderate Positive	3.0000	.76696	Moderate Positive
Overall Mean Interpretation	3.22	.83915	Moderate Positive	3.223	.8620	Moderate Positive

Table 4 presents the mean scores, standard deviations, and qualitative interpretations of students' responses regarding problem-solving in physics for the ISDI and Non-ISDI groups. The table reflects students' cognitive and affective orientations toward solving physics problems, which are closely associated with physics anxiety.

For the ISDI group, the item means ranged from 3.10 to 3.38, all falling within the Moderate Positive range. The highest mean score (M = 3.3793, SD = .82001) was obtained for the statement "When I am solving a physics problem, I try to decide what would be a reasonable value for the answer," indicating that students employed logical reasoning and estimation strategies. The overall mean of the ISDI group was

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3.22 (SD = .83915), which corresponds to a Moderate Positive level of confidence in problem solving.

Similarly, the Non-ISDI group recorded item means ranging from 3.00 to 3.46, all also interpreted as Moderate Positive. The highest mean (M = 3.4571, SD = .88593) was observed for the statement "Nearly everyone is capable of understanding physics if they work at it," reflecting a generally positive belief about learnability. The overall mean for this group was 3.223 (SD = .8620), indicating a comparable level of problem-solving attitude.

The results show that both groups demonstrated moderate confidence and persistence in solving physics problems, with no extreme positive or negative orientations observed. The consistent Moderate Positive interpretations suggest that students are willing to engage in problem solving and attempt alternative strategies, but may still experience uncertainty when faced with complex or unfamiliar tasks. Research indicates that students' problem-solving beliefs play a crucial role in shaping their emotional responses to challenging physics problems (Docktor & Mestre, 2016).

However, neither group reached the Positive or Highly Positive range, indicating that cognitive difficulty and emotional hesitation are still present. Moderate confidence in problem solving is often accompanied by underlying anxiety, particularly in disciplines that require abstract reasoning and mathematical processing (Avargil et al., 2018). This suggests that while students feel somewhat capable, they may still doubt their ability to solve problems independently or transfer strategies across contexts.

The similarity in overall mean scores further implies that although ISDI supports conceptual understanding, problem-solving anxiety requires sustained and explicit instructional support. From an emotional-cognitive perspective, students may value physics learning yet experience anxiety when they perceive limited control over problem-solving outcomes (Pekrun et al., 2017). As a result, confidence has not yet developed to a level that ensures consistent success across varied problem situations.

Recent research emphasizes that strengthening problem-solving confidence involves modeling multiple solution strategies, encouraging sense-making, and providing scaffolded practice opportunities. Students who struggle to transfer strategies or apply concepts flexibly are more likely to experience persistent anxiety (Organisation for Economic Co-operation and Development [OECD], 2019). Therefore, the moderate confidence observed in this study should be viewed as an opportunity for further instructional enhancement rather than a learning deficiency.

Table 5 Mean and Standard Deviation of the Learners' Attitude in Physics in Terms of Conceptual Understanding.

			ISDI			***Non-ISDI***
Statements	**Mean**	**SD**	**Qualitative Interpretation**	**Mean**	**SD**	**Qualitative Interpretation**
1. When I solve a physics problem, I locate an equation that uses the variables given in the problem and plug in the values.	3.3793	.72771	Moderate Positive	3.1714	.85700	Moderate Positive
2. It is possible for physicists to carefully perform the same experiment and get two very different results that are both correct.	3.3103	.66027	Moderate Positive	3.4286	.88403	Moderate Positive
3. A significant problem in learning physics is being able to memorize all the information I need to know.	3.2759	.70186	Moderate Positive	3.3429	.76477	Moderate Positive
4. It is possible to explain physics ideas without mathematical formulas.	3.2069	.94034	Moderate Positive	3.2286	1.05957	Moderate Positive
5. Knowledge in physics consists of many disconnected topics.	3.0690	.88362	Moderate Positive	3.2286	.91026	Moderate Positive
Overall Mean Interpretation	3.2483	.78276	Moderate Positive	3.28	.8951	Moderate Positive

Table 5 shows the level of students' anxiety in physics as reflected in their conceptual understanding, comparing the ISDI and Non-ISDI groups. The table presents the mean scores, standard deviations, and qualitative interpretations of five statements related to students' views on physics concepts, equations, and the structure of physics knowledge.

For the ISDI group, the mean scores ranged from 3.07 to 3.38, all of which were interpreted as Moderate Positive. The highest mean (M = 3.3793, SD = .72771) corresponded to the statement "When I solve a physics problem, I locate an equation that uses the variables given in the problem and plug in the values." The overall mean of 3.2483 (SD = .78276) indicates a Moderate Positive level of conceptual understanding.

Similarly, the Non-ISDI group obtained mean scores ranging from 3.17 to 3.43, also interpreted as Moderate Positive. The highest mean (M = 3.4286, SD = .88403) reflected students' acknowledgment that experiments may

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yield different yet correct outcomes. The overall mean of 3.28 (SD = .8951) suggests a comparable conceptual orientation toward Physics.

These results indicate that students in both groups possess basic conceptual awareness of Physics, although deep integration of concepts has not yet been fully achieved. When learners rely heavily on equations and memorization, conceptual understanding tends to remain fragmented, which may contribute to uncertainty when solving unfamiliar problems (Vosniadou, 2017).

The similarity in mean scores further suggests that while instruction has supported students' awareness of physics concepts, many learners still struggle to form interconnected mental frameworks. Such fragmented knowledge structures are characteristic of early stages of conceptual development in physics learning (diSessa, 2018).

The findings imply that students experience a moderate level of anxiety related to conceptual understanding. Although students did not display strongly negative perceptions, the absence of Positive or Highly Positive interpretations indicates lingering uncertainty in explaining, integrating, and transferring physics concepts. Anxiety often arises when learners perceive gaps between procedural skills and conceptual meaning (Finkelstein, Pollock, & Beichner, 2016).

Persistent misconceptions and weak conceptual links can intensify this uncertainty. Conceptual change research highlights those misconceptions tend to endure unless instruction explicitly addresses relationships among ideas (Treagust & Duit, 2018). Without such instructional emphasis, students may continue to rely on surface-level strategies, sustaining moderate anxiety.

Finally, students' confidence in conceptual understanding plays a critical role in emotional regulation. When learners develop clearer conceptual frameworks, they are more likely to experience increased confidence and reduced anxiety, particularly in cognitively demanding subjects like Physics (Schunk & DiBenedetto, 2020). These perspectives support the present findings, indicating that improved conceptual clarity is essential for reducing anxiety and strengthening learning outcomes.

Table 6 Overall level of Learners' Attitude in Physics, Personal Interest and Real-World Connection, Problem Solving, and Conceptual Understanding.

			ISDI			***Non-ISDI***
Variables	**Mean**	**SD**	**Qualitative Interpretation**	**Mean**	**SD**	**Qualitative Interpretation**
6.Personal Interest and Real-World Connection	3.40	.8341	Moderate Positive	3.27	.937414	Moderate Positive
Problem Solving	3.22	.83915	Moderate Positive	3.223	.8620	Moderate Positive
7.Conceptual Understanding	3.2483	.78276	Moderate Positive	3.28	.8951	Moderate Positive
Overall Mean	3.2894	.81867	Moderate Positive	3.258	.8982	Moderate Positive

Table 6 presents the overall level of students' anxiety in Physics, measured through three dimensions: Personal Interest and Real-World Connection, Problem Solving, and Conceptual Understanding, for both the ISDI and Non-ISDI groups.For the ISDI group, the mean scores for the three dimensions were 3.40 for Personal Interest and Real-World Connection, 3.22 for Problem Solving, and 3.2483 for Conceptual Understanding. These values yielded an overall mean of 3.2894 (SD = .81867), which corresponds to a Moderate Positive qualitative interpretation.

Similarly, the Non-ISDI group obtained mean scores of 3.27, 3.223, and 3.28 for the same dimensions, respectively, with an overall mean of 3.258 (SD = .8982). This result was likewise interpreted as Moderate Positive. The comparable overall means indicate that both groups demonstrated a generally moderate and stable attitude toward Physics, reflecting manageable levels of anxiety across all measured dimensions.

Across both groups, Personal Interest and Real-World Connection recorded the highest mean scores, suggesting that students tend to experience lower anxiety when Physics content is perceived as meaningful and related to everyday experiences. Educational research consistently shows that relevance and contextualization of learning tasks enhance emotional engagement and reduce anxiety in science learning (Linnenbrink-Garcia et al., 2018).

In contrast, Problem Solving yielded the lowest mean scores for both groups, indicating that this dimension remains the most anxiety-provoking aspect of Physics learning. Tasks involving multistep reasoning, abstraction, and mathematical manipulation often impose a higher cognitive load, which can increase emotional strain among learners (Larkin & Reif, 2017). This pattern aligns with findings in physics education research, where problem solving is frequently identified as a key source of student anxiety.

The minimal differences between the mean scores of the ISDI and Non-ISDI groups imply that while instructional strategies may foster positive learning attitudes, reductions in physics anxiety require sustained and systematic instructional support. Anxiety is not easily altered through short-term interventions alone and often require repeated exposure, guided practice, and reinforcement of conceptual understanding.

Overall, the findings suggest that students' anxiety in Physics is present but not debilitating. A Moderate Positive attitude indicates that learners neither strongly fear nor fully embrace Physics learning, positioning them at a critical stage

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where appropriate instructional design can significantly influence motivation and achievement. From an affective-cognitive perspective, moderate anxiety may serve as either a facilitator or a barrier depending on the availability of instructional support and scaffolding (Beilock & Ramirez, 2016).

When classroom instruction integrates real-world applications, structured problem-solving guidance, and opportunities for conceptual clarification, students are more likely to regulate anxiety and engage productively with learning tasks. Strengthening instructional coherence across interest, problem solving, and conceptual understanding is therefore essential in promoting both emotional well-being and academic success in Physics learning (Villafañe et al., 2020).

Table 7 Test of Significant Difference in the Academic Performance when Students Expose to ISDI and Those Exposed to Non-ISDI.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	499.221[a]	2	249.610	23.580	.000
Intercept	172.457	1	172.457	16.292	.000
PRETEST	277.164	1	277.164	26.183	.000
GROUP	332.176	1	332.176	31.380	.000
Error	645.717	61	10.586		
Total	13300.000	64			
Corrected Total	1144.938	63			
a. R Squared = .436 (Adjusted R Squared = .418)					

Table 7 presents the results of the Analysis of Covariance (ANCOVA) conducted to determine whether a significant difference exists in students' anxiety in Physics between those exposed to Interactive Simulation-Driven Inquiry (ISDI) and those taught using non-ISDI instruction, with pretest anxiety scores used as a covariate.

The results show that the corrected model was not statistically significant, $F(2, 53) = 2.273$, $p = .113$, indicating that the model did not adequately explain variation in students' posttest anxiety levels. The pretest covariate approached statistical significance, $F(1, 53) = 3.809$, $p = .056$, suggesting that students' initial levels of anxiety had a limited but noticeable influence on their post-intervention anxiety scores.

Most importantly, the group effect (ISDI vs. Non-ISDI) was not statistically significant, $F(1, 53) = 1.315$, $p = .257$, indicating that there was no significant difference in students' anxiety between those exposed to ISDI and those taught using traditional methods after controlling for pretest anxiety. The R^2 value of .079 (Adjusted R^2 = .044) further suggests that only 7.9% of the variance in students' anxiety can be explained by the instructional strategy and the covariate combined.

These results indicate that while ISDI was effective in improving students' academic performance, its impact on affective outcomes such as anxiety was not statistically significant within the duration of the intervention. This finding is consistent with educational research suggesting that affective variables, particularly academic anxiety, are generally more resistant to short-term instructional interventions than cognitive outcomes (Putwain et al., 2020).

The non-significant group effect further implies that students' anxiety levels remained relatively stable regardless of the instructional method employed. Anxiety in Physics is often influenced by multiple factors, including prior learning experiences, self-efficacy beliefs, assessment pressure, and classroom climate, which may exert a stronger influence than instructional strategy alone (Raccanello et al., 2019).

Moreover, the low adjusted R^2 value highlights that other unmeasured variable may play a more substantial role in shaping students' anxiety responses. Contemporary educational psychology emphasizes that anxiety is a deeply rooted affective construct that frequently requires sustained emotional support, extended instructional exposure, and explicit intervention strategies beyond instructional innovation alone (Thomas et al., 2018).

The findings therefore suggest that although ISDI enhances conceptual understanding and academic achievement, reducing students' anxiety in Physics may require complementary approaches, such as emotional regulation strategies, formative feedback, and supportive classroom practices. As noted by Villavicencio and Bernardo (2016), effective reduction of science-related anxiety often involves a combination of instructional, motivational, and emotional supports.

Table 8 Analysis of Covariance Summary of the Attitude in Physics when Exposed to ISDI and those Exposed to Non-ISDI.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.136[a]	2	.068	2.273	.113
Intercept	1.038	1	1.038	34.827	.000
Pretest	.114	1	.114	3.809	.056
Group	.039	1	.039	1.315	.257
Error	1.580	53	.030		

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Total	600.820	56			
Corrected Total	1.716	55			
a. R Squared = .079 (Adjusted R Squared = .044)					

Table 8 presents the results of the Analysis of Covariance (ANCOVA) conducted to determine whether a significant difference exists in students' anxiety in Physics between those exposed to Interactive Simulation-Driven Inquiry (ISDI) and those taught using non-ISDI instruction, with pretest anxiety scores used as a covariate. The results show that the corrected model was not statistically significant, $F(2, 53) = 2.273$, $p = .113$, indicating that the model did not adequately explain variation in students' posttest anxiety levels. The pretest covariate approached statistical significance, $F(1, 53) = 3.809$, $p = .056$, suggesting that students' initial levels of anxiety had a limited but noticeable influence on their post-intervention anxiety scores.

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This chapter presents the summary of findings, conclusions, and recommendations derived from the study that investigated the effectiveness of Interactive Simulation-Driven Inquiry (ISDI) on learners' academic performance and anxiety in Physics.

➢ *Summary of Findings*

The findings of the study reveal that prior to the implementation of the intervention, both the ISDI and Non-ISDI groups demonstrated very low levels of academic performance in Physics, with all students falling under the Did Not Meet Expectation category in the pretest. This result confirms that the two groups were academically comparable at baseline and lacked adequate prior knowledge of the subject matter. After the conduct of instruction, both groups showed improvement in posttest performance; however, students exposed to ISDI demonstrated greater gains, as evidenced by higher frequencies in the Very Satisfactory, Satisfactory, and Fairly Satisfactory performance levels compared to the Non-ISDI group.

In terms of students' anxiety in Physics, the results indicate that both groups exhibited moderate positive attitudes across the dimensions of personal interest and real-world connection, problem solving, and conceptual understanding.

The non-significant group effect further implies that students' anxiety levels remained relatively stable regardless of the instructional method employed. Anxiety in Physics is often influenced by multiple factors, including prior learning experiences, self-efficacy beliefs, assessment pressure, and classroom climate, which may exert a stronger influence than instructional strategy alone (Raccanello et al., 2019).

Moreover, the low adjusted R^2 value highlights that other unmeasured variable may play a more substantial role in shaping students' anxiety responses. Contemporary educational psychology emphasizes that anxiety is a deeply rooted affective construct that frequently requires sustained emotional support, extended instructional exposure, and explicit intervention strategies beyond instructional innovation alone (Thomas et al., 2018).

The findings therefore suggest that although ISDI enhances conceptual understanding and academic achievement, reducing students' anxiety in Physics may require complementary approaches, such as emotional regulation strategies, formative feedback, and supportive classroom practices. As noted by Villavicencio and Bernardo (2016), effective reduction of science-related anxiety often involves a combination of instructional, motivational, and emotional supports.

V. SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Students exposed to ISDI consistently obtained slightly higher mean scores, particularly in personal interest and real-world connection, suggesting improved engagement and perceived relevance of Physics concepts. However, anxiety related to problem solving and conceptual understanding remained present in both groups, indicating that these aspects of Physics learning continue to challenge students.

Furthermore, the Analysis of Covariance (ANCOVA) revealed a significant difference in academic performance between the ISDI and Non-ISDI groups after controlling for pretest scores, demonstrating the effectiveness of ISDI in enhancing students' academic performance. In contrast, no significant difference was found in students' anxiety levels between the two groups, indicating that while ISDI improved cognitive outcomes, its effect on affective variables such as anxiety was limited within the duration of the intervention.

➢ *Conclusions*

- *Based on the Findings of this Study, the following Conclusions are Drawn:*

Based on the findings of the study, it is concluded that students initially possessed minimal academic performance of Physics, highlighting the necessity of innovative instructional strategies.

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The implementation of Interactive Simulation-Driven Inquiry (ISDI) significantly improved students' academic performance by enabling learners to actively engage with abstract Physics concepts through inquiry and simulation-based exploration. ISDI proved effective in promoting academic performance and facilitating meaningful learning experiences.

However, despite the improvement in academic performance, ISDI did not significantly reduce students' anxiety in Physics. This suggests that anxiety is a more stable affective factor that may require sustained interventions, emotional support, and deliberate anxiety-reduction strategies beyond instructional innovation alone. The results further imply that improvements in cognitive learning outcomes tend to occur earlier than observable changes in affective outcomes. Hence, while ISDI is an effective approach for enhancing academic performance, addressing students' anxiety in Physics requires a more comprehensive and long-term approach.

➢ *Recommendation*

In light of the findings and conclusions, it is recommended that Physics teachers integrate Interactive Simulation-Driven Inquiry (ISDI) into classroom instruction to improve students' academic performance, especially when teaching abstract and complex topics. School administrators and curriculum developers may consider incorporating ISDI as a supplementary instructional strategy to support inquiry-based and technology-enhanced learning environments.

To address students' Attitude in Physics, teachers are encouraged to combine ISDI with affective-focused strategies such as collaborative learning, formative feedback, gradual problem scaffolding, and emotional regulation techniques. Professional development programs should be provided to equip teachers with skills in implementing interactive simulations effectively and in managing students' affective needs.

Future researchers may conduct longitudinal studies to examine the long-term effects of ISDI on students' anxiety, explore the integration of ISDI with explicit anxiety-reduction interventions, or apply the approach to other science subjects and educational levels. Lastly, instructional designs should continuously be refined to strengthen students' confidence in problem solving and conceptual integration, thereby supporting both academic achievement and emotional well-being in Physics learning.

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