Improving Students' Performance in Earth Science Through Inquiry-Based Learning and System Model Integration

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ABSTRACT

As modern education seeks to improve students' comprehension of science, innovative teaching approaches like inquiry-based learning (IBL) and system model integration have become essential in promoting student engagement and critical thinking. This research study sought to assess the impact of integrating inquiry-based learning and system model among seventh-grade students, specifically in their Earth Science performance. It was conducted in one of the public schools in Misamis Occidental during the S.Y. 2024–2025. The study employed a one-group pretest-posttest design using a 50-item test to evaluate students' knowledge in Earth Science. Data were analyzed using Minitab software. The results indicated a notable improvement in students' academic performance after the intervention. Prior to the implementation of IBL and the system model, most students performed below the expected level with a relatively low average score. However, the majority of students eventually showed exemplary performance following the intervention, with a marked increase in their average scores. Statistical analysis showed a highly significant difference in students' performance before and after the intervention. This study concludes that integrating IBL and system models into teaching can effectively enhance learning outcomes in Earth Science, providing good support in science education. Hence, further research is encouraged to expand the application of these approaches across different grade levels, extended implementation periods, and other areas in science to generate more meaningful insights and effective learning.

Index Terms — academic performance, critical thinking, Earth Science, inquiry-based learning, system model

INTRODUCTION

The Organization for Economic Cooperation and Development (OECD) administered the Program for International Student Assessment (PISA), which measures students' scientific competence alongside reading and mathematics skills on an international scale (Urdanivia et al., 2023). The increasing incidence of poor academic performance in scientific courses at school could affect students' chances to study at universities and achieve lifelong goals (Rebucas, 2022). From this viewpoint, schools and educational systems worldwide have consistently aimed to enhance the quality of education by promoting scientific literacy through the development of strategies and tools that encourage students' positive attitudes toward science (Simamora et al., 2020).

Science education is a vital component of 21st-century learning, yet it continues to face significant challenges. Many students develop negative attitudes toward the subject, often finding it difficult, abstract, or disconnected from their daily lives (Kalogiannakis et al., 2021). This can lead to disengagement during lessons and a lack of motivation to learn. It has also been argued that students' underperformance in science may stem from a general lack of enthusiasm and interest in the subject (Lim et al., 2023). Additionally, the absence of engaging and student-centered teaching strategies may hinder their ability to understand and appreciate scientific concepts. Hence, students need strong motivation to succeed academically, posing a challenge for teachers to employ effective teaching strategies (Gopalan et al., 2020).

In relation to the existing dilemma which is concerned to science learning, other studies have implemented ways to address this challenge. One of these challenges is the application of educational gamification to the classroom, which uses playful techniques to involve learners, motivate action, and address problems (Manzano et al., 2022). Yet another study suggested that gamified learning should incorporate activities that consistently balance learning and motivation, aligning with specific goals and strategies (Brackenbury & Kopf, 2022).

Building on these approaches to address challenges in science education, this study emphasizes on integrating inquiry-based learning (IBL) and system models. These strategies aim to enhance student interest and engagement by promoting active exploration, problem-solving, and hands-on learning experiences. In this 21st century, there has been a transition from teacher-centered instruction to active learning approach like inquiry-based learning (Ünlü & Dökme, 2020). This learning approach greatly supports student involvement through learning experiences that are authentic, purposeful, and linked to real-life situations (Higde & Aktamis, 2022). IBL is an approach to teaching that employs asking questions and finding out the answers through scientific processes, allowing the students to participate fully in their education and enhance learning outcomes (Gasterland, 2021). Along with this approach, system models are integrated into classroom instruction to help students enhance their understanding of science lessons. Moreover, some studies have found that one of the factors contributing to scientific learning challenges is the prevalence of ineffective teaching practices dominated by traditional approaches (Manishimwe et al., 2023). With this identified concern, this study will implement these two combined approaches that aim to help address the common challenge in science education among the students at the secondary levels. Hence, both IBL and system models can provide valuable solutions to motivation and disengagement in science education by establishing a more meaningful and interactive learning environment.

A gap in practical knowledge seems evident in previous research regarding the integration of IBL and system models in science education. Previous studies lack in depth investigation into the challenges of effectively integrating these approaches in classrooms, particularly regarding the need for strong instructional support and accommodating students' diverse learning needs (Sam, 2024). Many of the previous studies concentrate on the theories about IBL and system models. However, there is a limited number of practical studies or action research projects in the eld of science conducted within classroom contexts (Miles, 2017). Thus, exploring this area is valuable for addressing persistent challenges like student disengagement and lack of motivation.

In teaching science education, a study revealed that utilizing inquiry-based learning approach inside the classroom has boosted students' engagement and has led to a richer conceptual grasp of scientific ideas (Abaniel, 2021). Hence, this research aims to explore the practical application of inquiry-based learning and system models in science education. The scope of the study targets explicitly Grade 7 students in secondary level in one of the public schools in the city, in order to address challenges such as disengagement and low motivation. The study seeks to examine how these approaches can enhance student interest, promote active learning, and promote a deeper understanding of scientific concepts. By focusing on practical implementation, this research aims to bridge the gap between theoretical frameworks and classroom practices, providing educators with actionable strategies to improve learning outcomes and cultivate positive attitudes toward science among seventh-grade students.

Inquiry-Based Learning (IBL) and system models are dynamic pedagogies that bridge theory and practice, enhancing student engagement and learning through active exploration and problem-solving. As student centered approaches, IBL and system models address the needs of 21st-century learners by fostering critical thinking, scientific inquiry, and active participation (Liu et al., 2019). These approaches immerse students in real world, problem-based experiences, allowing them to connect theoretical knowledge with practical application, making them essential tools for modern science education.

IBL and system models improve educational outcomes by encouraging students to investigate, analyze, and solve complex problems (Chang et al., 2020). These methods promote scientific literacy, collaboration, and problem-solving skills as students engage in hands-on activities, design experiments, and apply systems thinking to understand scientific phenomena. Furthermore, IBL and system models have been shown to increase motivation, engagement, and academic performance in science subjects (Hofstein & Rosenfeld, 2021).

The intervention was implemented over six weeks in the Earth Science curriculum using inquiry-based learning

(IBL) and system models. At the beginning of each lesson, the researcher introduced a specific model relevant to the topic to serve as a guide for student exploration. Students were encouraged to ask questions and explore concepts through group activities, where they manipulated mini models to visualize and analyze key ideas. These collaborative tasks helped students apply their learning in meaningful ways, reinforcing both individual understanding and group cooperation.

In a lesson on the layers of the atmosphere, students explored the model by identifying the features and interactions among layers. In another lesson on faults and seismic waves, students were given resources to simulate movements that could trigger earthquakes. They discussed their observations, shared insights, and presented their interpretations through comprehensive reporting. Overall, the intervention promoted active engagement, critical thinking, and deeper understanding of Earth Science concepts through inquiry and model-based learning.

Research Questions:

This action research aimed to improve Grade 7 students' performance in Earth Science through inquiry-based learning and system model integration.

Specifically, this study intended to answer the following research questions:

1. What is the level of academic performance among Grade 7 students in Earth Science prior to the implementation of inquiry-based learning and system model integration?
2. What is the level of academic performance among Grade 7 students in Earth Science after the implementation of inquiry-based learning and system model integration?
3. Is there a significant difference in students' performance in Earth Science before and after the implementation of IBL and system models integration?

METHODS

Research Design

This study utilized a one-group pretest-posttest quantitative design to determine the effectiveness of the intervention. Students' performance in Earth Science was measured before and after the implementation of IBL and system model integration. Comparing the pretest and posttest scores helped determine whether the strategy led to improvements in student performance, providing a clear basis for evaluating its effect on academic achievement. This design was well-suited to the study as it combined measurable engagement data with in-depth qualitative insights, aligning with the research objectives. It was particularly appropriate for exploring the impact of inquiry-based learning combined with system models to enhance students' performance in understanding Earth Science concepts.

Research Setting

The study was carried out in one of the junior high schools in the province of Misamis Occidental. In particular, it was conducted among Grade 7 students from a specific class section. This institution is a complete secondary school, catering to distinct learners from junior to senior high school. Moreover, it provided a diverse learning environment, welcoming students of varying backgrounds.

Respondents of the Study

The study involved forty Grade 7 students from a class handled by the researcher. A purposive sampling technique was applied in identifying the participants. They were selected based on the following criteria: (1) officially enrolled in Grade 7 for the S.Y. 2024 - 2025, (2) observed to need support in science learning, and (3) provided voluntary consent to participate in the study. Prior to the survey, the researcher ensured that all criteria were met, but did not include students from other Grade 7 sections.

Research Instruments

To gather data, the researcher employed the following research instruments:

Test. The instrument was a 50-item test covering the intended topics of Earth Science 7 from the fourth grading period. These topics addressed key concepts such as the sun's influence on Earth and earthquakes, which included the geological types of faults, understanding how natural phenomena begin, and examining their effects on communities. The same set of questions was used for both the pretest and posttest; however, in the posttest, the items were rearranged to prevent memorization. The pretest measured the students' baseline knowledge of Earth Science concepts, while the posttest evaluated the effectiveness of the inquiry-based learning approach with the system model intervention in improving their academic performance in science. The test underwent expert evaluation by the research adviser, cooperating teacher, school head, and principal to verify its content validity. The evaluation focused on content, alignment with the curriculum, clarity of questions, and appropriateness for the target grade level. Moreover, a pilot test was carried out on a separate group of students from other sections. The instrument's reliability was then analyzed using Cronbach's Alpha, and the researcher ensured that it achieved a score between 0.7 and 1.0, indicating acceptable to excellent internal consistency.

In determining the test performance, the following scale was used.

Score	Grade Equivalent	Interpretation
42 – 50	90-100	Outstanding
38 – 41	85-89	Very Satisfactory
34 – 37	80-84	Satisfactory
30 – 33	75-79	Fairly Satisfactory
1 – 29	Below 75	Did not meet expectations

Lesson Plan. The researcher developed several lesson plans centered on Earth Science topics, based on the topic provided by the cooperating teacher. These lesson plans integrated inquiry-based learning activities and system models during science discussions to enhance students' performance in Earth Science. Prior to implementation, the cooperating teacher thoroughly checked the lesson plans, and the researcher revised them accordingly to ensure alignment with the curriculum and achievement of the intended learning goals.

Data Collection

Pre-Implementation Phase. The researcher obtained consent to conduct the study from the dean of the College of Education, the Schools Division Superintendent, the principal, the participating teacher, and the parents of the students. After receiving approval, the researcher provided consent forms to parents and secured assent from students, affirming their voluntary participation in the conduct of the study. Upon securing the necessary forms and approvals, the researcher proceeded with administering a pretest to assess the students' baseline knowledge about Earth Science and related concepts targeted in the study. The researcher also prepared the lesson plans and relevant materials, which included the plan of implementing the IBL approach and utilizing system models to support more effective student learning. Furthermore, corresponding drill activities and quizzes were developed during this phase, which aligned well with the teacher's lesson plans and instructional materials to ensure coherence and effective delivery of the content.

Implementation Phase. The researcher thoroughly discussed the lessons using a crafted system model, while providing inquiry-based learning activities for students to demonstrate in class. Detailed instructions were provided to the students regarding the process and application of the IBL approach and system models in exploring Earth Science concepts. Following a month-long implementation period, a post assessment was conducted to evaluate the conceptual understanding and academic progress of students. The test questionnaire used was the same as the one provided during the pretest. But in the posttest, the researcher rearranged the items to prevent rote memorization. Additionally, the students were assigned a final science project, wherein they selected two lessons from the fourth quarter and created models based on them. Furthermore, they discussed their models thoroughly, demonstrating a clear understanding of the science concepts they had learned.

Post-Implementation Phase. In the post-implementation phase, the researcher collected, tallied, and analyzed the data to interpret the findings and draw conclusions. Based on the results, actionable recommendations were formulated to enhance Earth Science instruction through inquiry-based learning and system models integration. The research report then underwent proofreading, editing, and finalization to ensure accuracy and clarity. Efforts were also made to appropriately disseminate the findings to relevant audiences, such as educators, policymakers, and academic communities. Furthermore, the researcher explored opportunities for follow-up studies, addressed potential limitations, and provided guidance for the practical application of the findings in educational settings.

Ethical Considerations

Research ethics outlines standards for appropriate conduct, ensuring researchers act responsibly and ethically through education and regulation (Jena, 2020). In line with these ethical principles, informed consent from the participants was secured prior to the administration of the survey. The researcher provided the participants with a comprehensive brie ng on the Data Privacy Act of 2012, and they were thoroughly informed about the study's objectives, advantages, as well as the significance of their participation. Furthermore, the researcher guaranteed that all data would be treated with strict confidentiality and that participants' anonymity would be preserved at every stage of the study.

Data Analysis

Using the Minitab software, the researcher utilized the following statistical tools:

Mean and standard deviation were employed to determine the students' average performance and the consistency of their scores before and after the integration of inquiry-based learning (IBL) and system models.

Frequency and Percentage were used to identify the level of students' performance before and after the integration of IBL and system models.

Paired T-test was used to examine whether there was a statistically significant difference in student performance before and after the integration of IBL approach and system models in teaching science concepts.

RESULTS AND DISCUSSIONS

Students' Performance Before the Implementation of Inquiry-Based Learning and System Model Integration

Table 1 shows the performance of students in Earth Science prior to the use of inquiry-based learning and system model integration. The results revealed that the majority of students were struggling, with an average score of (M = 29.10), which falls under the Did Not Meet Expectations category on the defined performance scale. A large portion of the class (n = 23, 57.50%) did not meet the expected level of performance, indicating that some students may have struggled to understand the concepts that were previously covered.

Only a small number of students achieved a Fairly Satisfactory rating (n = 10, 25.00%) or reached the Satisfactory level (n = 7, 17.50%). Notably, no students attained the Very Satisfactory or Outstanding performance levels. This distribution indicates some arising concerns such as a lack of engagement, insufficient instructional alignment with student needs, or limited opportunities for active participation and inquiry.

The data obtained strongly suggest the need for a change in instructional strategies. Since over half of the students performed poorly, it becomes clear that there must be a more interactive and student-centered way of teaching. Herein, an inquiry-based learning and system models encourage students to explore, ask questions, and understand how systems work, skills that are crucial for enhancing educational experiences, particularly in science learning (Sam, 2024).

By employing these more engaging methods into the classroom, teachers can create a learning environment where students are more involved and better supported. These interventions not only help in developing critical thinking but also make learning more meaningful and easier to remember. Training teachers on how to effectively use these approaches can significantly improve students' performance and confidence in Earth Science.

Recent studies support the use of inquiry-based and model-based learning strategies in science education. Using inquiry and modeling approaches promotes deeper understanding and significantly increases the academic achievement of students in science (Kaçar et al., 2021). This is further supported by findings that system-based teaching methods increase student involvement and promote better comprehension of the phenomena related to the main science concepts (Ke et al., 2021). Together, these studies highlight that integrating inquiry-based learning and system models is both timely and grounded in evidence to address learning gaps in science.

The students' performance before the implementation of inquiry-based learning and system model integration indicates that many struggled to understand key Earth Science concepts. More than half of the class did not meet the expected level, revealing challenges in comprehension and engagement that need to be addressed to improve overall performance.

Table 1. Students' Performance Before the Implementation of Inquiry-Based Learning and System Model Integration

Students' Performance	**Frequency**	**Percentage**
Satisfactory	7	17.50
Fairly Satisfactory	10	25.00
Did not Meet Expectations	23	57.50
Overall Performance:	29.10 – Did not Meet Expectations	

Note: Performance Scale: 42-50 (Outstanding); 38-41 (Very Satisfactory); 34-37 (Satisfactory); 30-33 (Fairly Satisfactory); 1-29 (Did Not Meet Expectations)

Students' Performance After the Implementation of Inquiry-Based Learning and System Model Integration

Table 2 shows the performance of students in Earth Science after the implementation of inquiry-based learning and system model integration. The results indicated a notable improvement in the performances of the students, with the overall mean score recorded at (M = 43.95), which falls under the Outstanding category based on the defined performance scale.

A majority of the class (n = 29, 72.50%) achieved an Outstanding rating, while the remaining students (n = 11, 27.50%) reached the Very Satisfactory level. Notably, no students were placed in the lower performance categories, including Satisfactory, Fairly Satisfactory, or Did Not Meet Expectations.

Herein, the obtained data revealed that the intervention had a substantial positive impact on student learning. The consistent high performance across all students points to improved understanding, greater engagement, and more effective learning experiences. The active, student-centered nature of IBL and the use of system models likely contributed to these gains by encouraging deeper thinking, stronger concept connections, and better retention.

Moreover, these findings are supported by earlier studies which emphasized the positive impact of inquiry-based and system model approaches in science education. Incorporating inquiry and system modeling approach revealed how teachers' interventions affect students' self-regulation abilities and academic performance (Abouelenein et al., 2025). Similarly, the systematic design of models based on sound instructional design principles has been shown to effectively support the development of critical thinking (Tiruneh et al., 2023). These findings help explain the high level of achievement observed after the intervention, demonstrating that IBL and system models are an effective approach for improving student performance in Earth Science.

The students' performance after the implementation of inquiry-based learning and system model integration reflects a marked improvement in their understanding of Earth Science concepts. A large majority of the class reached the highest performance levels, with the rest also demonstrating strong achievement. The absence of students in the lower performance categories suggests enhanced comprehension and engagement, pointing to the effectiveness of the instructional shift in addressing previous learning gaps.

Table 2. Students' Performance After the Implementation of Inquiry-Based Learning and System Model Integration

Students' Performance	Frequency	Percentage
Outstanding	29	72.50
Very Satisfactory	11	27.50
Overall Performance:	43.95 – Outstanding	

Note: Performance Scale: 42-50 (Outstanding); 38-41 (Very Satisfactory); 34-37 (Satisfactory); 30-33 (Fairly Satisfactory); 1-29 (Did Not Meet Expectations)

Significant Difference in the Performance of Students Before and After the Implementation of Inquiry-Based Learning (IBL) and System Model Integration in Earth Science

Table 3 presents the comparison of students' performance before and after the use of inquiry-based learning and system model integration in teaching Earth Science. The mean score before the implementation was (M = 29.10), while the mean score after the intervention increased significantly to (M = 43.95), indicating a clear improvement in students' academic performance.

The standard deviation before the intervention was (SD = 3.79), decreasing slightly to (SD = 3.11) afterward, suggesting more consistent performance. The computed t-value was (t = 18.48) and the p-value was (p = 0.000), indicating a highly significant difference, confirming that the improvement in scores resulted from the intervention.

These results showed that the application of IBL and system models had a meaningful impact on student learning, with students achieving higher and more consistent results. The findings support the effectiveness of integrating IBL and system models as evidence-based strategies for improving science learning outcomes.

Educational research confirmed the effectiveness of inquiry-based learning (IBL) and system-based approaches in enhancing science education. IBL significantly improved both student engagement and academic achievement (Dian, 2024). Similarly, system-based learning approaches enhanced conceptual understanding, classroom participation, and creative thinking (Lei et al., 2024). These findings support the integration of IBL and system models as effective, evidence-based strategies for improving science learning outcomes.

The comparison of students' performance before and after the implementation of inquiry-based learning and system model integration showed a clear improvement in their understanding of Earth Science. This implies that engaging students through active exploration and system thinking can effectively address learning gaps and enhance academic performance in a practical and meaningful way. Thus, it is crucial to employ a teaching approach that promotes inquiry activities and introduces real-life phenomena in the classroom (Umamah et al., 2023).

Table 3. Significant Difference in the Performance of Students Before and After the Implementation of Inquiry-Based Learning and System Model Integration in Earth Science

Variables	**M**	**SD**	***T*-value**	***P*-value**
Before the implementation of IBL and SMI	29.10	3.79	18.48***	0.000
After the implementation of IBL and SMI	43.95	3.11		

Note: Probability Value Scale: **p<0.001 (Highly Significant); *p<0.05 (Significant); p>0.05 (Not Significant)

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This action research explored how the integration of inquiry-based learning (IBL) and system models influenced the Earth Science performance of Grade 7 learners. A quantitative approach using a single-group pretest-posttest design was applied to determine changes in academic achievement throughout the intervention period. Data were gathered from 40 students through a researcher-made test that is aligned with the Earth Science curriculum. The intervention involved implementing IBL strategies and utilizing system model techniques across selected lessons.

The data were processed and analyzed using Microsoft Excel, with statistical measures including the mean, percentage, and paired sample t-test to determine the significance of the results. Ethical considerations were observed by securing parental consent and ensuring the confidentiality of student data. The findings revealed a marked improvement in students' academic performance, with most learners progressing from the "Did Not Meet Expectations" level to "Outstanding" after the intervention.

These results support the use of IBL and system models as effective, student-centered teaching approaches that promote active engagement, deeper conceptual understanding, and improved academic outcomes in science education. This study provides practical implications for science teachers seeking to enhance classroom instruction and student achievement through innovative and inquiry-driven strategies.

Findings

The following are the salient findings of the study:

1. Before the implementation of inquiry-based learning (IBL) and system model integration, the majority of Grade 7 students performed poorly in Earth Science. The mean score was (M = 29.10), falling under the "Did Not Meet Expectations" category. Most students (n = 23, 57.50%) did not reach the expected performance level, indicating difficulty in understanding the concepts taught using traditional methods.

2. After the implementation of IBL and system models, there was a remarkable improvement in student performance. The mean score increased to (M = 43.95), which falls under the "Outstanding" category. A large portion of the students (n = 29, 72.50%) achieved an Outstanding rating, and the remaining (n = 11, 27.50%) reached the Very Satisfactory level. No students fell into the lower performance categories.

3. There was a statistically significant difference in student performance before and after the intervention. The computed t-value of (t = 18.48) and p-value of (p = 0.000) indicate a highly significant improvement in scores. This suggests that the use of IBL and system models had a strong positive impact on student learning outcomes in Earth Science.

CONCLUSIONS

Based on the findings, the following conclusions were made:

1. Grade 7 students demonstrate low academic performance in Earth Science prior to the integration of Inquiry-Based Learning (IBL) and system models, indicating a need for more engaging and student-centered instructional strategies.

2. The use of IBL and system models significantly improves student performance, with all learners achieving either Very Satisfactory or Outstanding levels, emphasizing how these approaches positively contribute to students improved conceptual grasp and academic performance.

3. The significant difference between pretest and posttest results confirms that the integration of IBL and system models positively impacted students' learning, proving these methods to be effective tools for improving science education in the classroom.

RECOMMENDATIONS

1. Science educators may consider incorporating Inquiry-Based Learning (IBL) approach and integrating system models into their instructional practices to promote greater student engagement and support deeper understanding of scientific concepts. Starting with selected topics in Earth Science, these approaches can gradually improve the learning experiences through making lessons more interactive, relevant, and student-centered.

2. School leaders and academic coordinators may initiate capacity-building programs such as professional development workshops, lesson studies, or peer mentoring focused on IBL and system modeling. These structured opportunities can equip teachers with practical tools and proven techniques to implement learner-centered instruction effectively.

3. Curriculum developers and subject area specialists may explore the broader application of IBL and system modeling across other science domains and grade levels. Additionally, integrating these approaches into interdisciplinary contexts, such as in Mathematics, TLE, or Social Studies, may further enhance the 21st century skills like problem-solving and critical thinking among students in diverse learning environments.

4. Future researchers may expand this study by applying it to different groups of students and incorporating additional science topics to generate more meaningful insights that can help improve students' academic performance in science.

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