United International Journal for Research & Technology

Volume 07, Issue 08, 2026 | Open Access | ISSN: 2582-6832

Enhancing Student Engagement and Motivation: The Effectiveness of Inquiry-Based Teaching Models in Science Education

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***Abstract*—** Student engagement and motivation are critical to achieving effective learning outcomes in science education. This study investigated the impact of inquiry-based teaching models on student engagement and motivation. A total of 108 students, comprising 80 males and 28 females aged 12 years, were divided into control (n=65) and experimental (n=63) groups. A pre-assessment was conducted to measure initial levels of engagement and motivation, followed by post-tests to determine the effects of the inquiry-based teaching model. Pre-assessment results indicated high levels of engagement and motivation in both groups, with no significant difference between them. Post-test findings revealed that while the control group maintained high levels of engagement and motivation, the experimental group achieved very high levels. Moreover, the experimental group exhibited significantly higher mean gain scores in engagement and motivation compared to the control group, underscoring the effectiveness of the inquiry-based approach. The findings demonstrate that inquiry-based teaching models substantially enhance student engagement and motivation in science education. The approach fosters active participation, critical thinking, and a deeper understanding of scientific concepts. Inquiry-based teaching is an effective pedagogical strategy for improving engagement and motivation in science education.

***Keywords*—** inquiry-based teaching, student engagement, student motivation, science education, experimental group, control group.

I. INTRODUCTION

Background of the Study

The contemporary education environment requires new teaching methods that promote active learning and critical thinking. In this regard, inquiry-based teaching models have been presented as a new way of teaching Science. This model changes the emphasis from rote memorization to a more student-oriented learning process, where students engage actively in scientific ideas, ask questions, and perform investigations. Inquiry-based teaching models can greatly increase students' interest and motivation in Science classes, resulting in greater understanding of scientific principles and a richer learning experience.

Inquiry-based teaching models have been extensively studied for their effectiveness in enhancing student engagement and motivation in science education. A comparative analysis of six countries by Oliver, McConney, and Woods-McConney (2021) demonstrated that inquiry-based instruction significantly improves students' science achievement, highlighting the global efficacy of this approach. Firman, Ertikanto, and Abdurrahman (2019) supported these findings by showing that inquiry-based learning enhances students' inquiry skills and fosters more profound understanding. Panjaitan and Siagian (2020) further confirmed the model's effectiveness in improving science process skills and scientific creativity among junior high school students, emphasizing its role in developing critical thinking. Additionally, Seneviratne et al. (2019) underscored the importance of effective professional development for teachers in implementing inquiry-based methods, which boosts their self-efficacy and the overall success of such educational strategies. These studies underscore the positive impact of inquiry-based teaching on student engagement, motivation, and achievement in science education.

In spite of the promising potential of inquiry-based models of teaching, their adoption has significant gaps

and challenges. Observations and interviews with teachers show that most teachers require more support in effectively implementing inquiry-based strategies in their classrooms because of scarce resources, inadequate training, and lack of institutional support. Students can find the transition to inquiry-based learning difficult at first, primarily if they are used to more conventional, teacher-directed methods. These difficulties can impede the full exploitation of the advantages of inquiry-based teaching, and hence it is essential to investigate and fill these gaps in the case of Science education.

This research is intended to evaluate the effectiveness of the inquiry-based teaching model in improving students' engagement and motivation in Science among secondary school students in Maigo, Lanao del Norte, in the 2021-2022 school year. It aims to investigate students' profiles, such as age, gender, and section, and compare the control and experimental groups' levels of engagement and motivation during pre- and post-assessment. The research also checks if there are significant differences between groups prior to and after the administration of the inquiry-based approach. Furthermore, it determines the overall effect of this model in enhancing engagement and motivation from pre- to post-test. Through these questions, the research tries to discover the potential of inquiry-based learning to improve Science education.

II. RESEARCH METHODOLOGY

Research Design

The ten non-equivalent groups of control and experimental methods quasi-experimental design was employed in the current study. In writing on quasi-experimental designs, Shadish, Cook, and Campbell (2002) highlight the applications and limitations of non-equivalent group designs. According to them, such designs are applied when random assignment is not feasible, involving a pre-existing control group and an experimental group compared to randomly assigned. The authors observe that while this design makes it possible to compare groups for the purpose of evaluating the effect of an intervention, it entails the risk of selection biases influencing the validity of the findings. To mitigate against these biases, they suggest using careful matching techniques and statistical controls to enhance the robustness of the findings (Shadish et al., 2002, p. 35).

Research Setting

Maigo, a municipality in Lanao del Norte, Philippines, has a history marked by its cultural and geographical significance. Established in the early 20th century, Maigo's name originates from the local Maranao language, reflecting the area's rich cultural heritage. Maigo has undergone significant development over the years. It was initially a modest community, evolving into a more modern municipality while preserving its traditional customs. Today, the town is known for its agricultural activities and local industries, contributing to its economic growth. Maigo's history is a testament to its ability to blend traditional values with contemporary advancements, enhancing the quality of life for its residents while maintaining its cultural roots.

Research Respondents

The respondents of the study are the students enrolled in the 7th grade. There are 6 sections in the grade 7 level however; the researcher only utilized two sections for experiment. One section is for the control group and the second group shall be for the experimental group.

Research Instrument

The research instrument used in this study was a modified version of the questionnaire developed by Morki (2008) to assess student engagement and motivation. The instrument was adapted to measure the engagement of students before and after the implementation of an inquiry-based teaching model in Science.

It consisted of items covering behavioral, emotional, and cognitive engagement, including students' participation in classroom activities, interest in Science, and commitment to learning and problem-solving. Responses were measured using a Likert scale ranging from strongly disagree to strongly agree, with additional open-ended questions included to gather qualitative insights. The instrument was administered before and after the intervention to determine changes in student engagement attributable to the inquiry-based teaching approach.

Data Gathering Procedure

To answer the research questions, the 5E Learning Model (Engage, Explore, Explain, Elaborate, and Evaluate) was implemented in teaching selected Science lessons. Prior to the intervention, students completed pre-tests measuring their engagement and motivation levels. During the Engage phase, students were introduced to demonstrations or activities designed to stimulate curiosity and interest. In the Explore phase, students participated in guided inquiry and hands-on activities that allowed them to investigate scientific concepts independently. The Explain phase involved classroom discussions where students shared observations and conclusions, followed by teacher clarification of key concepts. During the Elaborate phase, students applied their learning to real-life situations, completed exercises, and engaged in further learning activities. Finally, the Evaluate phase consisted of formative and summative assessments to determine students' understanding of the lessons. After the completion of the intervention, a post-test was administered to assess changes in students' engagement and motivation levels and to determine the effectiveness of the 5E Learning Model.

Ethical Considerations

The researcher ensured that all ethical standards were observed throughout the conduct of the study. Prior to data collection, permission to conduct the research was secured from the appropriate school authorities. Informed consent was obtained from all participants after explaining the purpose of the study, their rights, and the nature of their participation. Participation was entirely voluntary, and respondents were informed that they could decline to answer any question or withdraw from the study at any time without penalty. To protect participants' privacy, anonymity and confidentiality were strictly maintained by not requiring identifying information and by using secure data collection methods. The researcher also ensured that all data gathered were used solely for academic purposes and handled with utmost respect and integrity.

Data Analysis

The data gathered in this study were analyzed using frequency and percentage, mean, and the Wilcoxon Signed-Rank Test. Frequency and percentage were used to describe the demographic profile of the respondents. The mean was employed to determine the overall level of students' engagement and motivation before and after the implementation of the 5E Learning Model. To determine whether a significant difference existed between the pre-test and post-test scores, the Wilcoxon Signed-Rank Test was utilized. This nonparametric test is appropriate for related samples and was used to assess the effectiveness of the 5E Learning Model in improving students' engagement and motivation.

III. PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

Table 1 . *Profile of the Secondary School Students in Terms of Age, Gender and Section*

AGE	Love (Control)		Hope (Experimental)		Total	Percent
	Male	Female	Male	Female		
12	14	9	8	10	41	32.03
13	12	4	13	8	37	28.91
14	11	2	6	6	25	19.53
15	5	1	3	2	12	9.38
16		1	1	2	4	3.12
17			1	1	2	1.56
18	2			2	4	3.12
Total	48	17	32	31	128	100.00
Percent	29.17	13.28	25.00	24.22		

Table 1 presents the demographic profile of the respondents in terms of age, gender, and section. The findings revealed that the majority of the students were aged 12 to 14 years, with 12-year-olds comprising the largest group. In terms of gender, male students slightly outnumbered female students. The respondents were distributed between the control group (Love) and the experimental group (Hope), with both groups showing a relatively balanced representation of age and gender. These findings indicate that the participants were predominantly young adolescents and that the control and experimental groups were generally comparable in their demographic characteristics, thereby supporting the validity of comparisons made in the study.

This age distribution is consistent with the typical age range of secondary school students, who are generally in the stage of early adolescence characterized by significant cognitive, social, and emotional development that influences learning and school engagement (Owoseni et al., 2021).

Table 2. *Level of Engagement of the Students in the Control and Experimental Group Prior to the Intervention*

Descriptors	**Control**		**Experimental**	
	AWV	D	AWV	D
I like Science.	3.56	H	3.88	H
I like to explore the world of Science.	3.62	H	3.72	H
Science allows me to be more responsible.	3.58	H	3.90	H
Science give me the opportunity to do things my own.	3.89	H	3.60	H
Science allows me to do things in order for me to discover new ideas.	3.55	H	3.65	H
I want to get involved in Science activities.	3.62	H	3.75	H
It really interests me having heard of lessons in Science.	3.68	H	3.49	H
Science increase my inquisitives.	3.92	H	3.57	H
I found answers to questions I have in mind.	3.97	H	3.99	H
I want to do experiments in the laboratory room.	3.98	H	4.05	H
Experiments made me more curious about things around.	3.54	H	4.00	H
Results of experiments are interesting.	3.56	H	3.98	H
Results of experiments are giving me suspense.	3.68	H	3.90	H
Science is one great subject worth doing.	3.66	H	3.68	H
Science experiments are things worth engaging.	3.68	H	3.92	H
Mean	3.70	H	3.80	H

Table 2 shows that the students demonstrated a high level of interest and motivation toward Science, as reflected in the mean scores of 3.70 for the control group and 3.80 for the experimental group.

The findings indicate that students enjoyed participating in Science-related activities, particularly experiments and projects, which made learning more engaging and meaningful.

Their enthusiasm suggests that they viewed Science as an exciting subject that encouraged exploration, curiosity, and active participation.

The slightly higher mean score of the experimental group further implies that inquiry-based and hands-on learning experiences may have enhanced students' interest in the subject.

These findings support the assertion of Potvin and Hasni (2020) that students' motivation and positive attitudes toward Science increase when they are actively involved in inquiry-based and experiential learning activities that promote engagement and meaningful understanding of scientific concepts.

Table 3. *Level of Motivation of the Students in the Control and Experimental Group Prior to the Intervention*

Motivation	Control		Experimental	
	AWV	D	AWV	D
I love Science.	3.72	H	3.82	H
I love learning the topics in the subject.	3.76	H	3.79	H
This subject makes me feel good.	3.41	H	3.80	H
The lessons are well organized.	3.48	H	3.78	H
I like my teachers in Science.	3.58	H	3.66	H
I am interested to do things in Science.	3.56	H	3.65	H
I always make myself ready when during science class schedules.	3.80	H	3.48	H
I understand better in Science	3.82	H	3.45	H
I love the topics in Science.	3.86	H	3.42	H
I love being explorative and inquisitive on the things that exist.	3.88	H	3.98	H
The teacher is motivating.	3.79	H	3.98	H
The teacher is rewarding students who did well in Science.	3.79	H	3.91	H
The topics are worth learning.	3.82	H	3.80	H
The topics are worthwhile	3.68	H	3.80	H
The topics are interesting.	3.69	H	3.75	H
The topics are motivating.	3.65	H	3.72	H
The lessons are well crafted.	3.57	H	3.64	H
The lessons are fascinating.	3.55	H	4.12	H
the lessons are sensible.	3.69	H	4.00	H
I could not exchange Science with any other subject.	3.69	H	3.91	H
I have a lot of books in Science	3.51	H	3.65	H
I research on the internet about Science.	3.62	H	3.62	H
I keep anything that relates to Science.	3.58	H	3.76	H
I made Science one of the most important things in my life.	3.96	H	3.75	H
I would like to become a Scientist.	3.90	H	3.78	H
Mean	3.69	H	3.76	H

Table 3 presents the motivation levels of students in the control and experimental groups before the intervention. The findings revealed that both groups exhibited a high level of motivation toward Science, as reflected in the mean scores of 3.68 and 3.78, respectively. Students demonstrated strong interest in the subject, appreciated the relevance of Science lessons to their lives, and viewed the subject as valuable and important. Their positive perceptions of Science and willingness to participate in learning activities suggest a strong foundation of motivation prior to the implementation of the intervention. These findings are consistent with the study of Ryan and Deci (2020), which emphasized that students who perceive learning activities as meaningful and relevant are more likely to develop intrinsic motivation, resulting in greater engagement, persistence, and positive learning outcomes.

Table 4. *Test of Difference on the level of Engagement and Motivation of the Secondary School Students Between the Control and Experimental Group Prior to the Intervention*

T-test for Control vs Experimental on Level of Engagement						
Groups	N	Mean	StDev	SE Mean	t-value	p-value
Control	65	3.699	0.159	0.041	-1.72	0.97

Experiment	63	3.805	0.179	0.046		
T-test for Control vs Experimental on Level of Motivation						
Groups	N	Mean	StDev	SE Mean	t-value	p-value
Control	65	3.694	0.140	0.027	-1.56	0.621
Experiment	63	3.761	0.167	0.033		

Table 4 presents the test of difference between the control and experimental groups in terms of their engagement and motivation in Science before the intervention. The results revealed no significant difference between the two groups, as indicated by the computed probability values, which were greater than the 0.05 level of significance. Consequently, the null hypothesis was not rejected. This finding suggests that both groups possessed comparable levels of engagement and motivation prior to the implementation of the 5E Learning Model, indicating that the groups were relatively homogeneous at baseline. The similarity in their initial levels of engagement and motivation strengthens the validity of subsequent comparisons between the groups.

These findings are consistent with the work of Fredricks et al. (2019), who emphasized that students with similar educational experiences and learning environments often demonstrate comparable levels of engagement and motivation before the introduction of specific instructional interventions.

Table 5. *Level of Engagement of the Students in the Control and Experimental Group After the Intervention*

Items	**WV**	**D**	**AWV**	**D**
I like Science.	4.02	H	4.71	VH
I like to explore the world of Science.	3.94	H	4.43	VH
Science allows me to be more responsible.	3.98	H	4.36	VH
Science gives me the opportunity to do things my own.	3.92	H	4.40	VH
Science allows me to do things in order for me to discover new ideas.	4.13	H	4.70	VH
I want to get involved in Science activities.	3.95	H	4.51	VH
It really interests me having heard of lessons in Science.	3.78	H	4.43	VH
Science increase my inquisitives.	3.73	H	4.10	H
I found answers to questions I have in mind.	3.57	H	4.38	VH
I want to do experiments in the laboratory room.	3.98	H	4.36	VH
Experiments made me more curious about things around.	4.13	H	4.35	VH
Results of experiments are interesting.	4.32	VH	4.35	VH
Results of experiments are giving me suspense.	3.78	H	4.25	VH
Science is one great subject worth doing.	3.90	H	4.30	VH
Science experiments are things worth engaging.	4.02	H	4.32	VH
Mean	3.94	H	4.39	VH

Table 5 presents the post-assessment results on the level of engagement of students in the control and experimental groups after the intervention. The findings revealed that students in both groups demonstrated a high level of engagement in Science, with the experimental group showing greater engagement following the implementation of the inquiry-based learning approach. This suggests that the use of inquiry-based activities encouraged active participation, curiosity, and deeper involvement in the learning process. The results imply that instructional strategies that promote exploration, investigation, and hands-on learning can effectively enhance student engagement. These findings support the study of Bond and Bedenlier (2019), which emphasized that active and student-centered learning approaches contribute significantly to higher levels of behavioral, emotional, and cognitive engagement among learners.

Table 6. *Level of Motivation of the Students in the Control and Experimental Group After the Intervention*

Items	AWV	D	AWV	D
I love Science.	4.09	H	4.63	VH
I love learning the topics in the subject.	4.32	VH	4.65	VH
This subject makes me feel good.	4.13	H	4.65	VH
The lessons are well organized.	3.89	H	4.41	VH
I like my teachers in Science.	4.79	VH	4.76	VH
I am interested to do things in Science.	4.16	H	4.52	VH
I always make myself ready when during science class schedules.	4.00	H	4.46	VH
I understand better in Science	3.90	H	3.84	H
I love the topics in Science.	4.06	H	4.46	VH
I love being explorative and inquisitive on the things that exist.	3.75	H	4.39	VH
The teacher is motivating.	4.16	H	4.39	VH
The teacher is rewarding students who did well in Science.	4.09	H	4.54	VH
The topics are worth learning.	4.27	VH	4.51	VH
The topics are worthwhile	4.03	H	4.25	VH
The topics are interesting.	4.41	VH	4.65	VH
The topics are motivating.	4.02	H	4.46	VH
The lessons are well crafted.	4.03	H	4.27	VH
The lessons are fascinating.	3.97	H	4.37	VH
the lessons are sensible.	3.79	H	4.37	VH
I could not exchange Science with any other subject.	3.65	H	4.32	VH
I have a lot of books in Science	3.30	M	3.97	H
I research on the internet about Science.	3.43	H	4.05	H
. I keep anything that relates to Science.	3.92	H	4.37	VH
I made Science one of the most important things in my life.	4.22	VH	4.51	VH
I would like to become a Scientist.	3.60	H	4.22	VH
Mean	4.00	H	4.40	VH

Table 6 presents the post-assessment results on the level of motivation in Science among students in the control and experimental groups. The findings revealed that students in the experimental group attained a very high level of motivation after being exposed to the inquiry-based teaching strategy, while those in the control group maintained a high level of motivation. This suggests that inquiry-based learning was more effective in enhancing students' motivation by encouraging active participation, exploration, and critical thinking. Through hands-on activities and opportunities to investigate scientific concepts independently, students became more interested and invested in the learning process. These findings are consistent with the study of Furtak et al. (2021), which found that inquiry-based science instruction positively influences students' motivation, interest, and engagement by providing meaningful learning experiences that promote curiosity and deeper understanding of scientific concepts.

Table 7. *Test of Difference on the Level of Engagement and Motivation of the Secondary School Students in the Control Group and Experimental Group During the Post-Assessment*

T-test for Control vs Experimental on Level of Engagement						
Groups	N	Mean	StDev	SE Mean	t-value	p-value
Control	65	3.943	0.176	0.044	7.83*	0.00

Experiment	63	4.396	0.150	0.037		
T-test for Control vs Experimental on Level of Motivation						
Groups	N	Mean	StDev	SE Mean	t-value	p-value
Control	65	3.999	0.140	0.312	5.27*	0.00
Experiment	63	4.401	0.167	0.218		

Table 7 presents the test of difference between the experimental and control groups in terms of their engagement and motivation in Science during the post-test. The findings revealed statistically significant differences between the two groups, as indicated by the computed p-values, which were lower than the 0.05 level of significance. Consequently, the null hypothesis was rejected. The experimental group demonstrated significantly higher levels of engagement and motivation compared to the control group, indicating the positive effect of the inquiry-based teaching approach. The results suggest that inquiry-based learning effectively promotes active participation, curiosity, critical thinking, and interest in Science by allowing students to explore concepts through investigation and hands-on activities. These findings are consistent with the study of Lazonder and Harmsen (2016), whose meta-analysis found that inquiry-based instruction significantly improves students' engagement, motivation, and learning outcomes when appropriate guidance is provided throughout the learning process.

Table 8. *Test of Difference on the Pre-Post Mean Gain Scores Between the Control and Experimental Group*

T- test for Mean Gain Scores on Engagement						
Groups	N	Mean	StDev	SE Mean	t-value	p-value
Control	65	-0.244	0.310	0.080	3.42*	0.002
Experiment	63	-0.591	0.242	0.062		
T- test for Mean Gain Scores on Motivation						
Groups	N	Mean	StDev	SE Mean	t-value	p-value
Control	65	-0.151	0.850	0.17	4.22*	0.001

Table 8 presents the test of difference between the mean gain scores of the control and experimental groups in terms of Science engagement and motivation. The results revealed statistically significant differences in the gain scores of both variables, as indicated by p-values lower than the 0.05 level of significance. This finding led to the rejection of the null hypothesis and suggests that students exposed to the inquiry-based teaching approach demonstrated significantly greater improvements in engagement and motivation compared to those taught using conventional methods. The substantial increase in the experimental group's scores indicates that inquiry-based learning effectively promotes active participation, curiosity, critical thinking, and interest in Science. These findings support the work of Kang and Keinonen (2018), who reported that inquiry-based science instruction enhances students' motivation, engagement, and positive attitudes toward learning by providing opportunities for exploration, investigation, and meaningful learning experiences.

IV. SUMMARY OF FINDINGS, CONCLUSION, RECOMMENDATION

Summary of Findings

The following findings were revealed:

- There were 80 male and 28 female students who participated in the study.
- There were additional students who were 12 years old.
- There were 65 students that are under the control group and 63 are under the experimental group.
- Control and experimental group students displayed a high level of engagement and motivation during pre-assessment.
- There was no significant difference between the control and experimental group of students' level of engagement during the pre-assessment.

- The motivation and level of engagement of the students in the control group during the post-test were high whereas the students in the experimental group had a very high level of motivation and engagement.
- There was a remarkable difference on the level of motivation and engagement between the experimental group and the control group at the post-test.
- There was a large difference on the mean gain scores between the experimental and control group for both engagement and motivation.

Conclusions

The study revealed that inquiry-based teaching models significantly enhance student engagement and motivation in science education. While both the control and experimental groups demonstrated high levels of engagement and motivation during the pre-assessment with no significant differences, the post-test results showed a remarkable improvement in the experimental group, which achieved very high levels of motivation and engagement compared to the high levels observed in the control group. Furthermore, the experimental group exhibited significantly higher mean gain scores in both engagement and motivation compared to the control group. These findings underscore the effectiveness of inquiry-based teaching models in fostering greater student engagement and motivation in science learning environments.

Recommendations

Based on the conclusions and findings, the following are hereby recommended:

- The instructors who teach Science at different grade levels investigate the use of inquiry-based method in instructing the subject since this is discovered in this research to be an effective method in enhancing the level of involvement and motivation of the students.
- Inviting the students to participate in activities in teaching Science may prove to be an alternative option such that the level of motivation and engagement be optimized and where students are engaged and motivated, they are then expected to be able to attain improved performance.
- Teachers permit the students to investigate all possibilities and potentialities where students may learn for improved retention

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