The Mediating Effect of Inquiry-Based Instruction on Science Motivation and Student Engagement

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ABSTRACT

This study focused on science motivation, student engagement, inquiry-based instruction, and the role of inquiry-based instruction in students' science motivation and engagement. The study adopted a quantitative correlational design, and revealed high level of science motivation, engagement and inquiry-based teaching by the students. Inquiry-based instruction and student engagement were significantly and positively correlated with science motivation, and there was a significant relationship between inquiry-based instruction and engagement. The results of the mediation analysis showed that, inquiry-based instruction partially mediated between science motivation and student engagement. The direct effect of motivation was still significant along with an indirect effect that passed through inquiry-based instruction was still significant with a Sobel test. The findings reflect the significance of integrating inquiry-based strategies to boost students' motivation and engagement, noting that the implementation of inquiry-based strategies has the potential to improve science learning outcomes as the children's learning is centered on their own learning process.

Keywords: science motivation, student engagement, inquiry-based instruction, mediation analysis, science education

INTRODUCTION

Current challenges in science education involve preparing students to be scientifically literate, critical-thinking, and actively engaged in solving real-life problems (National Research Council, 2000). To address these demands, the K to 12 Basic Education Curriculum of the Philippines emphasizes student-centered and inquiry-based learning as important strategies for teaching science at the Senior High School (SHS) level, especially in a context as Grade 12 in Maramag II District, Maramag, Bukidnon (DepEd, 2016). In this sense, learners should not only learn the concepts, but also show curiosity, persistence and the involvement in scientific research and investigation (National Research Council, 2000; Pedaste et al., 2015).

Student engagement is an important factor in addressing learning outcomes within secondary and tertiary education and is also believed to underpin student success and motivation (Kahn, 2014; Boulton, Kent, & Williams, 2019). Student engagement has been described as the combination of internal and external motivation together with the active commitment and purposeful effort that students apply toward all aspects of their learning (Rajan et al., 2024). Previous studies have shown that engagement is closely related to academic success, especially in traditional face-to-face learning environments, and recent works highlight that students' intrinsic and extrinsic motivations and the ways they engage with content changed notably during and after the COVID-19 pandemic (Mukhtar et al., 2020; Dzaniels et al., 2021; Rincon-Flores et al., 2022; Rajan et al., 2024). It is therefore essential to recognize the factors that have led to student disengagement in both pre- and post-COVID-19 periods, as recent studies point to a continuing gap in how to effectively support student engagement after the "COVID-19 learning disruption," when modes of delivery and classroom dynamics have changed dramatically (Mukhtar et al., 2020; Daniels et al., 2021). Many educators observe that the pandemic has made visible how easily students can feel detached from their learning environments, emphasizing the need for proactive strategies to address engagement now and in the future (Rincon-Flores et al., 2022; Rajan et al., 2024).

Inquiry-based Instruction (IBI) is now considered an essential part of science teaching and science education more broadly (National Research Council, 2000; Pedaste et al., 2015). Inquiry has been defined as the set of thinking and interpretive methods that scientists use to analyze nature and to evaluate evidence as the basis of scientific work (Azizoğlu, 2022). In inquiry-based science education, learners are engaged in many of the same activities and thinking processes that scientists use to produce new knowledge, such as asking questions, designing investigations, analyzing data, and constructing explanations (Abdi, 2014). In principle, this kind of instruction should foster both motivation and engagement; however, research explicitly linking inquiry-based learning and student engagement remains more limited than research on other forms of instruction (Weatley, 2018). The COVID-19 pandemic further complicated this picture by shifting instruction from face-to-face to various forms of distance and blended learning (online, modular, or mixed), which affected learners' motivation and perceptions of their learning experiences (Beboso & Bual, 2022; Mukhtar et al., 2020). Motivation is a multidisciplinary construct that encompasses students' thoughts, emotions, and actions, shaping how they approach tasks, regulate their emotions, and participate in classroom activities (Ryan & Deci, 2017).

In science learning, motivation is the driving force that orients students toward successful acquisition of concepts and skills; it involves building psychological bonds with learning, sustained participation, and the behavioral development needed for academic accomplishment (Thohir, 2017; Beboso & Bual, 2022). Various studies in the Philippines have examined students' motivation, self-directed learning, self-efficacy, and learning strategies, reflecting sustained interest in understanding why some students persist and thrive while others disengage (Beboso & Bual, 2022; Anderman & Anderman, 2010).

Previous studies consistently demonstrate that science motivation is positively associated with student engagement. Students who are highly motivated in science are more likely to participate actively in classroom discussions, persist when faced with challenging learning tasks, and invest greater cognitive effort in understanding scientific concepts. Guay (2022) explained that students with higher autonomous motivation demonstrate greater behavioral, emotional, and cognitive engagement because they willingly participate in learning activities and remain committed to achieving meaningful learning outcomes. Similarly, students who are more motivated in science tend to be more engaged in the classroom and also more persistent in their studies, achieving better learning outcomes (Areepattamannil et al., 2023; Lacoste & Carreon, 2025). These results facilitate the assumption that motivated students are more likely to get involved in science learning, thus science motivation is an important predictor of student engagement.

There is also other research that suggests that science motivation is closely related to inquiry-based teaching. Inquiry-based learning encourages students to ask questions, investigate scientific phenomena, construct explanations, and communicate evidence-based conclusions, all of which require curiosity, persistence, and active participation. Recent studies have shown that inquiry-based instructional approaches enhance students' motivation by providing opportunities for exploration, collaboration, and authentic problem-solving experiences that promote meaningful learning (Stieha et al., 2024; Edillor & Mongas, 2025). Students who possess higher levels of science motivation are more willing to participate in inquiry-oriented activities, persist during scientific investigations, and engage in higher-order thinking tasks. Consequently, science motivation strengthens students' responsiveness to inquiry-based instructional practices, inquiring an effective learning approach for motivated learners.

Several recent studies have likewise established a positive relationship between inquiry-based instruction and student engagement. Inquiry-based instruction promotes active participation by encouraging learners to investigate authentic scientific problems, analyze evidence, collaborate with peers, and communicate their findings. Recent systematic reviews have concluded that inquiry-based science instruction significantly enhances students' behavioral, emotional, and cognitive engagement while fostering critical thinking, scientific reasoning, and meaningful participation in classroom learning (Gomez, 2025). Similarly, recent educational studies have found that inquiry-oriented learning environments encourage learners to become more engaged by allowing them to actively construct knowledge through investigation and evidence-based reasoning (Ligutom & Ocdenaria, 2025). Collectively, these findings provide strong empirical evidence that inquiry-based instruction contributes significantly to improving student engagement in science education.

This study is anchored on Self-Determination Theory (SDT), originally developed by Deci and Ryan and recently discussed by Guay (2022). Self-Determination Theory explains that students are more likely to become motivated and actively engaged in learning when their basic psychological needs for autonomy, competence, and relatedness are satisfied. Autonomy refers to students' ability to make meaningful choices in their learning; competence refers to their confidence in successfully completing learning tasks, and relatedness pertains to their sense of connection with teachers and peers. Recent educational research has highlighted that learning contexts that foster these psychological needs lead to more students' autonomous motivation, engagement in class, persistence and academic engagement (Guay, 2022; Howard et al., 2021).

In the context of the present study, Self-Determination Theory provides the theoretical explanation for the relationship among science motivation, inquiry-based instruction, and student engagement. Students who possess high science motivation are more likely to become actively engaged when inquiry-based instructional strategies provide opportunities to ask questions, conduct investigations, solve authentic scientific problems, and collaborate with their classmates. These inquiry experiences support students' autonomy through independent exploration, competence through the development of scientific knowledge and skills, and relatedness through meaningful classroom interactions. Therefore, the researcher believes that inquiry-based instruction serves as an important mechanism that translates students' science motivation into higher levels of behavioral, emotional, and cognitive engagement. Thus, Self-Determination Theory serves as the primary theoretical foundation of this study.

Expectancy-Value Theory explains that students' motivation and engagement depend on two important beliefs: their expectation of succeeding in a task and the value they attach to completing that task. Students who believe they can perform well and perceive learning activities as useful, interesting, or relevant are more likely to demonstrate persistence, effort, and active participation in learning (Wigfield et al., 2021). In science education, learners who recognize the value of scientific knowledge in their daily lives and future careers are more likely to become motivated and actively engaged in classroom activities. In this study, the theory supports the relationship between science motivation and student engagement by explaining that motivated students are more willing to participate in inquiry-based science learning because they recognize its importance and believe they can succeed.

Achievement Goal Theory proposes that students' learning behaviors are influenced by the goals they pursue during academic tasks. Learners with mastery goals are more interested in learning and gaining knowledge, building competence, than in demonstrating their competence in relation to others, while those with performance goals are more interested in demonstrating their competence in relation to others. Recent research has shown that mastery-oriented goals are associated with greater intrinsic motivation, persistence, and classroom engagement (Senko & Dawson, 2022). In the context of the present study, the Achievement Goal Theory can be integrated with the notion that when students are motivated to increase their scientific understanding, they are more likely to be involved in an inquiry-based activity and to continue with the process of learning. Although Self-Determination Theory emphasizes students' psychological needs and Achievement Goal Theory focuses on the goals they pursue, these perspectives complement one another by explaining both the development of students' motivation and how that motivation is translated into active engagement through inquiry-based instruction,

The concept of student engagement is complex, consisting of behavioral, emotional, and cognitive dimensions. Behavioral engagement refers to participation and on-task behavior; emotional engagement includes interest, enjoyment, and sense of belonging; cognitive engagement involves effortful, strategic, and deep approaches to learning (Fredricks, Blumenfeld, & Paris, 2004). Positive and supportive teacher–student relationships, as well as a safe and inclusive school climate, have been proven to strengthen engagement by enhancing students' feelings of connection, value, and respect in the learning community (Skinner, Kindermann, & Furrer, 2009; Finn & Rock, 1997). When students experience such support, they are more likely to participate actively, persist with challenging tasks, and invest cognitively in learning (Fredricks et al., 2004; Skinner et al., 2009).

Another supporting theory of this study is John Dewey's Experiential Learning Theory, which emphasizes that meaningful learning occurs through active participation, inquiry, and reflection rather than passive reception of information (Dewey, 1938). Learners build knowledge by investigating authentic problems, reflecting on their

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experiences, and applying, Dewey writes. How they have applied what they have learned in new situations. Dewey's philosophy is still being acknowledged recently in the literature as one of the principles of inquiry-based learning, where inquiry-based science education fosters active knowledge construction, thinking, collaboration, and deepening of concepts based on authentic investigations and evidence-based reasoning (Strat et al., 2024; Urdanivia Alarcon et al., 2023). Dewey's Experiential Learning Theory justifies the role of inquiry-based instruction as the mediating variable in the context of the present study based on the assumption that the meaningful learning experience of learners through inquiry can mediate in the learning process. To increase students' motivational state in science into behavioral, emotional and cognitive involvement. Based on this, the researcher thinks that by giving learners opportunities to investigate scientific questions, reflect on the results of their investigation, and discuss the results with peers, science learning motivation will be strengthened, and it will be easier for them to be engaged.

In classrooms such as senior high school level as in Maramag II district, the relationship between the three factors, namely inquiry-based learning, the motivation of science learning, and student involvement is not always simple (Pedaste et al., 2015; Abdi, 2014). Some students remain passive or disengaged even when teachers introduce inquiry activities, which suggests that inquiry-based instruction may not automatically translate motivation into engagement (Weatley, 2018; Beboso & Bual, 2022). The way students experience inquiry—the level of scaffolding, relevance, challenge, and support— may play a mediating role in determining whether motivated students actually participate, persist, and think deeply in science tasks (Pedaste et al., 2015; Linn et al., 2004).

Although previous studies have examined science motivation, inquiry-based instruction, and student engagement as separate constructs (Pedaste et al., 2015; Beboso & Bual, 2022; Rajan et al., 2024), limited studies have explored the mediating role of inquiry-based instruction in explaining how science motivation influences student engagement, particularly among Grade 12 senior high school students in public schools in Maramag II District, Bukidnon. This gap limits the understanding of how inquiry-based instructional practices facilitate the translation of students' motivation into meaningful classroom engagement within the local educational context (Abdi, 2014; Pedaste et al., 2015). Therefore, there is a need to examine the mediating effect of inquiry-based instruction on science motivation and student engagement to provide evidence that may guide science teachers in designing more engaging and learner-centered instructional practices.

The present study is *"The Mediating Effect of Inquiry-Based Instruction on Science Motivation and Student Engagement"* was conducted to find out the mediating effect of inquiry-based instruction on the relationship between science motivation and student engagement of senior high school students in Grade 12 at Maramag II District, Maramag, Bukidnon. Specifically, it seeks to determine the level of science motivation, the level of inquiry-based instruction, and the level of student engagement among the respondents. It also aims to determine the significant relationships among science motivation, inquiry-based instruction, and student engagement, and to determine whether inquiry-based instruction significantly mediates the relationship between science motivation and student engagement. These objectives aim to provide a deeper understanding of how inquiry-based instructional practices influence the relationship between students' motivation and engagement in science learning.

By achieving these objectives, the study aims to provide valuable insights into science motivation and student engagement by allowing students to use their creativity and critical thinking to develop new approaches in science classrooms, thereby informing educators and policymakers on how to build learning environments that genuinely support active, motivated, and engaged learners (Anderman & Anderman, 2010; Linn et al., 2004). Taken together, these theories provide a unified explanation of how science motivation can lead to greater student engagement through the use of inquiry-based instruction. Drawing from these theories, the study proposes that students with stronger science motivation are more likely to engage in inquiry-based learning, which in turn promotes higher levels of student engagement.

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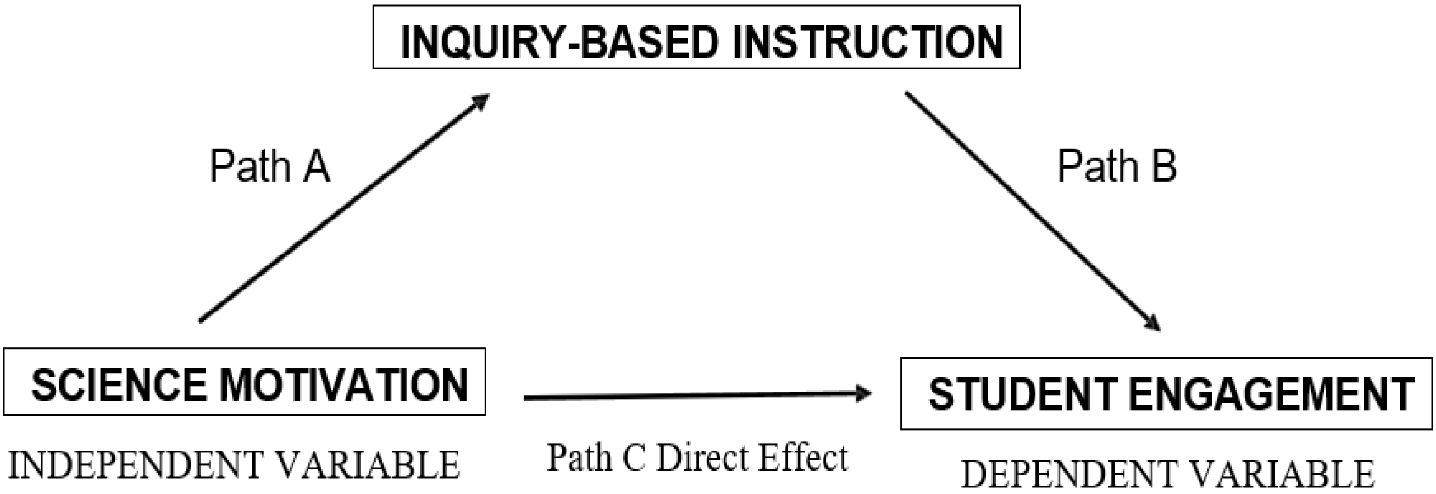
Mediating Variable

Figure 1. Schematic Diagram of the Study Showing the Direct and Mediated Effects of Science Motivation on Student Engagement through Inquiry-Based Instruction.



The conceptual schema of the study shows the proposed relationships between science motivation, inquiry-based teaching and student engagement. The science motivation is the independent variable, student engagement is the dependent variable and inquiry-based instruction is the mediating between the independent and dependent variables. The science motivation framework suggests a direct relationship between science motivation and student engagement, and indirect relationship between science motivation and inquiry-based instruction. The instrument used to measure students' science motivation in this study is the instrument developed by Zhdanov et al. (2022) which consists of six dimensions of students' motivation to learn science, namely intrinsic motivation, extrinsic motivation, academic self-efficacy, self-regulatory learning, academic interest, and external norms.

Self-efficacy, self-determination, grade motivation, career motivation and value motivation. The instrument adapted by Chang et al. (2010) is used to measure the inquiry-based instruction, which consists of five dimensions namely investigation, evidence, explanation, connection, and communication. The instrument developed by Baraquia (2019) is used to measure student engagement which focuses on behavioral, emotional and cognitive aspects in the learning process. These two variables together form the theoretical framework for the study of science motivation as a mediating factor between science motivation and student involvement.

The results of the present study are supposed to add to the science education literature on the intervening role of inquiry-based teaching between science motivational and student engagement. Although these constructs have been previously studied individually, the present study aims to understand how the practices of inquiry-based instruction help to account for the translation of students' motivation into meaningful involvement in science learning. Based on the relationships of the Grade 12 senior high school students of Maramag II District, Bukidnon, the study adds to the related studies of science education.

Adds further evidence that can help inform the implementation of learner-centred practice. Recent SRLs have underscored that inquiry-based learning remains an effective method for fostering meaningful student learning, scientific literacy, and critical thinking skills, thereby highlighting the importance of research into its application in real-world classroom settings (Strat et al., 2024; Urdanivia Alarcon et al., 2023).

The findings from this study should be useful for Grade 12 students to facilitate them in enhancing their science motivation and promoting better science learning behaviors, emotions and cognition. The results can be used by science teachers, especially in Maramag II District and other public secondary schools, as a basis for strengthening inquiry-based teaching learning styles that have the potential of facilitating students to be active, think critically, and have meaningful learning experiences. School administrators and instructional leaders can use the results to design professional development programs and instructional support programs to reinforce learner-centered science instruction. Similarly, the DepEd and curriculum developers can use the results of the evaluation to reflect and improve the science curriculum and instructional policies that promote inquiry-based teaching and learning. Finally, the study can be used as a reference for other researchers who want to study science motivation, inquiry-based teaching, student involvement and mediation model in other contexts specifically in educational contexts; thus, advancing science education research (Strat et al., 2024; Urdanivia Alarcon et al., 2023).

METHOD

The methodology and procedures used in the implementation of the study are presented in this chapter. It discusses the research design, research respondents, sampling technique, research instruments, data collection procedures, validity and reliability of the instruments, and ethical aspects that are noted in the research process, data scoring and statistical treatment.

Research Respondents

The student respondents of the study were 300 Grade 12 senior high school students from three selected public secondary schools in the Maramag II District in Bukidnon, namely Dologon National High School, Bukidnon National School of Home Industries and Dologon National High School – Kiharong Annex for the school year 2025 – 2026. The students selected were deemed suitable respondents as they had been exposed to science instruction and science classroom learning experiences that allowed them to assess their science motivation, science inquiry based learning experiences, and their involvement in science. Grade 12 children aged 16-18 years exhibited similar developmental, cognitive and academic characteristics, which made them ideal for the present study.

The target population were all the Grade 12 senior high school students of the three participating public secondary schools for the data collection period. Of this population, 300 respondents were randomly selected. Hair et al. (2019) suggested that a sample size of 300 should be sufficient for multivariate statistical analysis, such as regression analysis and mediation analysis. Similarly Cohen (1988) stated that an adequate sample size enhances the accuracy of the statistical estimates and reduces sampling error in correlational studies. Hence, a sample size of 300 was deemed adequate for the purpose of this research to reach the desired level of precision and therefore the required sample size was 300.

For that reason, proportionate stratified random sampling was used to make sure that the respondents were representative of the target population. Each of the three schools in the sample was a stratum and samples were taken from each school in proportion to its size within the overall sample of Grade 12 students. This procedure helped to reduce sampling bias, and provide a representative sample of participating schools in the sample, while also providing a representative sample of the study population (Cochran, 1977; Creswell & Creswell, 2018). The respondents were proportionately distributed, based on the number of Grade 12 students in each school between Dologon National High School (DNHS), Bukidnon National School of Home Industries (BNHS) and Dologon National High School–Kiharong Annex (DNHS–KA).

Students were included only if they were officially registered in participating in schools during the data collection period and were willing to participate in the study, and only when in Grade 12. The respondents were briefed about the purpose of the study and their rights as research subjects prior to filling out the questionnaire. Students who were absent when the questionnaire was given, refused or completed part of the questionnaire were excluded from the study. The same applied to respondents who left before answering the questionnaire, who were not included in the final data analysis. There was 100% voluntary participation in this study and respondents were advised that they were free to withdraw from the study at any time without penalty or adverse consequences.

Proposed Study Locale

The study was carried out in Maramag II District of Bukidnon, Region X (Northern Mindanao) in the Philippines. The district is one of the educational District in Schools Division of Bukidnon and includes various public secondary Schools offering secondary School education from Junior High School to Senior High School. The study was conducted in three schools which are Dologon National High School, Dologon National School of Home Industries and Dologon National High School–Kiharong Annex. These are Senior High School programs that cater to students from several barangays in the Municipality of Maramag and neighboring barangays.

Maramag is a 1st class municipality in the Southern part of the Province of Bukidnon. It is known as one of the educational hubs of the province and has several public schools for children from various socio-economic and educational backgrounds. The participating schools provide quality secondary education through various Senior High School programs and implement the curriculum prescribed by the Department of Education (DepEd), including science subjects that emphasize inquiry-based learning and the development of higher-order thinking skills.

The study locale was selected because the participating schools have a substantial population of Grade 12 students who have experienced science instruction under the K–12 curriculum. These schools provide an appropriate setting for examining science motivation, inquiry-based instruction, and student engagement because students have been exposed to various science learning activities that encourage investigation, collaboration, and critical thinking. Furthermore, no previous study in the district has specifically examined the mediating role of inquiry-based instruction in the relationship between science motivation and student engagement. The study conducted in Maramag II District, therefore, offers good empirical data that can help the school administration, science teachers and curriculum planners in designing instructional strategies to improve student involvement in science learning.

Materials and Instruments

This study was conducted using a structured questionnaire, which was derived from the already validated and published questionnaires related to science motivation, inquiry-based teaching and student engagement. There were four parts of the questionnaire. Parts II, III and IV respectively measured science motivation (independent variable), inquiry related to instruction (mediating variable) and student engagement (dependent variable) respectively. Use of adapted instruments guaranteed that the questionnaire has already known validity and reliability that is suitable for measuring variables investigated.

Science Motivation

The study's independent variable – science motivation – was assessed by the Science Motivation Questionnaire by Zhdanov et al. (2022). There are 25 items that evaluate students' motivation in learning science. It is divided into 5 indicators and each indicator includes 5 items, thus making it a total of 25 items. It consists of five indicators each having five items, a total of 25. Intrinsic motivation is the measure of students' intrinsic interest and fun of learning science. Grade motivation is an indicator of students' motivation to excel academically in science subjects. The students' motivation in their careers contributes to the level of students' perception of the relevance of science in their future career. Anxiety is a students' feeling of nervousness or apprehension towards science learning, and self-efficacy is a students' confidence in successfully performing science-related tasks (Zhdanov et al., 2022).

Inquiry-Based Instruction

Inquiry-based Instruction was used as the mediating variable, which was assessed with the Competence Scale for Learning Science: Inquiry and Communication (Chang et al., 2011). The revised instrument is comprised of 20 items that are evenly spaced in two scales: Scientific Inquiry Scale and Communication Scale. The Scientific Inquiry Scale assesses students' capacity to recognize scientific issues, make scientific explanations, collect evidence and carry out investigations. The Communication Scale measures students' capabilities to present scientific ideas, to communicate their results, to cooperate with other students, and to present scientific explanations based on evidence in science learning activities (Chang et al., 2011).

Student Engagement

The study's dependent variable was student engagement measured by Students' Science Engagement Scale (SSES), by Baraquia (2019). There are 15 items and three indicators: engagement, involvement and effort, and preparation. The engagement indicator is the measure of the students' interest and participation in the learning activities that are carried out in science. The involvement and effort indicator represents how well students want to put in effort and time in doing science related tasks. Preparation indicator is an indicator that assesses the readiness of students in science class by examining the preparation of the students in science class before the lesson began in science class including lesson review, assignment doing, and preparation of learning material in science class (Baraquia, 2019).

Response Scale and Interpretation

The three instruments used a 5-point Likert scale that measured the extent to which they agreed with each statement. In order to keep consistency in the data analysis a same interpretation was used in all study variables.

Scale	Range of Means	Descriptive Interpretation
5	4.20 – 5.00	Very High
4	3.40 – 4.19	High
3	2.60 – 3.39	Moderate
2	1.80 – 2.59	Low
1	1.00 – 1.79	Very Low

The computed weighted mean for each variable and indicator was interpreted using the descriptive categories presented above.

Instrument Validation

The adapted questionnaire was content validated by five experts who have specialization in science education, educational research, research methodology, before the actual data collection to check the relevance, clarity, organization and appropriateness of the instrument. The overall mean rating of the validation process was 4.854, which was interpreted as Excellent. This meant the questionnaire was very appropriate in measuring the variables that were included in the study. Validator recommendations were accepted and implemented to enhance the clarity and organization of some of the items in the questionnaire prior to pilot testing.

Reliability of the Instrument

After the validation process, the revised questionnaire was then pre-tested with 30 grade 12 students with characteristics similar to the target group in the study but not part of the target group. The purpose of pilot testing was to find internal consistency and reliability of the instrument. The Cronbach's alpha coefficient was used to evaluate reliability, 0.70 or more was considered acceptable for educational research (Taber, 2018). The result of the reliability analysis showed that the questionnaire had good internal consistency, meaning that the questionnaire was reliable and suitable for the actual data collection.

Design and Procedure

The study was of a non-experimental type and descriptive-correlational survey design was used. It is suitable for quantitative research because it is a systematic gathering and statistical analysis of numerical data, which is used to test research hypotheses and investigate the relationships between variables (Creswell & Creswell, 2018). The researcher did not manipulate the independent variable, nor did he introduce any treatment or intervention; thus, a non-experimental design was used. Rather, the study focused on the naturally occurring relationship between science motivation, inquiry-based teaching, and student's engagement that existed in the respondents. The design is commonly adopted in educational studies where research action does not need to impact the research environment, i.e., when investigating relationships between variables (Fraenkel et al., 2019).

In this research, the descriptive-correlational research design was used. The descriptive component was used to obtain the level of science motivation, inquiry-based instruction, and students' engagement of grade 12 senior high school students in Maramag II District, Bukidnon. The correlational part studied the significant relationship between the study variables and if there was any correlation between the variables. The study aimed to explore relationships, and not cause and effect relationships, making descriptive-correlational design the most suitable research design for the study (Creswell & Creswell, 2018).

The study's perspective in the objective dimension is descriptive and correlational since the study will describe the existing levels of study variables and be able to determine the relationship between the variables through statistical analysis (Fraenkel et al., 2019). The study is cross sectional from the point of view of the time dimension because the data were gathered only once within the data collection period. Cross-sectional research is a snapshot of the respondents' perception and experience at a specific time in the past and is typically used in educational survey research (Creswell & Creswell, 2018).

In order to find the result of this study to answer the first goal, mediation analysis method was used to investigate whether the science motivation significantly mediated the relationship between the science motivation and student engagement. Mediation analysis is used to ascertain whether the effect of an independent variable on a dependent variable is indirect via a third variable (the mediator: Baron & Kenny, 1986). The independent variables were science motivation, the mediating variable was inquiry-based instruction, and student engagement was the dependent variable in this study. The mediation analysis was based on the Baron and Kenny (1986) regression sequence, which involved analyzing the direct and indirect effects of the variables in a series of regressions. The validity of the indirect effect was also confirmed by utilizing the Sobel z-test as this is a widely used test for mediation effect (Sobel, 1982).

In general, the quantitative non-experimental descriptive correlational research design along with the mediation analysis was deemed appropriate as it allowed the researcher to determine the level of science motivation, inquiry-based instruction and student engagement, examine the significant relationship between the variables, and identify the mediating role of inquiry-based instruction between science motivation and student engagement in Grade 12 senior high school students in Maramag II District, Bukidnon.

After ethical approval was granted by the thesis adviser and the advisory committee, the researcher has obtained ethical clearance from the University of Mindanao Ethics Review Committee (UMERC) with Approval No. UMERC-2026-207 to start doing the actual research. Once the researcher got the ethical clearance, he sent a formal letter to the Office of the Schools Division Superintendent for Bukidnon requesting permission to conduct the study. Once approved, the researcher then sent separated correspondence to the principals of Dologon National High School, Bukidnon National School of Home Industries and Dologon National High School–Kiharong Annex for the permission to administer the research instrument to the selected respondents.

The questionnaire was adapted for content validation with five experts in science education, educational research and research methodology before the actual data collection, to assess the relevance, clarity, organization and appropriateness of the questionnaire. The instrument received an overall rating of 4.854, which is considered Excellent (4.854 was the highest rating). This score was determined to be very suitable for the purpose of measuring the variables contained in this study. Researcher added the suggestions of the validators in the questionnaire before pilot testing. Thus, the researcher tested the revised instrument with 30 grade 12 students but not included in the sample. The pilot test was used to validate the instrument with Cronbach's alpha, which indicated good internal consistency for the instrument to be used in the study.

Once the required approvals were obtained, the researcher discussed the questionnaire distribution with the principals and focal persons of the school. The researcher personally applied the questionnaires to the selected respondents during the set time for data collection from February 2026 to April 2026. The researcher introduced the study and gave instructions on how to fill the questionnaires before the questionnaire was given out. Time was provided for the respondents to respond to the questionnaire, and the researcher was on hand to explain instructions as needed but did not influence the answer provided.

Completed questionnaires were retrieved and analyzed for completeness and consistency by the researcher. Questionnaires that had a significant number of missing answers and questionnaires that were returned by those who dropped out of the study were not included in the analysis following the set inclusion/exclusion criteria. The researcher then coded, organized and checked the collected data to ensure it was accurate and submitted it to the research statistician. The interpreted data were used as an interpretation basis for the results, conclusions and recommendations of the study. After analysis, the data obtained from the research was properly kept and treated, taking care of the confidentiality and security of the respondents' information, with the use of the University of Mindanao's research ethics policies.

RESULTS AND DISCUSSION

The collected data is presented, analyzed and interpreted in relation to the research objective in this section.

Science Motivation

This section is a statistical analysis of the students' motivation for science. This shows the level of science motivation of the students in Grade 12 in the senior high school in Table 1. The result shows that the level of science motivation of the respondents was high as the overall mean is 3.76 with standard deviation 0.49. The standard deviation was relatively low, indicating that the respondents' ratings were relatively consistent. The highest mean (M = 3.94, SD = 0.65) was obtained for career motivation, followed by intrinsic motivation (M = 3.93, SD = 0.63) and self-efficacy (M = 3.87, SD = 0.66), which were all considered high. Motivation, another grade, was also highly descriptive with a mean of 3.69 (SD = 0.66). Anxiety, on the other hand, had the lowest mean (M = 3.35, SD = 0.68) and was considered a "moderate" level of anxiety. The result of the overall analysis can be concluded as follows: From the overall result it can be seen that the respondents had high levels of scientific motivation in learning even though the respondents experienced moderate levels of anxiety in learning.

Table 1. Level of Science Motivation

Indicators	SD	Mean	Descriptive Equivalent
Intrinsic Motivation	0.63	3.93	High
Grade Motivation	0.66	3.69	High
Career Motivation	0.65	3.94	High
Anxiety	0.68	3.35	Moderate
Self-efficacy	0.66	3.87	High
Overall	**0.49**	**3.76**	**High**

The high motivation towards science reflected that the respondents had positive attitudes towards science learning and understood the importance of science learning for further studies and their future profession. Students strongly saw the importance of the study of science for their future, as indicated by the highest rated indicator, career motivation. This is evident in the item "Learning Science will help me achieve my career goal", which had the highest meaning in this indicator. This suggests that there is some recognition of the importance of science as a basis for attainment of future educational and occupational aspirations. Likewise, the high scores for intrinsic motivation and self-efficacy suggest that respondents were happy to learn about science and felt confident in their ability to undertake science related activities. However, the lowest mean was for anxiety. This finding is corroborated by the item "I become nervous when taking science exams" with one of the lowest ratings. The results showed that overall, the anxiety level was moderate, but the result suggests that certain students might still experience anxiety in science assessment, which teachers could provide more emotional and didactic support. Though the mean score for anxiety was lowest, it was moderate, which implies that certain students were still anxious during science-related tests and learning activities. The moderate level of anxiety indicates that while students generally demonstrated high science motivation, reducing science-related anxiety through supportive inquiry-based learning experiences may further strengthen their participation and engagement in science clasess.

The results are consistent with the Self-Determination Theory of Ryan and Deci which posits that learning activities which meet students' needs for autonomy, competence, and relatedness are more likely to result in higher levels of motivation. The findings are also consistent with the most recent research that has suggested that students who view science as relevant and meaningful to their future career have higher science learning motivation, confidence and persistence. Similarly, Zhdanov et al. (2022) recognized intrinsic motivation, career motivation, and self-efficacy as key factors influencing science motivation, and empirical studies in the last few years found that science highly motivated students were more engaged, persistent, and successful in science education. All told, these results indicate that further research is needed to investigate how to increase students' motivation as a key element in creating meaningful science learning experiences.

Student Engagement

The results of the statistical analysis are presented in this section in terms of the degree of student engagement. This is presented in Table 2 to show the level of student engagement among the senior high school (SHS) students of Grade 12. The overall mean value of 3.87, and a standard deviation of 0.58, suggest that students were highly engaged. The standard deviation was relatively small, indicating that the respondents had similar perceptions on their involvement in science learning. The three indicators showed a high rating with engagement having the highest mean (M = 3.97, SD = 0.67) and involvement was almost as high (M = 3.94, SD = 0.66). Effort and preparation had the lowest mean (M = 3.70, SD = 0.67) but it still fell within the high descriptive level. The results overall suggest that all the respondents were involved in science learning, involved in class activities and expressed positive learning behaviors although their levels of effort and preparation were relatively lower than other dimensions.

Table 2. Level of Student Engagement

Indicators	**SD**	**Mean**	**Descriptive Equivalent**
Engagement	0.67	3.97	High
Involvement	0.66	3.94	High
Effort and Preparation	0.67	3.70	High
Overall	**0.58**	**3.87**	**High**

The students showed high level of engagement suggesting that the respondents were generally interested in science learning activities and actively involved in the activities in the classroom. Engagement is the top-rated

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indicator indicating that students perceived their science lessons to be meaningful and motivating. This was corroborated by the item entitled, “I am inspired to learn new things in science class” with the highest mean (M = 4.21, SD = 0.73), and it was interpreted as Very High. While effort and preparation yielded the lowest indicator mean, it was still high. This is reflected in the relatively lower rated item “I review my science lessons before coming to class, "which indicates that students are active in lessons, but may not be as active in studying outside the classroom. Similarly, the high score on involvement suggests that students were engaged in collaborative learning, learning with peers in class discussions, and other science-related activities. Effort and preparation had the lowest average of the indicators, but they still got a high descriptive equivalent, indicating that on average, students fulfilled their responsibilities and prepared for science learning. The relatively low score suggests, however, that further support may be required to build students' study habits, preparation in class, and persistence in science.

The results highlight the need to create motivating learning activities for pupils to stay active, and to cultivate regular preparation and persistence. The results agree with the theory of Student Engagement by Fredricks, Blumenfeld and Paris (2004) which states that students are more engaged when they show behavior, emotion and cognition in their learning. They were engaged in science activities and collaborated with their classmates with high engagement, which means they were active in science activities, worked with their classmates and were interested in classroom learning. Similarly, the results align with Baraquia (2019) who posits that engagement, involvement and preparation are the key factors of effective science learning, suggesting that these are critical factors that should be considered when developing curriculum for science. The results are also consistent with the latest studies reporting that students engaged in meaningful, interactive and learner-centred science learning engage more, participate more, and are more committed to learning. Overall, the results indicate that keeping the learning atmosphere in the class interesting and active, will further improve students' learning outcomes in science.

Inquiry-Based Instruction

This part evaluates the extent of inquiry-based teaching/learning based on the analyzed statistical data. The results of this study are shown in table 3 from the perspective of the Grade 12 senior high school students. The overall mean was 3.82, and the standard deviation was 0.58, which suggests that the inquiry-based instruction was at a high level. The relative standard deviation was low, indicating that the respondents' perceptions were consistent. The highest mean was for the Scientific Inquiry Scale (M = 3.86, SD = 0.65), and the Communication Scale (M = 3.79, SD = 0.59). High scores were obtained on both the indicators and were interpreted as if the respondents had experienced inquiry-oriented teaching at a high frequency and opportunities for scientific communication was also high.

Table 3. Level of Inquiry-Based Instruction

Indicators	**SD**	**Mean**	**Descriptive Equivalent**
Scientific Inquiry Scale	0.65	3.86	High
Communication Scale	0.59	3.79	High
Overall	**0.58**	**3.82**	**High**

The overall level of inquiry-based learning is high, indicating that science teachers often offered learning opportunities to students to ask questions, solve the problems, gather evidence, analyze information, and communicate scientific ideas. The highest-rated indicator (Scientific Inquiry Scale) suggests that students participated in a science lesson regularly in inquiry processes. This is reflected in the item 'In science class, I had opportunities to use appropriate study strategies for the question' with the highest mean (M= 4.03, SD = 0.81). This suggests that students had many chances to make decisions in the process of inquiry learning, thus they were taught to learn independently. In contrast, the relative lower rating for "I could present scientific information in a clear and understandable way from raw data" indicates that students may need further support

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to organize, interpret and effectively communicate scientific information. At the same time the Communication Scale was rated highly, but with a slightly lower mean than scientific inquiry. The rating of the lowest item under this indicator was 'In science class, I could convert raw data into a readily understandable form and present it' (M= 3.56, SD = 0.88) which indicates that students may need more opportunities to improve their scientific communication and data presentation skills. The results suggest that inquiry-based teaching is seen in the schools that took part in the study, and there are still some aspects that need to be developed.

The findings are consistent with the inquiry-based learning paradigm of Chang et al. (2011) that focuses on scientific inquiry and communication skills as critical skills for effective learning in science. The high scores of the respondents suggest that inquiry-oriented teaching helped them to be active in investigations, build scientific explanations and express understanding. The findings are also in line with previous studies which have found that inquiry-based instruction does better to promote understanding, active participation, critical thinking and meaningful involvement in learning science. This confirms that the continuation of inquiry-based instruction could be expected to further boost students' motivation, engagement and science learning outcomes.

Significance of the Relationship among Science Motivation, Student Engagement, and Inquiry-Based Instruction *(Science Motivation × Student Engagement)*

The relationship between science motivation and student engagement and inquiry-based instruction will be explored. The results of the significance of the relationship between science motivation and student engagement are shown in Table 4. Results showed that there existed a high positive correlation and statistically significant relationship between the two variables ($r = .788$, $p < .001$). Because the probability value was less than the 0.05 level of significance the null hypothesis was rejected. This suggests that science motivation was related to student engagement, which was also higher for the respondents with higher science motivation. Similarly, all science motivation indicators (except for anxiety) were moderately to strongly correlated with the dimensions of student engagement.

Table 4. Significance of the Relationship among Science Motivation, Student Engagement, and Inquiry-Based Instruction

Science Motivation	**Student Engagement**			
	Engagement	Involvement	Effort and Preparation	**Overall**
Intrinsic Motivation	.706** .000	.636** .000	.499** .000	**.708**** **.000**
Grade Motivation	.609** .000	.606** .000	.549** .000	**.678**** **.000**
Career Motivation	.693** .000	.606** .000	.497** .000	**.690**** **.000**
Anxiety	.137* .018	.064 .267	.158** .006	**.139*** **.016**
Self-efficacy	.758**	.662**	.529**	**.749****

	.000	.000	.000	**.000**
Overall	**.772**** **000**	**.684**** **.000**	**.595**** **.000**	**.788**** **.000**

The presence of a significant positive correlation between the students' science motivation and their involvement in science learning activities suggests that science motivation is directly proportional to students' involvement in the learning process of science, which means that if a student has a high level of science motivation, he will be more involved in science learning activities, and in the opposite direction, if a student has a low level of science motivation, he will be less involved in the learning process of science. Students' perceived science's meaning and relevance to their academic and career future are associated with behavior, emotional engagement and classroom learning. In the same way, students who feel confident in their capacity to learn science feel comfortable engaging in scientific discourse, work collaboratively with others, and stay with a rigorous scientific concept. The results suggest that greater student motivation could potentially help to enhance students' general participation in science classes.

The results corroborate Self-Determination Theory, which states that learning conditions that meet the needs for autonomy, competence and relatedness increase students' engagement. The satisfaction of these psychological needs creates more autonomous types of motivation, which encourages active learning and perseverance in learning. Similarly, the present results corroborate recent research that has found that student motivation is one of the most important factors in student engagement in the classroom, especially when the teaching methods used promote active student involvement and meaningful learning experiences. Recent studies in STEM education have revealed that motivation and teaching strategies interact to impact students' engagement and participation in science learning.

This is the same as what Zhdanov et al. (2022) found where they identified five important dimensions of science motivation which include intrinsic motivation, career motivation, grade motivation, anxiety and self-efficacy. Likewise, there is recent evidence that learning environments that are inquiry-oriented and autonomy-supportive foster students' motivation and engagement through offering opportunities for students' investigation of real-life scientific problems, interaction with peers and building their knowledge of scientific concepts.

Significance of the Relationship among Science Motivation, Student Engagement, and Inquiry-Based Instruction (Science Motivation × Inquiry-Based Instruction)

Table 5 presents the relationship between science motivation and inquiry-based instruction. The analysis revealed a strong, positive, and statistically significant relationship between the two variables, $r = .719$, $p < .001$. Because the probability value was lower than the .05 level of significance, the null hypothesis was rejected. This result indicates that respondents with higher levels of science motivation also tended to report greater experiences of inquiry-based instruction.

Among the science motivation indicators, self-efficacy demonstrated the strongest relationship with overall inquiry-based instruction, $r = .648$, $p < .001$. Grade motivation, $r = .620$, $p < .001$, and career motivation, $r = .619$, $p < .001$, also demonstrated strong positive relationships with the overall inquiry-based instruction score. Anxiety showed the weakest, although still statistically significant, relationship with inquiry-based instruction, $r = .230$, $p < .001$. The results indicate that confidence, academic goals, and perceived career relevance were more closely associated with inquiry-based learning experiences than feelings of anxiety.

Table 5. Significance of the Relationship among Science Motivation, Student Engagement, and Inquiry-Based Instruction

Science Motivation	**Inquiry-Based Instruction**		
	Scientific Inquiry Scale	Communication Scale	**Overall**
Intrinsic Motivation	Communication Scale	.525** .000	**.579**** **.000**
Grade Motivation	.608** .000	.546** .000	**.620**** **.000**
Career Motivation	.602** .000	.550** .000	**.619**** **.000**
Anxiety	.183** .001	.248** .000	**.230**** **.000**
Self-efficacy	.654** .000	.551** .000	**.648**** **.000**
Overall	**.693**** **.000**	**.646**** **.000**	.719** **.000**

This significant correlation between science motivation and inquiry-based instruction implies that science motivation and inquiry-based learning experiences go hand in hand. Students motivated by the task will be more likely to ask questions, to explore scientific issues and problems, gather information, interpret data, and tell their explanation about the science. Meanwhile, inquiry-based activities can also enhance student motivation as they have opportunities to actively participate in learning and acquire knowledge instead of passively listening to the teacher. Students' interests of science may be stimulated and they may see science as being more useful, relevant, or linked to their personal objectives if they are encouraged to investigate relevant problems and make explanations.

The strongest association with inquiry-based instruction was with self-efficacy, suggesting that confidence is crucial when students are asked to conduct investigations and share and explain scientific concepts. With inquiry activities, learners may be asked to make decisions, use materials in some way, interpret findings, and justify conclusions. When students think they can do these things they might be more willing to engage in, and more likely to reap more benefit from, the inquiry process. In the same way, students may feel that inquiry activities are important ways to build their competence so that they are prepared for academic and/or career needs in the future. The weaker link between anxiety indicated that inquiries should be designed, and supported, to be neither too easy nor too hard, otherwise students may become overwhelmed.

The findings are consistent with the framework of inquiry and communication in science learning proposed by Chang et al. (2011) that the two key skills in science learning are scientific inquiry and communication. The results further support Self-Determination Theory as inquiry-based instruction can foster students' autonomy by enabling them to make decisions, competence by enhancing their scientific skills, and relatedness by providing opportunities for students to interact and communicate with each other. Inquiries which allow for questioning and creativity have also been linked to students' confidence and interest in science. Thus, the inquiry-based teaching should not be considered as a teaching method exclusively but as a learning environment which could serve as an effective means to maintain and enhance students' motivation to learn science.

Significance of the Relationship among Science Motivation, Student Engagement, and Inquiry-Based Instruction (Inquiry-Based Instruction × Student Engagement)

Table 6 presents the relationship between inquiry-based instruction and student engagement. The results revealed a strong, positive, and statistically significant relationship between the two variables, $r = .785$, $p < .001$. Since the probability value was below the .05 level of significance, the null hypothesis was rejected. This finding indicates that respondents who reported higher levels of inquiry-based instruction also tended to exhibit higher levels of student engagement.

At the indicator level, the Scientific Inquiry Scale showed a strong positive relationship with overall student engagement, $r = .776$, $p < .001$. It was also significantly correlated with engagement, $r = .624$; involvement, $r = .689$; and effort and preparation, $r = .703$, with all probability values below .001. The Communication Scale was likewise significantly related to overall student engagement, $r = .684$, $p < .001$, as well as engagement, $r = .594$; involvement, $r = .609$; and effort and preparation, $r = .576$, all at $p < .001$. The results demonstrated that scientific inquiry had a somewhat stronger association with student engagement than communication, although both dimensions were significantly related to all engagement indicators.

Table 6. Significance of the Relationship among Science Motivation, Student Engagement, and Inquiry-Based Instruction

Inquiry-Based Instruction	**Student Engagement**			
	Engagement	Involvement	Effort and Preparation	**Overall**
Scientific Inquiry Scale	.624** .000	.689** .000	.703** .000	**.776**** **.000**
Communication Scale	.594** .000	.609** .000	.576** .000	**.684**** **.000**
Overall	**.654**** **.000**	**.698**** **.000**	**.689**** **.000**	.785** .000

The strong relationship between inquiry-based instruction and student engagement indicates that students become more engaged when science instruction actively involves them in investigation, evidence collection, data analysis, explanation, and communication. Rather than remaining passive recipients of information, students participating in inquiry-based activities are required to think, discuss, make decisions, and apply scientific processes. These opportunities may increase their interest in lessons, involvement in group activities, and willingness to exert effort in completing learning tasks. The findings therefore suggest that inquiry-based instruction contributes to behavioral, emotional, and cognitive dimensions of engagement.

Scientific inquiry showed a stronger relationship with engagement than communication. This may be because investigative activities provide concrete and immediate opportunities for students to participate through observation, experimentation, problem-solving, and evidence-based explanation. The strong relationship between scientific inquiry effort and preparation suggests that investigations require students to organize materials, follow procedures, record observations, and complete assigned tasks carefully. Communication was also positively related to engagement, demonstrating that discussing evidence, explaining ideas, asking peers for clarification, and presenting findings help students remain involved in the learning process. Nevertheless,

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its comparatively lower coefficients suggest that teachers may need to provide more structured opportunities for students to express scientific ideas and communicate data confidently.

The findings support Chang et al.'s (2011) framework, which emphasizes that inquiry and communication operate together in the development of science learning competence. Inquiry enables students to generate and examine evidence, while communication allows them to clarify, defend, and refine their understanding. The results are also consistent with research indicating that questioning, creativity, collaboration, and active investigation can strengthen students' interest and participation in science learning. Overall, the present findings imply that inquiry-based instruction should be sustained and strengthened in science classrooms because it provides the active, collaborative, and intellectually meaningful experiences needed to promote student engagement.

Regression Analysis Showing the Influence of Science Motivation on Student Engagement as Mediated by Inquiry-Based Instruction

The results of the regression analysis to determine the mediation of inquiry-based instruction between science motivation and student engagement were presented in Table 7. The results indicated that science motivation had a significant effect on inquiry-based instruction (Path a) and the student engagement significantly to science motivation (Path b). Similarly, the importance of science motivation was a significant predictor of student engagement both before (Path c) and after (Path c′) the inclusion of the mediating variable. The regression coefficient for science motivation for student engagement was statistically significant, but it dropped after changing the model from the traditional approach to inquiry-based approach. This finding suggests that science motivation accounted for some of the relationship between science motivation and student engagement but still had a direct effect on student engagement.

Table 7. Regression analysis showing the influence of science motivation on student engagement as mediated by inquiry-based instruction

Step	**Path**	**B**	**SE**	**β**
1	c	.932	.042	.788***
2	a	.851	.048	.719***
3	b	.452	.044	.452***
4	c	.548	.052	.463***

The regression analysis indicates that inquiry-based instruction contributes significantly to explaining how science motivation influences student engagement. Students with higher levels of science motivation were more likely to experience or perceive inquiry-based instructional practices, and these instructional experiences subsequently enhanced their engagement in science learning. The reduction in the regression coefficient after the inclusion of inquiry-based instruction suggests that part of the influence of science motivation operates through inquiry-oriented teaching practices. However, because science motivation remained a significant predictor of student engagement even after controlling for inquiry-based instruction, the findings indicate that motivation itself continues to play an important role in promoting engagement.

These findings support Self-Determination Theory (Ryan & Deci, 2017), which proposes that students are more likely to become engaged when learning environments satisfy their needs for autonomy, competence, and relatedness. Inquiry-based instruction provides opportunities for students to ask questions, investigate scientific problems, communicate ideas, and construct knowledge actively, thereby strengthening the influence of motivation on engagement. Likewise, the findings are consistent with the inquiry-based learning framework of Chang et al. (2011), which emphasizes that inquiry and scientific communication promote meaningful learning experiences. Recent studies have also shown that inquiry-oriented instructional strategies improve students' motivation, participation, and engagement by encouraging active learning, critical thinking, and collaborative problem-solving, thereby reinforcing the present findings.

Mediating Effect of Inquiry-Based Instruction on the Relationship between Science Motivation and Student Engagement

The result of the Sobel test to check the difference between science motivation and student engagement through inquiry-based learning is presented in table 8 below. The Sobel test statistics were calculated at 8.887482 and the probability value was found to be < 0.05 (level of significance). Hence, the null hypothesis was rejected. The results showed that the science inquiry-based teaching mediated the relationship between science motivation and student engagement significantly. This means that both science motivation and science learning motivation have a direct and indirect effect on the engagement of students in science learning.

Table 8. Results of statistical analysis on the presence (or absence) of a mediating effect

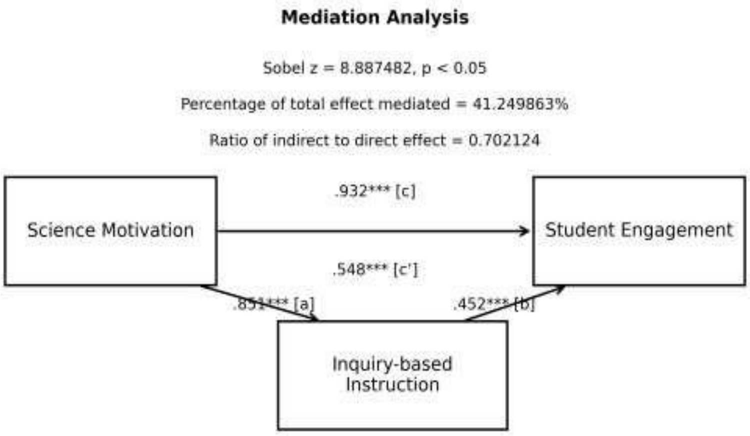
Combination of Variables	Sobel z	p-value	Mediation
Science motivation → inquiry-based instruction→ Student engagement	8.887482	$p<0.05$	Partial mediation

The results of this significant Sobel test indicated that inquiry-based teaching is an effective mechanism to increase students' engagement in learning science because it has a positive effect on students' motivation in learning science. When science teachers apply inquiry-based teaching strategies, the relationship between motivated students and their involvement increases, yet when teachers do not apply the strategy, there is partial mediation that shows that students who have higher motivation will have higher involvement. Inquiry-based teaching invites students to ask questions, investigate, collect evidence, work collaboratively, and communicate scientific ideas and methods, making students' motivation more likely to become effective participation and sustained engagement in the classroom. The results indicate, therefore, that only when motivation is backed up by effective learner-centred instructional practices will it achieve full engagement.

The results are congruent with the Self-Determination Theory, which holds that learning environments that foster freedom of choice, mastery and connection are more likely to elicit students' participation. Inquiry-based instruction supports these psychological needs by affording students the opportunity to take an active role in learning to build scientific explanations, to work in groups with fellow students, and to investigate real scientific problems. The results further corroborate the inquiry-based learning model proposed by Chang et al. (2011) that learning through scientific inquiry and communication is the key process for meaningful science learning. Additionally, empirical research in recent years found that using inquiry-based teaching models can enhance the positive effects of learners' motivation on their participation in the classroom, which includes critical thinking, collaboration, and conceptual understanding. Hence, the results of the present study support the conceptual framework of the study, which indicates that inquiry-based instruction is an important instructional approach that affects increasing student participation by intervening science motivation.

Mediation Model of the Relationship between Science Motivation and Student Engagement through Inquiry-Based Instruction

Figure 2 illustrates the mediation model showing the role of inquiry-based instruction in the relationship between science motivation and student engagement. The figure indicates that science motivation exerted a significant total effect on student engagement (c = 0.932**).** Science motivation also had a significant positive effect on inquiry-based instruction (a = 0.851), while inquiry-based instruction significantly influenced student engagement (b = 0.452**).** After the inclusion of inquiry-based instruction as the mediating variable, the direct effect of science motivation on student engagement decreased from 0.932 to 0.548 (**c'**), indicating that part of the effect of science motivation was transmitted through inquiry-based instruction. The Sobel test yielded a **z-**value of 8.887482 with a probability value less than 0.05**,** confirming that the indirect effect was statistically significant. Furthermore, 41.25% of the total effect of science motivation on student engagement was mediated through inquiry-based instruction, while the ratio of the indirect to the direct effect was 0.702124, indicating a substantial contribution of the mediating variable to the overall relationship. The finding that inquiry-based instruction accounted for 41.25% of the relationship between science motivation and student engagement suggests that providing students with meaningful inquiry experiences is an important way for teachers to transform students' motivation into active classroom engagement.



The mediation model is illustrated in Figure 2 between the variables between science motivation and student engagement is dominated by the role of inquiry-based learning. The total effect of science motivation on student engagement is significant with the value of c = 0.932. In addition, inquiry-based instruction had a significant positive effect on inquiry (Science motivation = 0.851) and inquiry significantly influenced student engagement (Science motivation = 0.452). The inclusion of inquiry-based instruction as the mediating variable reduced the direct effect of science motivation on student engagement from 0.932 to 0.548 (c'). This means that invention of science motivation was partly mediated by the presence of inquiry-based instruction in student engagement. The Sobel test gave a z value to be 8.887482 and the probability value to be less than 0.05, which showed that the indirect effect was statistically significant. Additionally, 41.25% of the total effect on student engagement of the science motivation was mediated by the teaching of inquiry-based instruction, and the ratio of the indirect effect to the direct effect was 0.702124, meaning that the effect of the science motivation on the student engagement was significantly mediated by the teaching of inquiry-based instruction.

The mediation model shows that inquiry-based instruction is a crucial mechanism in the increase of students' engagement, mediated by science motivation. The direct effect of science motivation on student engagement is evident, but its reduction in regression coefficient after the inclusion of inquiry-oriented teaching practices suggests that inquiry-oriented teaching practices had increased the correlation. The results indicated that students who are highly motivated towards science subjects become even more motivated when the learning activity in science subjects is carried out in a way that encourages students to ask questions, conduct scientific investigations, work together, think scientifically and communicate scientific ideas. The discovery also suggests that motivation is not the only factor that can maximize students' engagement if it is not combined with teaching strategies that are interactive, which engage students in creating scientific knowledge. Therefore, science teachers need to keep using inquiry-based teaching methods to transfer students' motivation into doing meaningful work in the classroom and making their work meaningful in the long run.

Results are consistent with Self-Determination Theory ("Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness," 2017) which suggests that students are more motivated when their learning environments meet their basic psychological needs for autonomy, competence, and relatedness. Inquiry-based instruction creates the conditions for students to make choices in investigating, builds scientific competence in an active way through the students' inquiry, and enables students to work with peers, meeting all these psychological needs and reinforcing the role of motivation in engagement. Similarly, the results are in line with the inquiry learning model of Chang et al. (2011) which emphasizes that the scientific inquiry and scientific communication will facilitate meaningful learning experiences and active involvement of students. Recent empirical studies have likewise reported that inquiry-based instructional approaches significantly enhance students' motivation and engagement by promoting critical thinking, collaborative learning, and deeper conceptual understanding (Lazonder & Harmsen, 2021; Srisawasdi & Panjaburee, 2022). Therefore, the present findings confirm the conceptual framework of the study by demonstrating that inquiry-based instruction partially mediates the relationship between science motivation and student engagement, highlighting its important role in promoting meaningful science learning.

CONCLUSION AND RECOMMENDATION

This section contains the conclusion and recommendations. These conclusions and recommendations stem from the study's results.

Conclusion

Based on the findings of the study, the respondents exhibited a high level of science motivation, student engagement, and inquiry-based instruction**.** Science motivation was characterized by high levels of intrinsic motivation, career motivation, grade motivation, and self-efficacy, while anxiety was found to be at a moderate level. Student engagement was high in terms of engagement, involvement, and effort and preparation. Likewise, inquiry-based instruction was highly implemented in terms of scientific inquiry and communication.

The findings further revealed significant positive relationships among science motivation, inquiry-based instruction, and student engagement. Science motivation was significantly related to student engagement, while inquiry-based instruction was significantly related to both science motivation and student engagement. Furthermore, the regression and Sobel analyses confirmed that inquiry-based instruction partially mediated the relationship between science motivation and student engagement, indicating that the null hypotheses were rejected.

The findings of the study support the Self-Determination Theory proposed by Ryan and Deci (2017) and the Inquiry-Based Learning Framework of Chang et al. (2011). The results confirm the proposed theoretical framework by demonstrating that inquiry-based instruction serves as a significant partial mediator in the relationship between science motivation and student engagement.

RECOMMENDATION

Based on the findings of the study, the study proposes the following recommendations:

Science teachers are encouraged to continue implementing inquiry-based instructional strategies while providing greater opportunities for students to strengthen their scientific communication skills, particularly in organizing, interpreting, and presenting scientific data. The teachers are also encouraged to offer supportive practices in their classrooms to reduce students' anxiety towards science learning, including the use of guided inquiry, timely feedback, and collaboration in learning. Teachers can give advanced learning materials, pre-class learning activities and formative assessment which encourages students to prepare before science lessons, to enhance students' effort and preparation. Such practices are aligned to those of inquiry-based learning that encourage active learning and meaningful learning (Chang et al., 2010).

School administrators are encouraged to promote inquiry-oriented teaching by conducting professional development programs, establishing laboratory facilities, enriching teaching resources, and equipping technology to improve the ability of teachers to carry out inquiry-oriented teaching. Training programs can also be designed to enhance teachers' capability to foster scientific communication skills and alleviate science anxiety of students based on learner-centered teaching.

Curriculum developers and education planners are urged to further integrate the use of inquiry-based learning experiences in the science curriculum by introducing activities that cultivate scientific investigation, communication, data interpretation skills, learning independence. The curriculum materials may also require structured learning tasks that facilitate students' preparation before class and sustained engagement during the learning process.

Students are actively involved in inquiry-based learning, asking questions, carrying out investigations and sharing scientific ideas and concepts in class and in their preparation for lessons. They are also supported to become confident in learning science by engaging in classroom discussion and inquiry activities, even if facing challenges or anxiety. These are consistent with the principles of Self-Determination Theory which focuses on building competence, autonomy, and relatedness to foster motivation ("Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness," 2017).

Future studies are encouraged to repeat the study to find a consistency of findings across other educational settings, subject areas, and grade levels. They can also explore other factors that could impact student engagement, such as teacher support, classroom climate, self-regulated learning, or technology use. Further, future research could use experimental, longitudinal, or structural equation modeling methods for further analysis of the variables' relationships.

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