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The Role of Curiosity in Academic Outcomes: A Study of Junior High School Science Students

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Abstract. In contemporary education, fostering curiosity in science learning is essential for enhancing students' academic performance, particulary in junior high school. This study aims to explore the relationship between students' curiosity in science learning and their learning outcomes in junior high school, focusing on three dimensions of curiosity: Stretching, Science, and Embrace. A correlational quantitative approach was employed, involving 147 students, with data collected through questionnaires, learning outcome assessments, and interviews. The results indicated that curiosity plays a role in improving learning outcomes, as evidenced by the average scores increasing from grade 7 (82.2) to grade 9 (85.8), influenced by the interactive teaching approach. However, despite an average curiosity score of 66.52, the correlation between the dimensions of curiosity and learning outcomes was found to be very weak ($p > 0.05$), highlighting the need for more innovative learning strategies to effectively harness curiosity in the classroom.
Keywords: Curiosity, learning outcomes, science education.

Introduction

In contemporary education, the challenge of improving the academic achievement of students, particularly in science education, has become a focal point for educators and researchers alike. Students' levels of curiosity is a major factor in determining their learning performance, particularly in disciplines like science. Curiosity not only drives engagement but also facilitates deeper cognitive processing, which is essential for understanding complex scientific concepts (Stokoe, 2012; Tariq et al., 2013). Understanding scientific concepts requires deeper cognitive processing, involvement, and inquiry which are fuelled by curiosity (Lindholm, 2018). But even with its acknowledged significance, there are still issues with encouraging and assessing students' curiosity, particularly in junior high school. Students' basic drive, interest in the subject, and capacity to relate what they learn to real-world experiences are just a few of the many variables that frequently impact academic outcomes, especially final grades or learning outcomes in science education (Singh & Manjaly, 2022). The main focus of this study is the connection between curiosity and academic achievement.

It has long been believed that curiosity, which is commonly described as the drive to learn or gain experience, is an essential component of learning (Alan & Mumcu, 2024).

Curiosity in scientific classes encourages students to enquire, look for answers, and participate more fully in the learning process. Having an interest in a subject is only one aspect of curiosity; another is the motivation to learn more and draw connections between ideas. According to research, students that exhibit high levels of interest are more likely to interact with the subject matter, persevere through difficulties, and eventually achieve superior academic results (Berg et al., 2019). Curiosity's effect on learning outcomes is especially pertinent to science education, where problem solving abilities and active participation are necessary for conceptual understanding (Peterson, 2020).

In contrast, students' learning outcomes, typically measured by their final grades, serve as an indicator of their comprehension and retention of the subject matter. These results are frequently impacted by a number of elements in science education, such as the pedagogical strategies used, the accessibility of learning materials, and the psychological aspects that impact a student's motivation and involvement. Students' academic success is greatly influenced by their level of interest, intrinsic motivation to learn, and capacity to relate personally to scientific concepts (Ryan & Deci, 2020). For educators looking to enhance their teaching methods and establish settings that encourage greater engagement and improved scientific performance, it is crucial to comprehend how curiosity affects these learning outcomes.

Several studies have examined the relationship between curiosity and academic achievement, with mixed findings depending on the context and educational setting. For instance, curiosity interacts with other cognitive and motivational factors to influence learning outcomes in secondary school science classrooms (Oudeyer at al., 2016). Their study found a significant positive correlation between students' intrinsic curiosity and their performance in science subjects. Curiosity is a precursor to higher order thinking and that students who engage with scientific concepts out of genuine curiosity often show improved problem solving skills and higher achievement levels in related assessments (Jackson, 2021).

Furthermore, studies have indicated that curiosity is not a static trait but rather a malleable quality that can be influenced by both internal and external factors, such as the teaching environment and the type of learning experiences provided (Choi, et al., 2023). In this regard, fostering a learning environment that stimulates curiosity through active learning strategies, inquiry based activities, and real world applications may significantly enhance student engagement and academic performance. Students are presented with opportunities for exploration and discovery, their curiosity increases, leading to improved academic outcomes (Makarova et al., 2021). These findings underscore the importance of considering curiosity as a critical element in designing effective science curricula that not only aim to transmit knowledge but also inspire students to actively seek it.

While research has consistently shown the benefits of curiosity for academic performance, it remains unclear whether these effects are uniform across all student populations and educational settings. Specifically, the degree to which curiosity can influence learning outcomes in junior high school students in science education has not been sufficiently explored. This gap in research highlights the need for further investigation into the role of curiosity as a potential driver of learning success, particularly in the context of science education at the junior high school level. This study aims to fill this gap by examining the relationship between students' curiosity and their final grades in science subjects. The research will focus on identifying how different levels of curiosity among junior high school students correlate with their academic outcome and will seek to explore whether fostering curiosity in the classroom can lead to improved learning outcomes.

The novelty of this study lies in its specific focus on junior high school students, an often under researched group in terms of curiosity and academic outcome. While much of the existing research has focused on primary and higher education, less attention has been given to middle school students, who are at a critical developmental stage where curiosity and motivation begin to play a pivotal role in shaping their academic futures. By focusing on this age group, the study aims to provide valuable insights that can inform pedagogical practices at the middle school level, contributing to the broader conversation about how curiosity impacts student learning and achievement. Hence, the reseach questions proposed in this study are: (1) How do the different dimensions of curiosity (streaching, science, and embrace) manifest in junior high school students? (2) What are the key factors that influence the learning outcomes of junior high school students in science? (3) What is the correlation between students' level of curiosity and their academic performance in science?

The purpose of this research is to explore the correlation between students' curiosity and their learning outcomes in junior high school science education. By examining this relationship, the study aims to contribute to the understanding of how curiosity influences academic outcome and to offer practical recommendations for educators seeking to enhance student engagement and achievement in science. The findings of this research have the potential to influence the design of science curricula and teaching strategies, encouraging educators to foster curiosity-driven learning environments that promote deeper understanding and improved academic outcomes for students.

Methods

The research employed a quantitative research design with a survey to explore the relationship between curiosity and academic performance among junior high school students in science learning. Quantitative research design utilizing survey is a systematic approach to collecting numerical data to answer specific research questions (McBeath, 2020). This method is particulary effective for gathering large amounts of information regarding individuals' experiences, beliefs, and attitudes. Surveys encompasses the use of scientific sampling method with a designed questionnaire to measure a given populations's characteristics through the utilization of statical methods (Sukamolson, 2007). The correlational approach was adopted to measure the strength and direction of relationships between the three dimensions of curiosity (streaching, science, and embrace) and students' academic outcomes. A quantitative design was chosen to provide objective, measurable data that allows for generalization across similar student populations. The approach specifically targeted cause and effect relationship between curiosity dimensions and academic performance.

The participants in this study were 147 junior high school students from two distanct schools, representing grades 7, 8, and 9. A purposive sampling technique was employed to select a sample that represented the diversity of the schools in terms of location, student demographic, and academic backgrounds. This method was chosen to ensure that the sample adequately reflected a range of curiosity levels and learning outcomes, which is crucial for exploring how these factors interact in different educational contexts.

The instrument used in this study were as follows:

1. Curiosity Questionnaire
   A standardized curiosity questionnaire adapted from the science interest in learning environments (SCILE) instrument developed by Weible & Zimmerman (2016) was used to measure curiosity. The questionnaire consisted of three dimensions:
   a. Stretching: Items measuring students' tendency to explore and engage with novel ideas and concepts (e.g., "I enjoy learning about new topics in science").
   b. Science: Items assessing interest in scientific phenomena and inquiry-based activities (e.g., "I like conducting experiments to understand how things work").
   c. Embrace: Items gauging willingness to face uncertainty and challenging concepts (e.g., "I'm excited to learn about topics I find difficult at first").

Responses were recorded on a 5 point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

2. Learning Outcome Assessment
   Students' academic performance was measured using their most recent science test scores, sourced from school records. These tests were standardized across the schools and assessed core topics aligned with the national science curriculum.
3. Interview with Open Ended Question
   Indepth interviews were conducted with a selected number of students to gain deeper insights into their perspectives. Besides, we do an interview to several science teachers too. Interviews were recorded and transcribed for analysis.

The collected data were analyzed using both descriptive and inferential statistical methods:

1. Descriptive Analysis
   The mean, standard deviation, minimum, and maximum scores were calculated to describe students' levels of curiosity and learning outcomes. This provided insights into the general trends and variability in the dataset.
2. Correlation Analysis
   Spearman's rank correlation coefficient (ρ) was used to examine the relationship between each dimension of curiosity and learning outcomes. This nonparametric test was chosen due to the ordinal nature of the curiosity data and the potential nonlinear relationships.
3. Comparative Analysis
   Independent t-tests and one-way anova were conducted to explore differences in curiosity and learning outcomes across demographic groups, such as gender and prior exposure to science activities.

Results and Discussion

Dimensions of Curiosity in Junior High School Students

This study examines the role of curiosity, as measured by three indicators (stretching, science, and embrace) in influencing the academic performance of junior high school science students. Curiosity is essential for encouraging increased engagement in learning, and each indicator provides a unique perspective on how curiosity manifests in individuals and affects their academic progress (Grossnickle, 2016; Jirout & Klahr, 2012). Curiosity plays a crucial role in enhancing student engagement and learning outcomes across various educational contexts. Research highlights that curiosity not only initiates the learning process but also enriches it, leading to deeper understanding and improved academic performance (Rotgans & Schmidt, 2011). Moreover, curiosity enhances engagement, boosts cognitive processes such as memory encoding and retention, and maintains student engagement (Ryan & Deci, 2016; Hunaepi et al., 2024).

According to the SCILE instrument created by Weible & Zimmerman (2016), students' curiosity can be assessed along three primary dimensions, as shown in Figure 1: stretching, science, and embracing. The stretching dimension, which focusses actively seeking information and experimenting with new concepts, received the highest average score (3.49) of all the curiosity markers. This suggests that students are likely to explore novel concepts and step outside of their comfort zones when studying science. Stretching cultivates a mindset that is favourable to investigating new concepts, which is essential for learning science (Roman, 2011). According to Weible and Zimmerman (2016), stretching is crucial for preserving scientific curiosity, and the results support their findings. Stretching encourages behaviours that are critical to scientific inquiry and problem-solving, including as questioning, analysing new information, and conducting experiments. Stretching exercises improve critical thinking and problem-solving abilities, which are crucial for scientific research (Reio, 2013). Students who exhibit extending curiosity (the drive to learn beyond of their immediate surroundings and push themselves) are more likely to interact with content outside of the classroom (Sharma, 2024). They are naturally curious and frequently find fulfilment in conquering obstacles, they seek knowledge. They take the initiative to investigate scientific ideas and have enquiries that go beyond the scope of textbook knowledge, students who demonstrate stretching curiosity typically perform better in science classes. By giving students the chance to learn on their own and encouraging them to explore subjects that interest them, teachers can pique their curiosity.

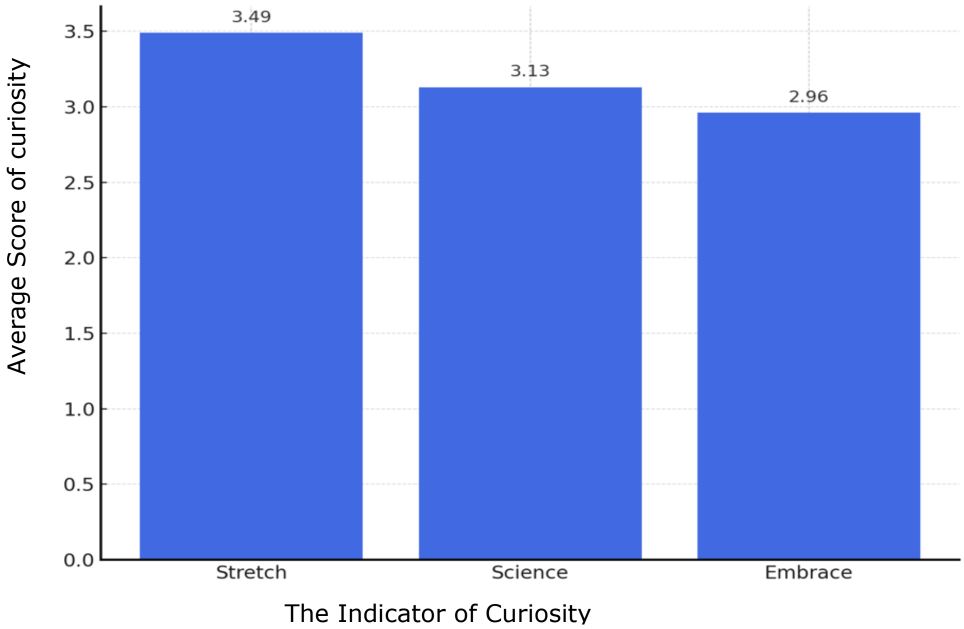

Figure 1. Graph of the average of students' curiosity in each indicator

The science indicator, which has a moderate average score of 3.13, shows that students are interested in scientific procedures. Weible & Zimmerman (2016) define science curiosity as the need for content specific knowledge about natural phenomena that is consistent with inquiry, problem solving, and question asking. This test assesses curiosity in relation to science related learning activities, such conducting experiments or investigating unexplained phenomena. Research indicates that students' interest in inquiry has a significant impact on their capacity for inquiry, particularly in terms of cognitive and emotional engagement (Wu & Wu, 2020). Science curricula and teaching strategies can be influenced by children's interests as expressed in their self generated enquiries, emphasising the value of matching student interests with instructional content (Baram-Tsabari et al., 2006). A particular interest in scientific investigation and comprehending the workings of the world is the focus of science curiosity. Strong scientific curiosity in students often results in deeper, more insightful enquiries about scientific subjects, which can improve critical thinking and problem solving skills. As junior high school science students start to investigate abstract ideas like chemistry, biology, and physics, this aspect of curiosity is particularly pertinent. Implementing hands-on activities in science classes significantly boosts students' curiosity, as evidenced by a study in Tanzania where such methods led to a marked increase in student engagement (Kibga et al., 2021). According to studies, children who have a curiosity for science are more likely to participate in extracurricular science events, scientific projects, and experiments (Kibga et al., 2021). Their knowledge of scientific ideas is improved by this active participation, which also promotes a deeper comprehension of the subject matter. Teachers can further pique students' scientific curiosity and boost academic performance in science courses by offering practical experiments or encouraging an inquiry-based environment.

The embrace component, which earned the lowest average score (2.96), gauges students' willingness to engage in uncertain or confusing situations, such as researching challenging scientific subjects. Students that are willing to accept diverse viewpoints and are open to investigating novel and unfamiliar concepts are described by the welcome curiosity dimension. This interest is especially beneficial in science since it pushes students to investigate alternative theories and challenge accepted scientific paradigms (Lindholm, 2018). Students that embrace curiosity are more likely to think critically and gain a deeper comprehension of scientific topics, surpassing mere knowledge acquisition (Jirout, 2020). Students who embrace discovery are less likely to be afraid of difficult subjects or new scientific ideas. As they are more flexible and able to take into account different strategies, students who are more open minded can improve their PSS. This kind of interest can be fostered by a teacher who supports inquiry based learning and exploration in science classes. This will enhance students' academic achievement as well as their capacity for critical and creative thought.

Factors Affecting Learning Outcomes in Science

The following figure illustrates the average learning outcomes for students in grades 7 through 9, reflecting how various factors contribute to students' academic performance in science. These factors include the increasing complexity of the material, envolving teaching strategies, and the growing engagement od students as they advance through their grades. Additionally, individual elements such as prior knowledge, study habits, and curiosity play significant roles in shaping the learning experience and outcomes.

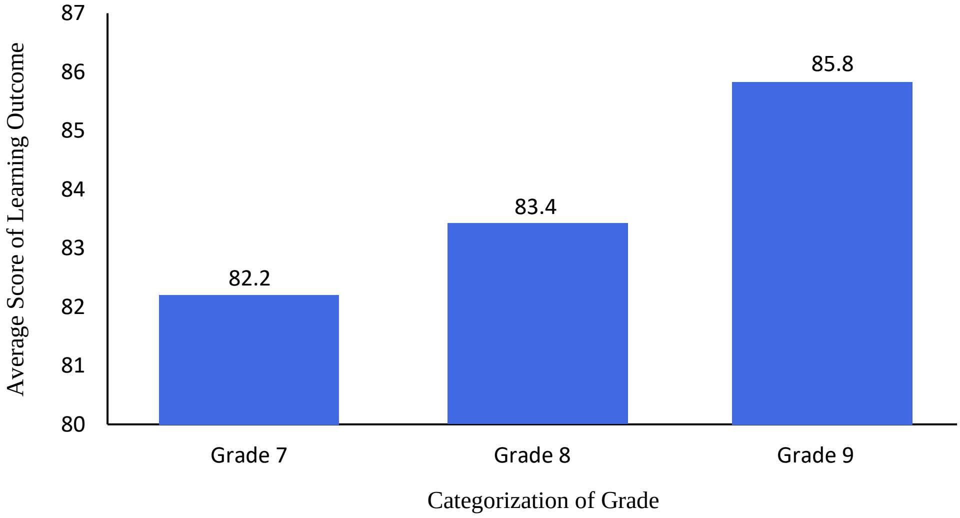

Figure 2. Graph of the average of students' Learning Outcome in each grade

Figure 2 shows an increasing trend in the average learning outcomes of students in science subjects from grade 7 to grade 9. This shows an increase in students' understanding of concepts and skills in science subjects along with increasing grade levels. The values used come from daily exam scores, midterm exam scores, and final exam scores. For the scores themselves, grade 7 got an average score of 82.2, looking at one level above it, grade 8 was at an average of 83.4. While at the final level in junior high school the average was 85.8. The results of the average were all 83.82. The results are quite high for a scale with a score of 100. A number of interconnected elements, such as greater material complexity, improved learning experiences, growing interest in science, and improved learning quality, can be blamed for the improving trend in science learning outcomes from grade 7 to grade 9. Students successfully adjust to increasingly difficult scientific ideas as they move through the grades. Various teaching approaches that promote comprehension and engagement facilitate this flexibility. Higher grades see increasingly difficult science courses that call for students to hone their critical thinking and problem-solving abilities. Project based learning (PjBL) dramatically improves students' cognitive outcomes, proving that they can understand challenging content (Abidin et al., 2024; Wibowos & Handayani, 2024). Both within and outside of the classroom, students are exposed to a variety of learning opportunities that enhance their comprehension of scientific ideas. It is stressed that practical work and hands-on activities are crucial for a deeper understanding and retention of scientific knowledge (Mondal et al., 2024). Students' interest in science tends to grow as they become older because they can better appreciate how important science is to everyday life. It has been demonstrated that captivating educational materials, such animated films, can successfully hold students' interest and enhance learning results (Sarina et al., 2024). A key factor is the quality of instruction; diverse teaching strategies and encouraging surroundings improve student success. Significant increases in student engagement and academic accomplishment have been associated with the use of creative tactics, such PjBL (Desiyanti & Nugroho, 2024; Wibowos & Handayani, 2024). On the other hand, even while these elements have a favourable impact on learning outcomes, obstacles including fluctuating student motivation and resource availability can impede advancement. Maintaining advancements in science education requires addressing these problems.

Student engagement is one of the most powerful factors affecting outcomes for learning. Effective online classroom management has been shown to increase student engagement, which has a favourable impact on learning results (Fei et al., 2024). Furthermore, elements like discipline, incentive, and the classroom setting are crucial for promoting student involvement (Amaliana & Kardoyo, 2024). According to the data, average grades increased steadily from Grade 7 to Grade 9, which would suggest that students are becoming more involved as they go. Students who receive higher grades in Grade 9 may be more motivated and interested in the material as they learn more about it and how it applies to real world situations. As one science teacher stated in one of the interviews conducted, "*In my classroom, I try to make science lessons as interactive as possible. I include more hands-on experiments and relate topics to real world issues that are relevant to students' everyday lives. For example, when discussing environmental science, I involve students in a project that measures pollution in their environment. This kind of project sparks curiosity and makes them more engaged in learning*.". Similarly, students reported that their interest in science increased as they progressed through the grades. "*In Grade 7, I was just starting to get used to science, but in Grade 9, I started to look forward to the experiments and class discussions. We were able to explore things that seemed more like real science*," which means that increased student engagement and motivation can lead to steady improvements in grades from Grade 7 to Grade 9, highlighting the importance of maintaining curiosity and interest in science.

Teaching strategies have a significant impact on how well students learn. Effective teaching methods are essential for promoting student engagement, which correlates with improved academic performance (Sajib, 2024). Improved teaching methods may be partly responsible for the increase in scores from Grade 7 (82.2) to Grade 9 (85.8). As children grow older, teachers may use more advanced teaching strategies that can improve understanding and retention of science topics, such as inquiry-based learning, project based learning, and hands-on activities. One teacher provided clarity about how she taught, "*In the early grades, I focused more on basic knowledge, using traditional methods like lectures and quizzes. However, in Grade 9, I was able to incorporate more inquiry-based activities. For example, in Grade 9, we focused on investigating scientific questions through experiments, and I encouraged students to come up with hypotheses and test* *them in the lab*.”. Additionally, one student agreed that teaching methods evolved as they progressed through their grade levels. “*I remember in Grade 7, we mostly read from the textbook and answered questions. But in Grade 9, we were able to design our own experiments and present our findings. It felt more like real science research.*” The increase in scores may reflect the introduction of more advanced and engaging teaching methods that were more in line with the learning needs of older students.

Student learning outcomes are heavily influenced by individual factors, including prior knowledge, study habits, and level of interest in the subject. Prior knowledge, study habits, and interest levels significantly impact student engagement and learning outcomes (Sajib, 2024; Amaliana & Kardoyo, 2024). As students get older and take on more responsibility for their education, these aspects tend to become more visible. When asked about the role of individual study habits, one science teacher explained, “*I noticed that as students progress from Grade 7 to Grade 9, they start to take more responsibility for their learning. They know how to manage their time better and seek out additional resources when they are struggling with certain concepts. In Grade 7, students often relied on me to guide them through every detail, but in Grade 9, they become more independent learners.*” One Grade 9 student testified about reflecting on her own development, sharing, “*In Grade 7, I didn’t have a clear study routine, and sometimes I found it difficult to stick to it. But in Grade 9, I started organizing notes and studying in groups with my friends. This helped me understand the material better*.” As students mature and develop better learning strategies, their academic achievement in science tends to improve, contributing to higher grades achieved in Grade 9.

The Link Between Curiosity and Academic Performance in Science

To better understand the relationship between students’ curiosity and learning outcomes, it is essential to first examine the desctiptive statistics of both variables. The following table represent the mean, standard deviation, and range of scores for students’ curiosity and their learning outcomes.

Table 1. Mean and standard deviation of students’ curiosity and learning outcome

Variabel	N	Mean	SD	Min	Max
Students’ Curiosity	147	66.52	12.833	76	98
Learning Outcome	147	83.82	3.605	35	96

According to the findings of descriptive statistics, this study had 147 participants with entirely valid data and no missing data. As shown in Table 1, the average curiosity score was 66.52 with a standard deviation of 12,833, indicating that the level of curiosity among students is moderate, with values ranging from 35 to 98. This suggests a considerable difference in students' curiosity for the topic or learning experience.

In contrast, the average score for student learning outcomes was significantly higher at 83.82, with a smaller standard deviation at 3.605. Student learning outcomes range towards the good category and are generally constant, according to the range of values 76 to 96. Low differences in outcomes for learning could be a sign of similar teaching quality or the efficacy of the used teaching strategies.

An intriguing first discovery is the disparity in distribution between learning outcomes and student curiosity. The diverse degrees of curiosity show that every student has a unique inclination to learn new things. The high and consistent learning outcomes, however, imply that other influences, like curriculum requirements or structured teaching strategies, may have a greater impact on academic achievement than students' natural curiosity.

These findings confirm the assertion made by Weible & Zimmerman (2016) that in order to significantly influence learning outcomes, student curiosity, particularly in the areas of stretching and embracing, needs to be guided and encouraged by a supportive learning environment. According to statistical findings, student interest varies in this setting, although it does not always have a direct impact on the learning outcomes attained. In order to improve both student engagement and academic performance, a learning method that combines curiosity-based activities with specific learning outcome targets may be useful.

This in line with the previous study which has found a moderate amount of student curiosity (M=66.52) compared to consistently good learning outcomes (M=83.82), implying that structured teaching approaches may have a greater impact on academic achievement than innate curiosity. These findings highlight the importance of future research into novel educational strategies for optimising curiosity's role in education.

All things considered, these descriptive data provide a first understanding of how a high level of interest does not always translate into successful learning outcomes when an appropriate learning approach is not used. The relationship between student curiosity and successful learning outcomes is complicated, as strong curiosity does not imply effective learning without adequate teaching approaches. Innovative approaches such as inquiry-based learning (IBL) and PjBL can help to close this gap by encouraging curiosity and improving educational outcomes. PBL has been demonstrated to significantly influence cognitive, emotional, and psychomotor learning outcomes, improving students' creativity and science skills (Sari, 2017). A study found that the use of PjBL considerably enhanced cognitive learning outcomes, with average scores going from 75.24 to 76.67 (Solihun & Aminullah, 2023). Several IBL strategies, including PBL and case-based learning (CBL), have been examined, demonstrating that PBL improves conceptual understanding and causal reasoning (Tawfik et al., 2020). Innovative IBL approaches, such as web based collaborative learning, have been highlighted as effective in solving the educational problems of the twenty first century (Bónus & Antal, 2021).

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Table 2. Correlation between dimensions of student curiosity and learning outcome

Dimention of Curiosity	Self Component	
	Correlation	Sig.
Strech	0.039	0.680
Science	0.055	0.565
Embrace	0.040	0.670

The three aspects of student curiosity (stretching, science, and embracing) and learning outcome had a very weak and negligible link, according to the findings of the Spearman correlation study. The stretching dimension, which reflects students' motivation to pursue novel challenges, has a significance value of 0.680 and a correlation coefficient of 0.039. The study found a weak link ($r = 0.039$, $p = 0.680$) between stretching and learning outcome, suggesting that while curiosity promotes exploration, its direct influence on academic scores may be lessened by other factors like teaching tactics, evaluation frameworks, and external motivations. The advantages of curiosity might be overshadowed by outside influences that have a substantial impact on learning results, such as motivation and teaching tactics (Oudeyer & Baranes, 2008). This suggests that student learning results have not been significantly impacted by the degree of curiosity in finding problems. Although this element motivates students to seek out new information and experiences, its poor relationship with academic achievement suggests that simple curiosity might not result in productive learning outcomes (Miljković & Jurčec, 2016). Accepting novelty and uncertainty is part of this dimension, which can increase interest but has little bearing on academic achievement (Pluck & Johnson, 2011). Curiosity is frequently suppressed by the standard curriculum, which lowers student engagement and learning. Teachers are urged to create spaces that value investigation and inquiry (Stokoe, 2012). Research has demonstrated that there is a need for more objective evaluations because self-reported measures of curiosity do not always correspond with academic achievement (Johnson, 2016; Raharja et al., 2018).

Additionally, there is a correlation of 0.055 with a significance of 0.565 for the Science dimension, which is associated with the students' curiosity in scientific phenomena. Despite being a strong motivator, curiosity does not ensure academic achievement, as shown by its poor relationship with learning outcomes (Liquin & Lombrozo, 2020). Although kids may exhibit science specific curiosity, this inquiry does not always lead to immediate academic success, as evidenced by the weak correlation ($r = 0.055$, $p = 0.565$) between science curiosity and learning outcomes. The discrepancy between formal learning assessments and curiosity-driven inquiry may be the cause of this. Bridging the gap between students' inquiry-driven learning experiences and the organised nature of formal assessments, which might not fully reflect them, is the problem. On the other hand, some contend that when structured learning environments are in line with students' interests and capacity for inquiry, they can successfully foster curiosity and enhance academic achievement. This finding suggests that, despite students' enthusiasm in investigating scientific topics, the activity had no discernible impact on their academic achievement. This aspect is probably caused by a lack of facilities that enable students to participate more deeply in science activities or by a lack of support from teaching strategies focused on scientific exploration. Inadequate funding may restrict scientific hands-on activities, which are essential for stimulating curiosity and gaining a deeper comprehension. Research shows that resource-rich environments improve learning outcomes and engagement, indicating that a lack of facilities may inhibit curiosity driven research (Hunaepi et al., 2024). Improving academic achievement requires the use of effective teaching practices that foster curiosity. Curiosity driven learning has been shown to boost educational performance by 30% (Hunaepi et al., 2024). However, information is frequently given precedence over inquiry in traditional curriculum, which can stifle kids' innate curiosity (Stokoe, 2021). Curiosity is not a prerequisite for academic achievement on its own, even while it is associated with improved learning and engagement. Educational outcomes are also significantly influenced by other factors, such as socioeconomic position and the calibre of the teachers (Hassinger-Das & Hirsh-Pasek, 2018).

Lastly, there is a 0.040 connection and a 0.670 significant value for the Embracing dimension, which gauges students' capacity to handle uncertainty. The weak correlation between embracing uncertainty and learning outcomes ($r = 0.040$, $p = 0.670$) suggests that while students may not see immediate academic benefits, their openness to uncertainty can foster broader scientific engagement. Effective learning requires curiosity, especially in science, where it can result in greater comprehension and improved diagnostic abilities in medical school (Roman, 2011). Uncertainty can hinder students' curiosity and learning potential since teachers frequently find it difficult to use it as an educational tool (Starrett et al., 2024). Students' engagement with scientific knowledge is greatly influenced by emotional elements, such as epistemic motivation, which also affects their willingness to tackle difficult subject (Jaber & Hammer, 2015). Curiosity can improve learning results, according to research, particularly when paired with structured learning settings like immersive virtual reality (Lee et al., 2022). On the other hand, a lack of support and a fear of failing could discourage curiosity driven research, indicating that in order to increase student interest in science, educational settings should actively foster a culture of inquiry and resiliency. According to this correlation, students are still not as comfortable handling difficult or confusing circumstances. This poor correlation might be caused by teaching strategies that place more emphasis on structure and tangible outcomes, leaving little room for students to experiment with ambiguous or adaptable solutions. Conventional teaching approaches frequently place an emphasis on observable, measurable outcomes, which can hinder students' capacity to deal with ambiguity (Patel et al., 2022). There are frequently little opportunities for students to try out uncertain situations, which makes them unconfident while handling challenging circumstances (Albertyn & Bennett, 2020).

All things considered, these results show no discernible relationship between students' learning outcomes and the three aspects of their curiosity. Conventional teaching strategies that haven't completely incorporated students' interest into the learning process may be to blame for the low correlation. Weible and Zimmerman (2016) assert that in order to positively influence learning outcomes, more creative teaching strategies like PjBL or inquiry-based learning must encourage students' curiosity, particularly in the areas of stretching and embracing uncertainty. Innovative teaching techniques like PjBL and IBL are crucial for raising academic attainment because they encourage students' curiosity and critical thinking (Oliveira & Lathrop, 2022). In order to maximise curiosity and connect it to better academic achievement, educators must create lessons that inspire students to actively explore, think critically, and confront uncertainty. Exploration and learning are naturally fuelled by curiosity, which is essential for academic achievement (Hassinger-Das & Hirsh-Pasek, 2018). Research indicates that increased curiosity is associated with better academic achievement, especially in early childhood education (Hassinger-Das & Hirsh-Pasek, 2018). Traditional approaches frequently fail to pique curiosity, which leads to disinterest (Oliveira & Lathop, 2022). It has been demonstrated that innovative teaching methods, such as discovery learning, improve students' engagement and critical thinking abilities.

Students' open-ended answers offer a deep and comprehensive grasp of the elements that affect curiosity throughout science learning, both favourably and unfavourably. Several major themes emerge from the students' perspectives as the qualitative data shows how curiosity is expressed through interest, difficulties, and learning contexts.

Numerous students stated that exploration, real world connections, and hands-on experiences are what fuel their scientific curiosity. Inspiration was frequently cited for practical experiments and subjects that describe natural processes. The idea of explanation seeking curiosity emphasises how students are inspired to enquire and look for answers, especially when they come across new or unexpected knowledge (Liquin & Lombrozo, 2020). One student offered, for example: *"The experiments are really fun, and science leads to many fields like medicine and other areas of science, which is why I really enjoy the subject."* This is consistent with curiosity's Stretching dimension, which emphasises taking on novel tasks. Students exhibit a strong desire for exploration, often driven by hands-on activities that allow them to engage directly with scientific phenomena (Luce & Hsi, 2014). Given the chance to conduct experiments and engage in discovery-based learning, students' inclinations to enquire, observe, and analyse are innate. Similarly, science becomes more approachable and meaningful when it is connected to the actual world, for as when studying about plant growth, organ processes, or ecosystems. As one student put it: *"Science teaches us about the beauty of nature and living things and many new things that can be discovered."* Science becomes more relevant and approachable when it is linked to practical uses. Studying plant development or ecosystems, for example, can pique attention by demonstrating how science is applicable to daily life (Kang et al., 2016). According to research, students become much more engaged and motivated to learn when they believe that scientific concepts are relevant (Kashdan et al., 2004). It has been demonstrated that experiential learning improves procedural knowledge by enabling students to apply ideas in real world contexts, which is essential for fostering scientific thinking (Glasson, 1989).

On the other hand, students pointed out a number of obstacles that impede their interest, which are frequently connected to conventional teaching strategies and the way that material is presented. Among the most prevalent problems were: (a) Over memorization: Students often complained about the deluge of information, especially theoretical ideas and formulas. *"There are too many summaries and formulas to memorize."* one student said. This is consistent with research showing that kids have a propensity to acquire things superficially by memorising terminology without comprehending the underlying ideas (Aziiza & Juandi, 2021). (b) Absence of visualisation: Without tests, instruments, or visual aids, abstract scientific subjects like physics or chemistry can be challenging to understand. This is mirrored in phrases like *"Science material is difficult to understand if it is only explained without examples or aids."* According to research, incorporating visual aids into scientific lessons is frequently necessary for improved comprehension and memory (Novianda, 2022). (c) Fear of failure: The facet with the lowest score was embrace, which gauges one's readiness to take on difficult or unknown situations. Many students acknowledged that they had trouble understanding ideas that intimidated them. *"I'm afraid to learn formulas, especially if I don't understand them straight away."* one student said. A lot of students show signs of fearing failure, especially when confronted with difficult ideas. Because they may be intimidated by the possibility of not understanding, this anxiety may prevent them from being willing to interact with difficult content (Rahmadani et al., 2023). These results point to a significant disconnect between the instructional methods used in classrooms and children' innate curiosity. Students' inclination to experiment, ask questions, and explore is frequently stifled by the emphasis on rote learning and prescribed information.

In order to close the gap between learning objectives and curiosity, teachers are essential. When teachers used creative and interesting teaching techniques, such experiments, films, or real-world examples, students responded favourably. For example: *"Teachers who explain the material in an interesting way, using experiments or videos, make me more curious."* To encourage curiosity, educators can use: (a) Inquiry based learning: The science dimension of curiosity is well aligned with encouraging students to formulate questions, plan experiments, and evaluate findings. Teachers can increase student engagement and comprehension by letting them research subjects that interest them. By enabling students to investigate subjects of personal interest, this method improves student engagement and comprehension and promotes a deeper comprehension of scientific ideas (MacKenzie, 2001). (b) Practical and visual learning: Integrating visual aids, experiments, and simulations can make abstract concepts more accessible. For example, teaching about the respiratory system using models or videos allows students to connect theory with real-life applications. Abstract ideas become more concrete when visual aids and practical trials are incorporated. For example, teaching the respiratory system via models links abstract concepts to practical uses (Scott-Barrett et al., 2023). (c) Safe learning environments: To address the reluctance highlighted in the embrace dimension, teachers must create supportive environments where students feel encouraged to take risks, make mistakes, and learn from them without fear of judgment. Fostering a positive learning environment in the classroom empowers students to take chances and grow from their errors without worrying about being judged (Handfield-Jones et al., 1993).

Although curiosity sparks engagement, it does not necessarily result in quantifiable success, as evidenced by the discrepancy between curiosity levels and consistent learning outcomes found in the quantitative data. This might be the result of outside influences like strict tests or inadequate instructional methods. A perceptive student asked: *" Why do science lessons always have formulas? Why not just practice more?".* This emphasises the necessity of a well-rounded strategy that blends organised learning objectives with curiosity driven inquiry. Teachers can accomplish this by: (a) PjBL: Through the application of curiosity in an organised way that also aims to meet learning objectives, projects enable students to delve deeply into scientific subjects. Fosters inquiry and critical thinking by coordinating curiosity with well defined learning objectives (Vracheva et al., 2019). (b)

Open ended assessments are replacing strictly formulaic exams with ones that gauge students' capacity for inquiry, critical thinking, and problem solving. According to research, these kinds of tests are better able to capture the subtleties of students' interest and engagement (Motz et al., 2017).

Curiosity is the cornerstone of lifelong learning, not just a means of enhancing academic achievement. As one student fervently put it: *"I want to continue studying science because there are many new things that I don't know yet.".* Teachers and legislators must make sure that scientific education has a strong emphasis on investigation, relevance, and discovery in order to maintain this curiosity. Students can gain a greater understanding of science outside of the classroom by cultivating their curiosity through interesting teaching strategies, practical applications, and encouraging surroundings.

The students' answers unequivocally demonstrate that scientific curiosity is complex and influenced by a variety of factors, including instructional strategies, the way material is presented, and exploratory opportunities. Engagement is fuelled by curiosity, especially in the stretching and science elements, but it needs to be fostered via creative approaches that overcome obstacles including memorisation, a lack of visualisation, and failure related anxiety. Teachers may close the gap between learning objectives and curiosity by converting classrooms into places of inquiry and discovery. This will produce a generation of students who are critical thinkers, curious, and scientifically literate.

Conclusion

Curiosity has many different dimensions, including streatching, science, and embrace. This study has examined the complex relationship between curiosity and academic achievement in junior high school sciencetific education. The results show that although curiosity is a powerful motivator for learning and student engagement, its direct effect on academic achievement are complex and impacted by a range of outside variables, such as instructional methods, classroom settings, and individual student traits. The results reveal that students show a modest amount of curiosity, particulary in streaching dimension, which emphasizes exploration and engagement with new concept. However, the correlation between curiosity and academic outcomes was found to be weak, suggesting that curiosity alone does not guarantee improved learning result. This disparity emphasizes how crucial it is to use effective pedagogical approaches that align with students' interest and foster an environment conducive to inquiry and exploration. Furthermore, the qualitative information obtained from student interviews sheds light on the obstacles to curiosity, including fear of failure, rote memorization, and lack of visualization. These difficulties show how important it is for teachers to use innovative methods of instruction like inquiry based and project-based learning, which not only pique students' interest but also improve their comprehension and memorization of sciencetific ideas. Encouraging greater engagement and better academic results in sciencetific education requires cultivating curiosity in the classroom. Teachers are urged to established nurturing classrooms that value inquiry, applications, and practical experience. Teachers may develop a generation of sciencetifically literaye students who are not only informed but also inspired to pursue lifetime learning in the sciences by bridging the gap between curiosity and defined learning objectives. In order to create solutions that successfully combine curiosity driven inquiry with academic success, future research should keep examining the dynamics of curiosity in various educational situations.

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