BHARATI INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH & DEVELOPMENT (BIJMRD)

(Open Access Peer-Reviewed International Journal)

DOI Link :: https://doi.org/10.70798/Bijmrd/020800020

Available Online: www.bijmrd.com|BIJMRD Volume: 2| Issue: 8| September 2024| e-ISSN: 2584-1890

Enhancing Student Engagement and Achievement in Geography through STEM Education

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Abstract:

Since the field of geography has traditionally focused on memorization of geographical names and physical characteristics, it has struggled to engage students in a meaningful and lasting way. Applying the STEM (Science, Technology, Engineering, and Mathematics) framework offers a game-changing approach to pique students' attention and boost their performance in geography courses. This study examines the many benefits of incorporating STEM concepts into geography classes, with an emphasis on interdisciplinary connections, experiential learning, and the growth of analytical and problem-solving skills. The study's sample size was 200 individuals, and it conducted in the Murshidabad region of West Bengal. Using descriptive analysis, researchers may learn a lot and look at numerous educational phenomena in detail. By collecting and analyzing data on student engagement, performance, and pedagogical approaches, researchers may get a comprehensive picture of the educational landscape. The use of descriptive analysis also facilitates the selection of high-quality STEM-integrated geography lectures and activities. By poring over student work, teacher remarks, and classroom observations, researchers find out what methods boost student engagement and performance. The integration of STEM and geography education is, finally yet importantly, a dynamic and effective way to increase student engagement and achievement. By putting an emphasis on hands-on learning, fostering connections across disciplines, and developing students' critical thinking and problem-solving skills, this approach helps students thrive academically and become ready for the contemporary world.

Keywords: *STEM Education, Geography Education, Student Engagement, Student Achievement, Hands-On Learning.*

1. Introduction:

Classes in geography have a significant impact on how students see the interconnected systems, cultural practices, and diverse landscapes of the globe. Nevertheless, traditional approaches to teaching geography fall well short of capturing students' attention and motivating them to fully engage with the subject. To combat this, more and more teachers are seeing STEM (Science, Technology, Engineering, and Mathematics) curricula as a game-changing approach to improving students' interest in and performance in geography classes. By encouraging students to make connections across disciplines, STEM education provides a rare chance to help students gain a more comprehensive grasp of the world around them, including geographical ideas (Lee & Bednarz, 2012). Students may uncover complicated spatial linkages and

patterns by analysing geographic phenomena holistically via the integration of mathematics, scientific investigation, and technology technologies. One characteristic of good STEM education is the incorporation of experiential learning opportunities for pupils. From the effects of climate change to the dynamics of urbanization, students may study real-world geographic phenomena via laboratory experiments, fieldwork, and geospatial technology (National Geographic Society, 2018). Not only do students become more invested in the learning process, but they also develop important life skills like data analysis, critical thinking, and problem solving via these immersive experiences. It gives them the tools they need to tackle global problems head-on and become innovators in the process. Environmental sustainability, natural resource management, and geopolitical conflicts are some of the complicated challenges solved by students using STEM concepts in geographic inquiry (UNESCO, 2017). Students learn to adapt and persevere in the face of constant change via design thinking and project-based learning. Various job paths unlocked by the integration of STEM into geography education, including urban planning, environmental conservation, geographic information science (GIS), and geospatial technology (National Geographic Society, 2019). Educators have a responsibility to prepare the next generation to address critical global issues by exposing them to STEM fields and giving them opportunities for hands-on experience in these fields. Equity and diversity in geographical education fostered via inclusive STEM education programmes. In addition, the conversation around geography becomes more nuanced and inclusive when marginalized groups and indigenous knowledge systems are included. This helps to advance educational equity. Incorporating STEM education into geography curricula has the potential to greatly improve student engagement and performance. Educators may prepare students to become intelligent global citizens who can tackle the complex issues of the 21st century by encouraging interdisciplinary inquiry, practical learning, problem-solving abilities, job preparation, and inclusiveness. A new generation of ecologists and geographers might be inspired to explore and protect our world via STEM-infused geography education's collaborative efforts and creative pedagogies.

1.1. Background of the Study:

In order for pupils to comprehend the global spatial patterns, ecological processes, and cultural landscapes, it is crucial that they get a geography education. Traditional methods of geography instruction, on the other hand, often fail to captivate pupils and cultivate meaningful learning opportunities. Disinterest and disengagement in geography stem from many students' perception that it is abstract and unrelated to their everyday life (Lambert, 2011). The goal of educators who include STEM ideas into geography curricula is to provide students real-world experiences that encourage them to think critically, be curious, and become spatially literate. Research demonstrating the advantages of transdisciplinary learning lends credence to the incorporation of STEM into geography curricula. Because geographic research often incorporates mathematical and scientific principles, geographical data analysis, and fieldwork, it is only logical that geographic investigation would naturally lead to links with STEM fields (Harris & Brueckner, 2016). Educators may help children better grasp geographic phenomena and solve real-world problems by combining math, environmental science, and technology. The fields of geospatial technology, environmental management, and urban planning are becoming more reliant on geographic information science (GIS), remote sensing, and spatial analysis (UNESCO, 2017). Geography classes that emphasize science, technology, engineering, and mathematics (STEM) may help students become well-rounded individuals who can succeed in the workforce and make positive impacts on the world. Nevertheless, there are obstacles to effectively applying STEM education in geography, despite the potential advantages. Shortages in funding, chances for professional growth, and curriculum alignment are some of the challenges that teachers may face (Becker et al., 2018). The study's overarching goal is to help educators better equip their students to thrive in a globalized and technologically advanced economy by shedding light on what works in STEM-based lesson plans for geography classes. By bringing together academics, educators, and policymakers, STEM-infused geography education may enable students to become educated global citizens, foster critical thinking, and stimulate curiosity.

1.2. The Statement of the Problem:

This study addresses the pressing need to enhance student engagement and achievement in geography education through the integration of STEM (Science, Technology, Engineering, and Mathematics) principles and practices. Four key research objectives guide the inquiry, each aiming to elucidate different facets of this multifaceted issue. The study seeks to explore the differences in student engagement in STEM integrated geography education concerning gender. Gender disparities in education have long been a concern, with research indicating variations in academic performance, participation, and interest between male and female students (Else-Quest et al., 2010). By investigating how gender influences student engagement within the context of STEM integrated geography education, the study aims to identify potential disparities and devise strategies to promote equitable participation and achievement for all students. The study aims to examine the differences in student engagement in STEM integrated geography education concerning locale. Students' geographic location can significantly impact their educational experiences, with urban and rural students often facing distinct challenges and opportunities (Howley et al., 2010). This project aims to find out why there are differences in student involvement and how to fix it by looking at how location affects STEM integrated geography education and how to implement targeted interventions so that everyone can obtain a good education. It compares the level of student involvement and academic performance in geography classes taught using STEM-based methods to those taught without. Fredericks et al. (2004) emphasize the need of understanding the connection between engagement and accomplishment in order to enhance learning outcomes and develop effective teaching practices. The purpose of this research is to evaluate the effect of STEM education on geography students' knowledge and performance by comparing their performance before and after the subjects were integrated. It examines several STEM-based teaching methods and how well they interest students in geography. Despite the availability of several methods of training, few studies have examined their effectiveness in the field of geography (Guzey et al., 2016). The research aims to find the best ways to get students interested in and doing well in geography by comparing the effects of several STEM-based tactics. These strategies include things like project-based learning, inquiry-based learning, and hands-on activities. In light of this, the study accomplishes important research goals in its pursuit of a better understanding of how STEM education might increase student engagement and performance in geography. The study's overarching goal is to increase the standard of geography education for all students by shedding light on gender and location-based disparities in engagement, the correlation between engagement and performance in the classroom, and the effectiveness of STEM-based teaching methods. Thus, the study entitled as "Enhancing Student Engagement and Achievement in Geography through STEM Education."

1.3. The Significance of the Study:

Understanding the effects of incorporating STEM education into geography lessons on student engagement and performance is crucial for informing educational practice and policy, which is where this research comes in. The study's results might help shape curriculum, professional development programmes, and evidence-based teaching approaches that had better engage students, boost their academic performance, and equip them to meet the challenges of a dynamic and unpredictable future. The overarching goals of this research are to promote educational fairness, encourage pedagogical innovation, and equip students to become knowledgeable, engaged citizens who can meet the complex problems of the modern world.

1.4. The Objectives of the Study:

O_1: To explore the differences in student engagement in STEM integrated geography education in respect of gender.

O_2: To explore the differences in student engagement in STEM integrated geography education in respect of locale.

O_3: To investigate the relationship between student engagement and academic achievement in geography before and after the implementation of STEM-based instructional practices.

O_4: To analyze the different STEM-based instructional strategies in enhancing student engagement in geography.

1.5. Hypotheses of the Study:

Ho_1: There were no significant difference in student engagement levels in STEM integrated geography education between male and female students.

Ho_2:There were no significant difference in student engagement levels in STEM integrated geography education between students from urban, suburban, and rural locales.

Ho_3: There were no significant relationship between student engagement and academic achievement in geography before and after the implementation of STEM-based instructional practices.

Ho_4:There were no significant difference in student engagement in geography between different STEM-based instructional strategies.

2. The Review of Related Literature:

Yeung, R. C. Y., Yeung, C. H., Sun, D., & Looi, C. K. (2024). Trends, pedagogies, and learning outcomes in secondary school STEM instruction via the use of drones (2005–2023): a comprehensive study. In the field of education and computing, 104999. The results highlight how secondary school students may use drones to develop their problem-solving and creative skills via multidisciplinary, hands-on applications that promote STEM disciplines.

Adegoke, O. T. et al (2024). Review of the literature on the incorporation of ICT in STEM education in Rwanda. Advances in STEM Education via the Use of ICT, 68–81. Both the usage and integration of ICTs to promote STEM education and the obstacles affecting the integration of ICT into STEM education were found as significant topics throughout the literature study. The results demonstrate that in Rwanda, STEM education made use of information and communication technology (ICT) resources like Geometers' Sketchpad, online discussion forums, geographic information systems, spreadsheets, YouTube videos, smart classrooms, and Physics Education Technology (PhET) simulations. According to the reviewed research, STEM education in Rwanda that makes use of technology boosts student performance, increases spatial thinking skills, and improves teaching practices.

Akon-Yamga. et al (2024, April). Student and educator viewpoints on the difficulties of STEM education in Ghana. This is Frontiers Media SA. As a further step towards sustainable growth, these students will get the training necessary to staff the STI system. This article suggests that, in order to make it compatible with Ghana's STI system, pre-tertiary STEM curricula should be redesigned to match tertiary STEM curricula.

.**Ješková, Z. et al (2022).** Active knowledge acquisition in STEM fields as it relates to the formation of investigative abilities. Although the research found that students' inquiry abilities started poor, there was a statistically significant development with a medium size impact among the 2,307 students who participated in the study.

2.1. Research Gap:

This study lacks a comprehensive examination of how integrating STEM education into geography curricula affects student involvement and performance. In order to fill this knowledge gap and improve teaching

methods and curriculum creation based on evidence, it is essential to do research on the ways in which STEM education may be used to improve geography student results.

3. Methodology of Study:

Two hundred people living in the Murshidabad region of West Bengal, India, were randomly selected to participate in this study's descriptive survey. This approach uses interviews or structured questionnaires to learn about the participants' actions in relation to STEM integration and geography education. In order to shed light on the existing situation of geography education and to identify particular elements affecting student involvement and accomplishment in this region, the research will use a representative sample from the Murshidabad area. Researchers may use the descriptive survey approach to systematically gather and analyse data, which in turn helps them develop meaningful conclusions and informs community-specific educational activities.

3.1. Research Tool:

- The researcher used student self-made scale on Student Engagement in Geography through STEM Education (30 items).
- The Academic Achievement records were collected through the implementation of achievement test at 2 months intervals.

3.2. The Reliability and Validity of Scale:

The reliability and validity of scale were .799 and .679 through split half and content validity methods respectively.

4. Analysis and Interpretation:

Ho_1: There were no significant difference in student engagement levels in STEM integrated geography education between male and female students.

To verify the hypothesis, Descriptive Analysis and Independent t test were performed by the investigator, which was shown in the following tables.

Table 4.1: Group Statistics on Student Engagement in STEM Education

Student Engagement in STEM Integrated Geography Education	Variations		N	Average	S.D.	Std. Error Mean
	Gender	Boys	100	126.02	4.027	.621
		Girls	100	141.69	8.348	1.288

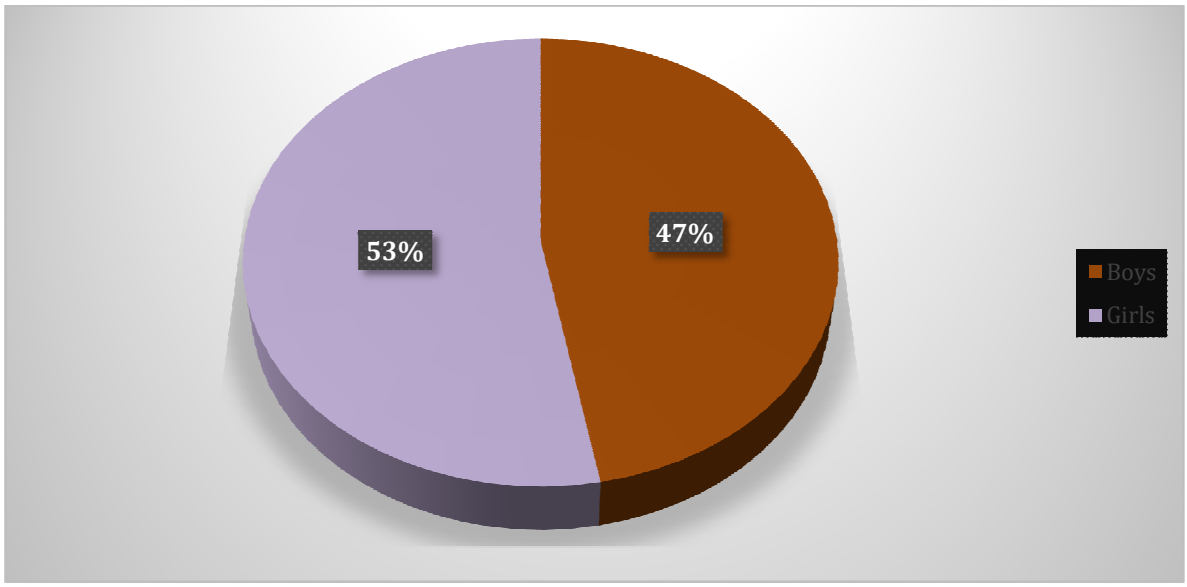

Figure 4.1: The Graphical Representation of Student Engagement in STEM Education

The statistical study shown in Table 4.1 compares the participation levels of male and female students in geography courses that include STEM themes. Women outperform males in terms of average engagement score, according to the research. On average, men score 126.02, while females score 141.69. It is clear from the significantly different averages that girls are often more enthusiastic about STEM integrated geography studies than boys do. The greater average score among females might be due to innate female interests in STEM subjects, alternative pedagogical practices, or differently structured courses. By examining the standard error of the mean (Std. Error Mean), one may get a sense of the dispersion of the sample mean and its potential comparison to the genuine population mean. Girls have a standard error of 1.288 while boys' is.621. The standard error is larger for female engagement ratings due to their greater variability.

Table 4.2: Analysis ofIndependent t test for Student Engagement in STEM Education

Student Engagement in STEM Integrated Geography Education	Equality of Variances according to Levene Test			t test for Identical of Average			
	Identical Variances not Assumed	F-Value	Sig. Value	t-Value	df	Remark	Average Difference
		22.896	.000	-10.955	198.105	.000	-15.667

Male and female students' engagement in STEM-infused geography classes was compared using an independent t-test, as shown in Table 4.2. This approach also incorporates Levene's test for equality of variances and the t-test for equality of means, with the assumption that the variances are not equal. This checked using Levene's test to see whether the variances of the females and boys are equal. Setting the significance threshold at.000 yields an F-value of 22.896. We may dismiss the idea that the variances are identical as the Sig. value is less than the usual cutoff of.05. With a significance level of.000, the t-value is -10.955. Given the strong result ($p < .001$), it cannot be believed that girls and boys have equal average levels of participation. The mean score for females is noticeably higher than that for boys, as shown by the negative t-value. After adjusting for the uneven variances in the two groups, the test yields 198.105 degrees of freedom (DF). On average, there is a 15.667-point gap between the male and female participation ratings. For STEM integrated geography classes, females often outperform boys by a margin of 15.667 points, as

seen by this negative figure. Motivating factors might stem from the subject's past, their hopes for the future, or perhaps just a more personal relationship with their desires.

Ho_2:There were no significant difference in student engagement in STEM integrated geography education between students from urban and rural locales.

To verify the hypothesis, Descriptive Statistics and Independent t-test was performed by the investigator, which was shown in the following tables.

Table 4.3: Group Statistics-Student Engagement in STEM EducationLocale-wise

Student Engagement in STEM Integrated Geography Education	Variations		N	Average	S.D.	Std. Error Mean
	Locale	Urban	100	141.41	5.685	1.038
		Rural	100	128.40	8.329	1.133

Source: Field Survey 2023-2024

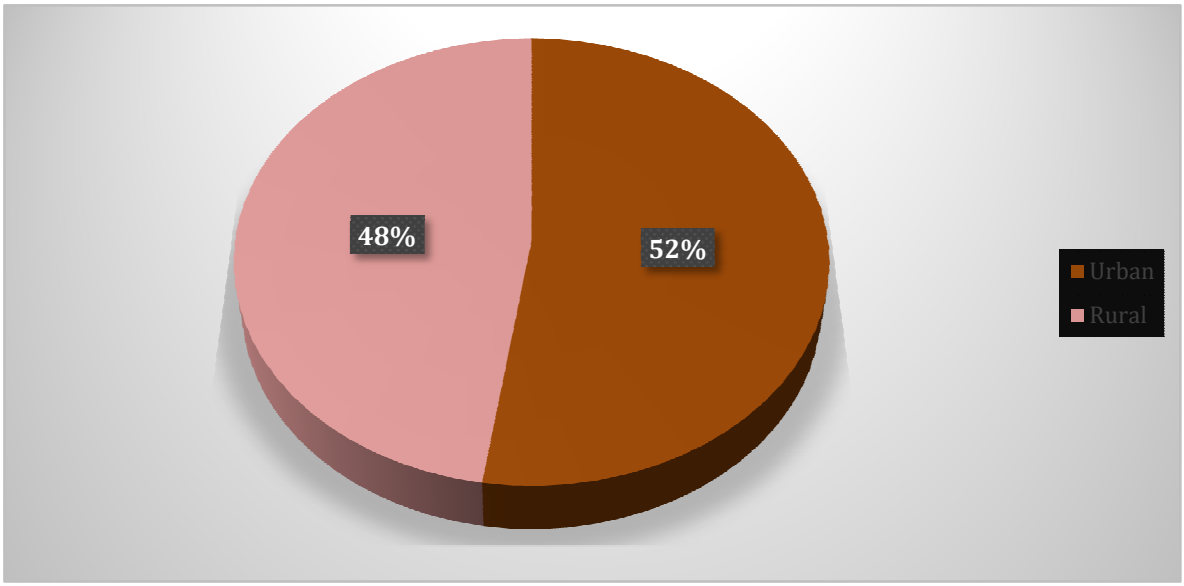

Figure 4.2: The Graphical Representation ofStudent Engagement in STEM EducationLocale-wise

Student participation in STEM integrated geography education in urban and rural areas is compared in Table 4.3. Compared to pupils in rural regions, whose average engagement score is 128.40, students in urban areas had a much higher average score of 141.41. Compared to their rural counterparts, urban students seem to be more engaged in STEM integrated geography instruction. Students in metropolitan areas may have more opportunities to learn, greater exposure to more types of instructional materials, and more engaging classroom settings, all of which contribute to higher average scores. Dispersion of engagement ratings among each group is measured by the standard deviation (S.D.). The standard deviation for students residing in urban areas is 5.685, suggesting that there is very little variation around the mean score. Students in rural areas seem to exhibit more variation in their levels of involvement, as seen by a larger standard deviation of 8.329 for this demographic. An approximation of the gap between the sample mean and the actual population mean is given by the standard error of the mean (Std. Error Mean). The rural students' standard error is a

hair higher at 1.133 than the urban students' 1.038. Educational resources, including labs, state-of-the-art technology, and extracurricular STEM activities, tend to be more readily available in urban schools. Students are more actively involved in their education when teachers in urban schools adopt these strategies. Student involvement enhanced by the broad and creative educational techniques used in urban schools, such as interdisciplinary teaching and project-based learning. The goal of developing urban curriculum is to make them more interesting and relevant to students' lives by addressing topical topics and providing practical examples.

Table 4.2.4: Analysis ofIndependent t test for Student Engagement in STEM Education

Student Engagement in STEM Integrated Geography Education	Equality of Variances according to Levene Test			t test for Identical of Average			
	Identical Variances not Assumed	F-Value	Sig. Value	t-Value	df	Remark	Average Difference
		8.970	.004	8.463	198.105	.000	13.007

Urban schools utilize innovative and diverse educational approaches that aim to engage students more deeply in their education, such as project-based learning and interdisciplinary teaching. The goal of this urban curriculum is to make learning about subjects that are essential to kids today more engaging and relevant to their everyday lives. Results from an independent t-test comparing rural and urban students' engagement with STEM integrated geography lessons are shown in Table 4.2.4. The purpose of this study is to examine the variations of urban and rural students using Levene's test. The calculated F-value is 8.970, which is significant at the.004 level. Since the Sig. value is less than the conventional threshold of.05. We may reject the null hypothesis that the variances are equal. The t-value is 8.463 at the.000 level of significance. Students in urban and rural locations do not have identical average engagement ratings, since this result is highly significant ($p < .001$). This independent t-test found that students' levels of engagement with STEM integrated geography teaching were significantly different across urban and rural settings. The much higher average engagement score, significant t-value, and average difference clearly indicate a difference between urban and rural children. It is possible that the higher involvement rates among urban students are a result of their greater access to resources, technology, and extracurricular activities. Extra funding and other resources are directed into urban schools in order to better support STEM education. Students in urban schools benefit from a more interesting and relevant curriculum and teaching methods. In order to spark students' interest in STEM areas, these tactics include project-based learning, the exploitation of digital tools, and the inclusion of real-world applications. Lower engagement scores among students in remote places highlight the need for concentrated measures to promote STEM education in these areas. Improved financing for teacher professional development, more accessible educational resources, and the launch of more engaging STEM programs tailored to rural areas are all potential steps in this direction.

Ho_3: There were no significant relationship between student engagement and academic achievement in geography before and after the implementation of STEM-based instructional practices.

To verify the hypothesis, Correlational Analysis were performed by the investigator, which was shown in the following tables.

Table 4.2.6: Correlational Analysis betweenStudent Engagement and Academic Achievement in Geography Before Implementation of STEM-based Instructional Practices

		Student Engagement	
Student Engagement	Pearson Correlation	1	.105
	Sig. Value		.000**
Academic Achievement	Pearson Correlation	.105	1
	Sig. Value	.000**	

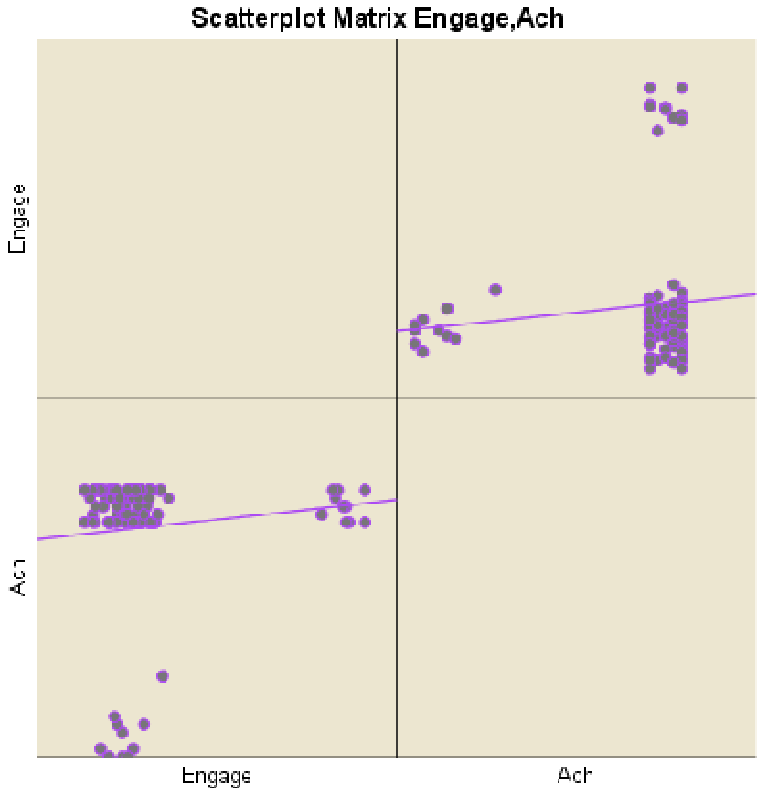

Figure 4.3: The Graphical Representation of Student Engagement and Academic Achievement in Geography before Implementation of STEM-based Instructional Practices

Since the observed correlation coefficients are statistically significant at the p <.001 level, the likelihood of their occurring by mistake is low. There was a weak but positive link between student engagement and academic achievement in geography prior to the introduction of STEM-based teaching methods (Pearson correlation = 0.105). According to the positive correlation, students' academic performance seems to increase as their interest in geography grows. Having said that, a correlation score of 0.105 indicates that the link is weak. Before the development of STEM-based instructional tactics, pupils were neither engaged nor captivated by traditional teaching methods. According to the correlation study in Table 4.2.6, there was a tiny but favourable link between student participation and academic achievement in geography before STEM-based teaching methodologies applied. There has to be a shift in how we educate and inspire children to thrive in geography (and maybe other subjects) since this link, although statistically significant, is still modest.

Table 4.2.7: Correlational Analysis betweenStudent Engagement and Academic Achievement in Geography After Implementation of STEM-based Instructional Practices

		Student Engagement	Academic Achievement
Student Engagement	Pearson Correlation	1	.705
	Sig. Value		.000**
Academic Achievement	Pearson Correlation	.705	1
	Sig. Value	.000**	

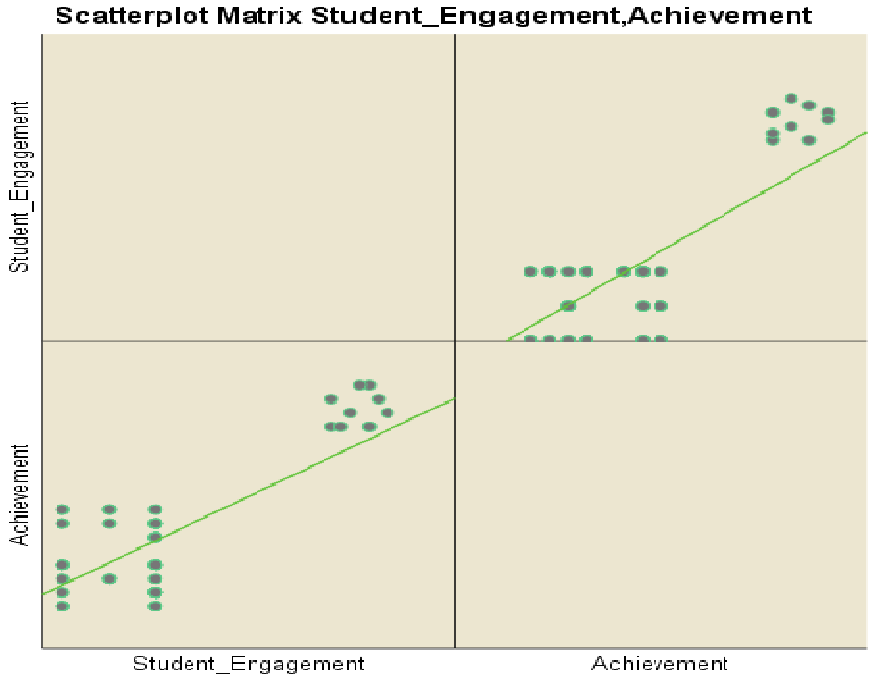

Figure 4.4: The Graphical Representation of Student Engagement and Academic Achievement in Geography after Implementation of STEM-based Instructional Practices

Table 4.2.7 shows the results of a correlational research that examined the impact of STEM-based pedagogical approaches on student engagement and achievement in geography courses. The correlation between active learning and passing a class is rather high (r=0.705). The use of STEM-based instructional strategies has had a profound effect on student engagement and academic achievement. The findings emphasize the need of incorporating STEM ideas into innovative pedagogical approaches to enhance student engagement and academic achievement. Through assessment, feedback, and ongoing professional development, teachers may better meet their students' evolving needs and attain the best possible learning results.

Ho_4:There were no significant difference in student engagement in geography between different STEM-based instructional strategies.

To verify the hypothesis, Descriptive Statistics was performed by the investigator, which was shown in the following tables.

Table 4.2.5: Analysis of STEM-based Instructional Strategies in Student Engagement in Geography

Factors	Mean	S.D.	F-Value	Result
Simulations and Modelling:	19.11	7.113	8.745	.000
Project-Based Learning	23.43	4.329	11.865	.001
Inquiry-Based Learning	21.39	8.685	15.163	.000
Collaborative Learning	18.62	9.678	10.134	.002
Hands-On Activities and Experiments	20.78	3.046	9.754	.000

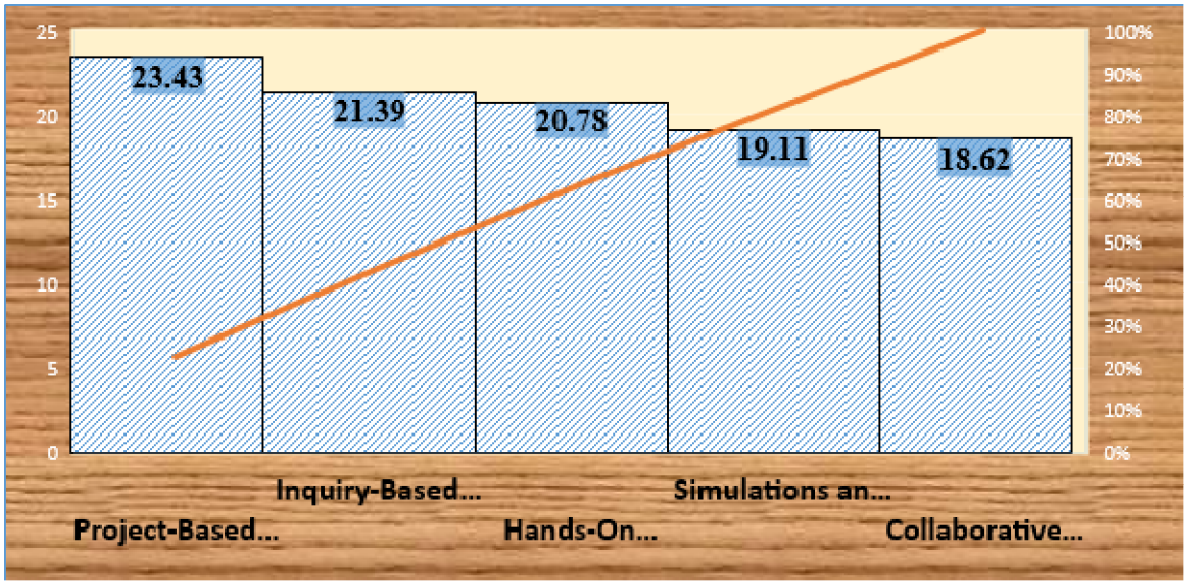

Figure 4.5: The Graphical Representation of STEM-based Instructional Strategies in Student Engagement in Geography

Table 4.2.5 presents an overview of the effects of incorporating STEM-based teaching methods into geography classes on student involvement. The effects of several STEM-based pedagogical approaches on students' interest in geography shown in Table 4.2.5. With a mean score of 23.43, project-based learning is the technique that enhances students' interest in geography the most. The next best approach, inquiry-based learning, which is great for encouraging interest and curiosity, comes in at 21.39 on average. Their average score of 20.78 shows that involvement is also greatly affected by experimental and hands-on activities. Despite much lower mean scores, student engagement was significantly increased via collaborative learning and simulations/modeling. This highlights the wide variety of approaches that teachers might use to establish engaging classrooms. The results of this study highlight the need of improving students' educational experiences and outcomes by integrating several STEM-based pedagogical strategies into geography curricula. The goal of this approach is to encourage more participation, critical thinking, and active learning.

5. Conclusion:

This study concludes that geography courses should include STEM education into their curriculum to increase student engagement and performance based on the results and insights from the research goals. Immediate action is required in response to the fact that STEM-integrated geography courses exhibit significant gender and location-based disparities in student involvement. Recognizing these variations calls

attention to the importance of tailoring educational approaches to the unique requirements of children from a variety of demographic backgrounds and to the necessity of targeted interventions to advance equality and inclusion. Research comparing students' engagement levels and academic performance before and after STEM-based teaching approaches may help us understand the influence of STEM integration on students' final grades. Results showed a positive relationship between student engagement and academic achievement after the implementation of STEM-based teaching strategies. The premise that STEM education is effective in providing relevant learning experiences is supported by the fact that adding STEM concepts to geography classes increases student engagement and leads to noticeable gains in test scores. Educators and curriculum creators might also benefit from research on several STEM-based educational practices that engage students in geography. This has made them more equipped to build a sustainable and interdependent society and to deal with the complex issues of our day.

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Citation: **Chattopadhyay. Dr. S. & Biswas. Dr. S.,** (2024) "Enhancing Student Engagement and Achievement in Geography through STEM Education", *Bharati International Journal of Multidisciplinary Research & Development (BIJMRD)*, Vol-2, Issue-8, September-2024.