EFFECT OF BRAINSTORMING INSTRUCTIONAL STRATEGY ON ACHIEVEMENT IN SCIENCE IN RELATION TO SCIENTIFIC ATTITUDE

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ABSTRACT

This research examines the impact of the brainstorming instructional technique on academic performance in the field of science, specifically in connection to the scientific mindset. The sample included 120 students from two private schools in Amritsar City, who were enrolled in the IX level and connected with CBSE, New Delhi. The research examined two distinct factors, namely instructional tactics and scientific mindset. There were two separate levels of analysis that were performed on the variable of instructional approaches. These levels were brainstorming instructional strategy and conventional teaching approach levels. A high, medium, and bad scientific attitude were the three degrees of scientific attitude that were investigated in this research, which focused on the variable of scientific student attitude. The achievement score was the dependent variable, and it was calculated by taking the pre-test score and subtracting it from the post-test score. The experimental group received training using the brainstorming instructional technique on five different subjects from the Science curriculum for ninth grade. The control group, on the other hand, was taught using the traditional teaching method by the researchers. The investigators designed the teaching material and achievement exam in Science. Data gathering was facilitated by the use of the technology. Both the Science achievement exam and the scientific attitude test were given. The mean gain scores were calculated after conducting pre- and post-testing for all the pupils. The examination of data included the use of statistical methods such as Mean (average) and SD (standard deviation). Both the F-ratio and the t-test were used in order to ascertain whether or not the calculated mean differences between the different groups and variables were statistically significant. A two-by-three analysis of variance (ANOVA) was performed on the data, and the results of the analysis brought the following conclusions: (i) The performance of the group using the brainstorming instructional technique was considerably better than the group using standard teaching methods. (ii) Science students with high scientific attitude scored higher than the students with medium and low scientific attitude group. (iii) A large Effect Size for the interaction for the teaching methodologies and the scientific attitude groups of science students was observed.

Keywords: Brainstorming Instructional Strategy, Conventional Teaching Strategy, Scientific Attitude, Achievement in Science

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Introduction

Science education in India is very much required indeed for the development of the country. Education promotes the brain to develop critical thinking skills, problem-solving skills, and creativity since the world has adopted complex challenges. Individuals are empowered to contribute to technological advancements, healthcare enhancements, and sustainable development when they have a solid scientific foundation. Science education helps prepare youngsters in India globally to compete, and the spirit of enquiry thrives, in a world that is rapidly evolving. Finally, to promote rational decision-making, economic growth, and the welfare of society, it sets the grounds to make India a knowledge-based empire in the 21st century.

Everybody knows that obtaining a good education in science is crucial for fostering the ability to think logically, solve problems and adopt a constructive attitude towards science. Conventional teaching methods that rely on the teacher in the first place are insufficient for preparing individuals for the present and future. However, this needs to be done by helping students understand how their knowledge applies to everyday problems. This is possible because; we are living in an open society which demands that we apply information and channel it to solve environmental issues. This encourages the growth of thinking skills as well as creativity and new ideas. The purpose of this study will be to determine the extent to which the approach to learning known as brainstorming affects students' degree of achievement in science and the extent to which the method impacts the formation of the scientific way of thinking. The use of brainstorming as a method that encourages collaboration and the generation of new ideas shows promise in terms of actively engaging students and fostering a better comprehension of scientific principles.

The term "brainstorm" refers to the process of employing one's brain in order to storm an inventive or creative challenge and to do it in a commando-like method, with each stormer boldly assaulting a comparable goal. The purpose of the exercise known as "brainstorming" is to generate a large number of potential solutions to a problem via the participation of a group of people. According to Raj and Saxena (2017), "It is a technique that is incredibly helpful in all disciplines, including business, industry, social organizations, training, politics, and so on". Utilizing one's intellect to solve a problem is what the term "brainstorming" really implies. Because brainstorming is one of the most unique methods for cultivating creative thinking, its concept is typically described as an effort to work on the flow of ideas without judgment and an endeavour to expedite thinking, break the impasse, and challenge the mind. The term "brainstorming" refers to the process of using one's brain in order to engage in "dynamic critical thinking" and holding a meeting in order to develop new ideas with the intention of coming up with innovative solutions to issues (Jarwan, 2005). Brainstorming offers a rapid and uncomplicated method for generating fresh concepts relevant to problem-solving and innovation. The term "Brainstorming" itself implies the intention to invigorate the mind to approach issues from unconventional angles. It prompts learners to break free from conventional, linear thinking and instead embrace spontaneity, originality, and imagination. In response to a specific problem or query, participants in a brainstorming session swiftly and instinctively share their ideas, devoid of extensive analysis. The strategy promotes free association and the expansion of others' ideas while discouraging criticism and constraints. The emphasis lies on quantity over quality, aiming to produce numerous ideas swiftly. The underlying premise is that a higher quantity of ideas boosts the likelihood of yielding inventive and efficacious solutions (Filgona, Sababa, & Iyasco, 2016).

The instructional method of brainstorming is a dynamic approach that sparks creative thinking and encourages group work in the context of learning. It develops participants' critical thinking and problem-solving abilities by providing an atmosphere free from judgment in which they are prompted to come up with a wide variety of ideas. This active learning approach goes beyond the conventional classroom setting, emphasizing both active participation and a sense of personal responsibility for acquired information. Brainstorming improves communication, enables individuals to explore novel solutions, and fosters collective intelligence. It is beneficial both in the classroom and in professional settings. Because of its malleable character, it may be utilized in a variety of contexts. It can serve as a source of creativity and as a catalyst for meaningful conversation, so facilitating efficient education and the production of new ideas across a wide range of fields.

Almost all facets of education are built on the foundation of achievement. The results of the majority of educational studies plan for educational accountability, and initiatives for enhancing education all emphasize achievement as a crucial concept. The accomplishment of learning objectives is implied by the term achievement. While learning can take place in many different contexts, in an educational setting, the learning objectives are linked to the teaching and learning environment. The goal of the teacher-student interaction in the classroom is to help students gain knowledge, comprehension, and skill development (Guskey, 2013). This improvement can be attributed to the fact that such experiences occur. Advancement in science education is a crucial area of attention in educational research, aligning with wider social objectives of promoting scientific literacy and encouraging innovation. The level of scientific knowledge and skills among students is not only associated with academic achievement but also has a vital role in equipping future generations to address global issues of health, technology, and sustainability (National Research Council, 2012). It is crucial for educators and policymakers who aim to improve educational results to comprehend the elements that impact science success.

The term "scientific attitude" refers to the temperament and mindset that define a person's approach to comprehending the environment and interacting with it in a manner that is scientific. In their endeavours, scientists and other people who have a strong predisposition for science demonstrate a set of characteristics and behaviours that are referred to as the scientific temper. A scientific attitude is the culmination of a number of different traits and virtues, which may be observed in a person's actions and how they conduct themselves. The persons in question are characterised by the following characteristics: an open mind, an experiment-oriented attitude, a methodical approach, a desire for information, intellectual honesty, objectivity, truthfulness, and a scientific temper. Additionally, they have the expectation that the issue will be resolved by using information that has been investigated and validated (Jancirani, Dhevakrishnan, & Devi, 2012). The approach to the process of instruction known under the term brainstorming is capable of producing a significant impact which is not only related to the academic outcomes of the learning process but also more general dispositions of learners to scientific exploration. Students produce ideas, solutions, or thoughts that are relevant to a certain topic through a process called brainstorming, which is a collaborative and creative activity. It has the potential to create a better comprehension of the topic, as well as critical thinking and a positive attitude toward the subject matter when applied properly in scientific education.

Need and Significance of the Study

The communication revolution caused by information and globalization is changing the world, along with its scientific, economic, and social aspects. It was crucial to raise a generation that could handle those issues in response to those advances and challenges. Today's fast-paced world requires creativity and invention in almost every field. We modified old learning and teaching methods and focused on training students in diverse thinking patterns. Hidayanti, Rochintaniawati, and Agustin (2018) argue that conventional teaching methods, which depend on the instructor, cannot adequately prepare students for the present and future. In this day and age of open communities, we have an obligation to make use of knowledge and use it towards the resolution of environmental issues. This develops students' critical thinking, creativity, and innovation. Guide students toward knowledge and understanding in relation to everyday problems. Indian schools should use the thinking method to teach science to engage students and build scientific minds. India's school system is changing, and rote learning no longer works. Brainstorming is useful for workplace problem-solving, project ideation, and creative problem-solving. Thus, educational methods that encourage productive brainstorming are needed. Brainstorming fosters curiosity, doubt, and adaptability, which are essential for scientific research and civic engagement. Indian schools can empower students to participate in their learning through brainstorming. This will equip them to overcome challenges, innovate, and advance India's science and society. This research is important because brainstorming and idea mapping can boost interest, creativity, and achievement in scientific education. The findings could be used to modify school instructional strategies to better meet student academic needs.

The investigator decided to conduct the current study to investigate the effect of brainstorming strategies as instructional strategies on creative thinking, science interest and accomplishment, and scientific attitude. Consequently, the investigator endeavoured to investigate the impact of using the brainstorming instructional technique on academic performance in science, specifically in connection to the scientific attitude.

Objectives

1. To investigate the groups that were instructed using the Brainstorming instructional strategy and the conventional teaching strategy
2. To assess the impact of high, average, and low scientific attitudes on science achievement by comparing different groups.
3. To investigate the interaction effect of both instructional strategies and scientific attitude on the academic performance of students in the field of science

Hypotheses

H_1: There exists no significant difference between the groups taught using the brainstorming instructional strategy and conventional instructional strategy on achievement in science.

H_2: There exists no significant difference between the groups having high, moderate and low scientific attitude on achievement in science.

H_3: There is no significant interaction effect of both instructional strategies and scientific attitude on science achievement.

Sample

The current investigation was carried out on English medium public schools in Amritsar city that are associated with the "Central Board of Secondary Education, New Delhi". Two schools were chosen at random from the whole set of schools in Amritsar. A sample of 120 pupils from the 9th grade was randomly selected from two schools, namely "DAV Public School, Amritsar" and "Khalsa College Public School, G.T. Road, Amritsar". The sample was both random and purposeful. The investigation was done on two separate groups in each school: an experimental group and a control group.

Design

This research undertook a factorial design involving both a pre-test and a post-test. To evaluate the data used, we have employed the mean, 'standard deviation' (SD), 'analysis of variance' (2×3), and t-ratio. These statistical measures were used for the two independent variables: instructional treatment as well as scientific attitude. The study investigated the effects of two teaching strategies: brainstorming instructional strategy and conventional instructional strategy. The scientific attitude group was classified into three levels: high, moderate, and low scientific attitude. These factors were considered independent variables. The main dependent variable was scientific accomplishment, calculated by subtracting the pre-test scores from the post-test results for the given subject.

Tools Used

The data-collecting process used the following tools:

1. The researchers used the "Standard Progressive Matrices by Raven, Raven, and Court" (2000) to evaluate the intellect of the pupils in order to categorise them accordingly.
2. The assessment tool used was the Scientific Attitude Scale (SAS-BM), which was created and validated by Bajwa and Mahajan (2012).
3. An Achievement test in science was prepared by investigators.
4. Instructional material for Brainstorming instructional strategy and conventional instructional strategy on selected topics of 9^{th} class science such as Sound, Matter- its nature and behaviour, and Cell- the basic unit of life was prepared by the investigators.

Procedure

The experiment was done in six steps once the sample was selected and the students were allocated to the two teaching styles. Initially, the investigator established the required preparations with the principal of the chosen school for the experiment. Furthermore, the usual progressive matrices exam was conducted to assess the intellect of pupils in three different groups. Furthermore, the scientific attitude exam was conducted in each school to assess the pupils' scientific attitude. Additionally, a preliminary evaluation was administered to the students who were a part of the experimental group as well as the students who were in the control group. The pupils' response papers were reviewed in order to collect information about their past knowledge. Additionally, the investigators used the brainstorming instructional technique to educate one group, whereas the control group was taught using the usual teaching strategy. In addition, the post-test was administered to students in both groups following the completion of the course. An evaluation was performed on the answer sheets by means of a scoring key.

Analysis and Interpretation of Results

- **Analysis of Descriptive Statistics**

In order to determine the distribution of scores, the data were analysed using the standard deviation and mean. The hypotheses about the instructional teaching strategy and scientific attitude in the realm of science were examined using the Analysis of Variance tool. Tables1,2,3,4, and 5 show the mean and standard deviation of several categories.

Table 1: "Means and SD of Mean Gain Achievement Scores for the Different Sub Groups"

Scientific Attitude	Teaching						Total		
	Experimental Group			Control Group					
	N	Mean	SD	N	Mean	SD	N	Mean	SD
High Scientific attitude	16	14.5	3.41	16	9.06	2.22	32	11.78	3.96
Average Scientific attitude	28	7.82	1.95	28	6.57	2.41	56	7.20	2.28
Low Scientific attitude	16	6.13	1.53	16	4.50	2.15	32	5.31	2.04
Total	60	9.15	4.05	60	6.68	2.84	N=120		

Source: "Field Study, 2024"

Figure 1 provides a bar diagram illustrating the average increase in achievement scores in science for high, average, and low scientific attitude science groups of both the experimental and control groups. This bar graphF serves to support the findings reported in Table 1.

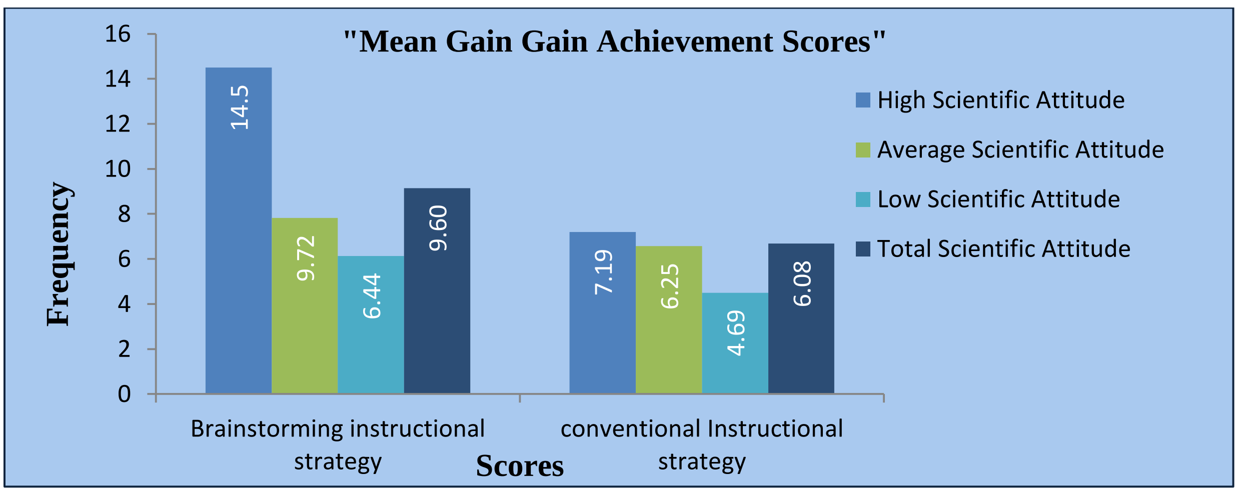

Fig 1: "Bar diagram showing a comparison between mean gain achievement scores of instructional teaching strategy groups"

The data from the table and Figure 1 indicate that the average gain scores of the group using the brainstorming instructional method (M=9.15) are greater than those of the group using the "traditional teaching strategy" (M=6.68). This demonstrates that the effectiveness of the brainstorming instructional strategy group surpasses that of the traditional teaching strategy group. The average gain of the three groups, which are the groups with a high, moderate, and low scientific attitude respectively, is verified to be 11.78, 7.20, and 5.31, respectively. The analysis reveals that there are substantial variations in the mean gain scores among high, moderate, and low scientific attitude science students while using the brainstorming teaching technique. These variations are also seen in relation to the several scientific mindset groups taught using traditional teaching methods.

- **Analysis of Variance on Gain Achievement Scores**

Table 2 displays the average values of various sub-groups, the total squared differences, the number of independent observations, the average squared differences, and the F-ratio.

Table 2: "Summary of Analysis of Variance (2×3) Factorial Designs"

"Source of Variance"	"Sum of Squares"	df	"Mean Sum of Squares"	F- ratio
Treatment Group (A)	182.54	1	182.54	32.25**
Scientific Attitude (B)	723.99	2	361.99	63.96**
Interaction (A×B)	96.98	2	48.49	8.57**
Error Term	645.66	114	5.66	

***Significant at 0.01 level*

("Critical Value 3.93 at 0.05 and 6.86 at 0.01 levels, df 1/114")

("Critical Value 3.08 at 0.05 and 4.80 at 0.01 levels, df 2/114")

Instructional Strategies (A)

Table 2 shows the F-ratio for the variation in mean gain scores between the group using the conventional teaching approach and the group applying the brainstorming instructional technique to be 32.25. This value is compared to the table value (t0.01=6.86, df 1/114) and was judged to be statistically significant at the 0.01 level of significance. It indicates that the groups did not vary significantly, except for the influence of random chance. Thus, hypothesis H1, which posits that there exists no significant difference between the groups taught using the brainstorming instructional strategy and conventional instructional strategy on achievement in science is refuted and rejected. The results indicate that the group instructed utilising the brainstorming teaching approach had higher levels of achievement in science compared to those instructed using the conventional instructional strategy.

To conduct a more detailed investigation, a t-test was performed after the F-ratio analysis. The t-ratio results for the experimental and control groups have been documented in Table 3.

Table – 3: "T-ratio of gain mean scores between experimental and control groups"

Variables	Experimental Group			Control Group			SE_D	t-value
	N	Mean	SD	N	Mean	SD		
Gain Scores	60	9.15	4.05	60	6.68	2.84	0.64	3.86**

The gain refers to the accomplishment scores of both the experimental and control groups, which have been shown using a bar diagram in Figure 2.

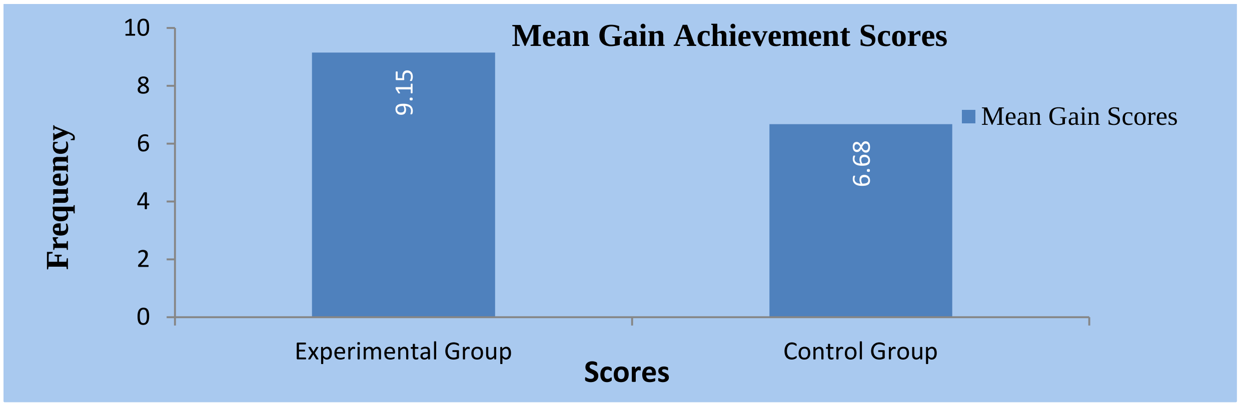

Fig-2: Bar graph illustrating the difference in average achievement scores between the experimental and control groups

According to Fig-2 and Table 3, the average gain score of the experimental group is 9.15, which is more than the comparable average gain score of 6.68 for the control group. The t-value, which compares the mean differences between the brainstorming teaching technique and the conventional instructional strategy, is 3.86. This is significant at the 0.01 level of significance when compared to the table value (for df 118, $t_{0.01}$= 2.62). The outcome shows that the group using a brainstorming instructional strategy outperformed the group using a conventional instructional strategy in terms of performance.

Scientific Attitude (B)

The F-ratio for the disparity in average gain scores across the "three scientific attitude groups is 63.96", as seen in Table 2. This value was determined to be significant at the 0.01 level of significance in comparison to the table value ($t_{0.01}$=4.80, df 2/114). It suggests that the three groups had variations in their accomplishment scores. Therefore, we reject hypothesis H2, which states that there exists no significant difference between the groups having high, moderate and low scientific attitude on achievement in science. The findings indicate that the average gain accomplishment scores of the high scientific attitude groups were superior to those of the medium and low scientific attitude groups.

To conduct additional investigation, a t-test was performed subsequent to the F-ratio analysis. The t-ratio values for the experimental and control groups are shown in Table 4.

Table 4: "T-ratio for different combinations of scientific attitude groups"

Scientific Attitude	**High Scientific Attitude** N Mean SD 32 11.78 3.96	**Average Scientific Attitude** N Mean SD 56 7.20 2.28	**Low Scientific Attitude** N Mean SD 32 5.31 2.04
High Scientific Attitude N Mean SD 32 11.78 3.96	**--**	**6.03****	**8.19****
Average Scientific Attitude N Mean SD 56 7.20 2.28	**--**		**4.02****
Low Scientific Attitude N Mean SD 32 5.31 2.04	**--**	**--**	**--**

A bar graph has been created to support the findings and is shown in Figure 3.

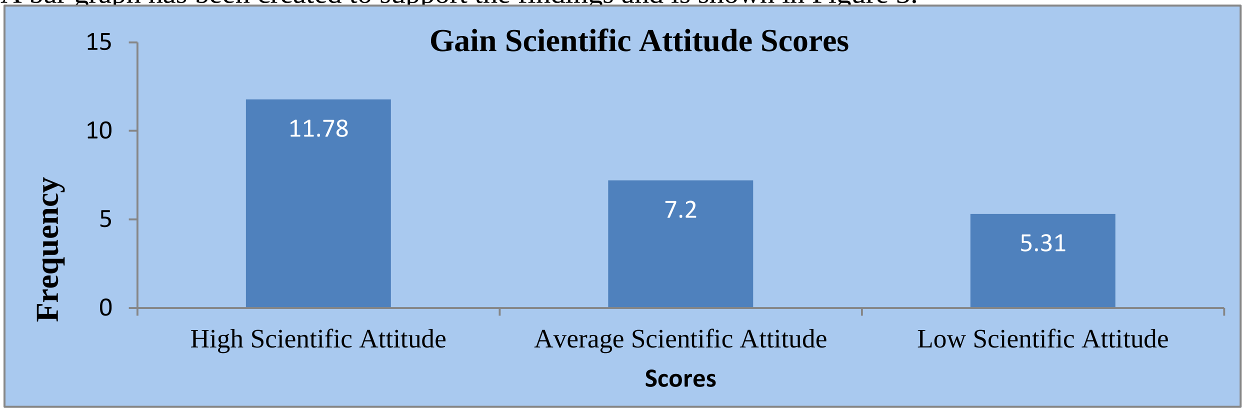

Fig-3 "Bar diagram showing comparison among mean gain achievement scores of different scientific attitude groups"

According to Table 4 and Fig-3, the group with a high scientific attitude, with a mean of 11.78, shows a higher mean gain score compared to the group with an average scientific attitude, which has a mean of 7.20. The t-ratio for the disparity in mean scores between high and average scientific attitude groups is 6.03. The value is compared to the table values (t0.01=2.63 df 86) and determined to be statistically significant at the 0.01 level of significance. Thus, the hypothesis of substantial differences is invalidated when examining high and average scientific attitudes, irrespective of grouping according to other factors. The results indicate a notable disparity in the gain scores between the high and average scientific attitude groups.

According to Table 4 and Fig-3, the group with a high scientific attitude, which has a mean of 11.78, exhibits a higher mean gain score compared to the group with a low scientific attitude, which has a mean of 5.31. The t-ratio for the disparity in average scores between high and low scientific attitude groups is 8.19. The value was compared to the critical value from the table (t0.01=2.66 df 62) and determined to be statistically significant at the 0.01 level of significance. Thus, the idea of a notable disparity is dismissed for both the high and low scientific attitude groups, independent of their categorisation in relation to other factors. The findings show that there was a significant difference in mean gain achievement scores between the high and low scientific attitude groups with regard to science achievement scores.

The average scientific attitude group has a mean gain score of 7.20, which is greater than the mean gain score of the low scientific attitude group, which is 5.31. This is shown by the fact that the average scientific attitude group has a difference between the two groups. The difference in mean scores of gain between the groups with an average scientific attitude and those with a low scientific attitude is 4.02, according to the t-ratio. The table value (t0.01=2.63 df 86) was compared to this value, and it was discovered that this value was statistically significant at the 0.01 level of significance. Therefore, the hypothesis of substantial differences is denied when it comes to the average and low scientific attitude, independent of the grouping based on other factors. For this reason, the hypothesis is rejected. This suggests that the average and low scientific attitude science group had statistically significant mean gain achievement scores.

Instructional Strategies and Scientific Attitude (A×B)

The data presented in Table 2 indicates that the F-ratio for the relationship between instructional strategies and the scientific attitude of science groups is 8.57. The value was compared to the table value (t0.01=4.80, df 2/114) and determined to be statistically significant at the 0.01

level of significance. It signifies that the two variables have a mutual influence on each other. Therefore, hypothesis H3, which states there is no significant interaction effect of both instructional strategies and scientific attitude on science achievement, is rejected. The findings suggest that there is a notable disparity in the improvement of success in science as a consequence of the combined influence of instructional methodologies and scientific attitude groups. The use of brainstorming as an instructional method did not result in the same degree of academic accomplishment for students with high, average, and low scientific attitudes in science as compared to standard teaching strategies.

T-ratios were computed and documented in Table -5 to assess the significance of the difference in averages across different combination groups.

Table 5: "T-ratio for the difference in mean gain achievement scores of instructional strategies and different scientific attitude levels"

	Variables	**Experimental Group**			**Control Group**		
		B_1 Mean SD 14.5 3.41	**B_2** Mean SD 7.82 1.95	**B_3** Mean SD 6.13 1.53	**B_1** Mean SD 9.06 2.22	**B_2** Mean SD 6.57 2.41	**B_3** Mean SD 4.5 2.15
Experimental Group	**High Scientific Attitude** N Mean SD 16 14.5 3.41	**---**	**7.18****	**8.90****	**5.33****	**8.18****	**9.90****
	Average Scientific Attitude N Mean SD 28 7.82 1.95	**—**	**—**	**3.19****	**1.85****	**2.12****	**5.11****
	Low Scientific Attitude N Mean SD 16 6.13 1.53	**---**	**---**	**—**	**4.37**	**0.75**	**2.47***
Control Group	**High Scientific Attitude** N Mean SD 16 9.06 2.22	**---**	**---**	**—**	**---**	**3.46****	**5.92****
	Average Scientific Attitude N Mean SD 28 6.57 2.41	**—**	**—**	**—**	**—**	**—**	**2.96****
	Low Scientific Attitude N Mean SD 16 4.5 2.15	**---**	**---**	**—**	**----**	**----**	**—**

A bar graph has been created to support the findings and is shown in Figure 4.

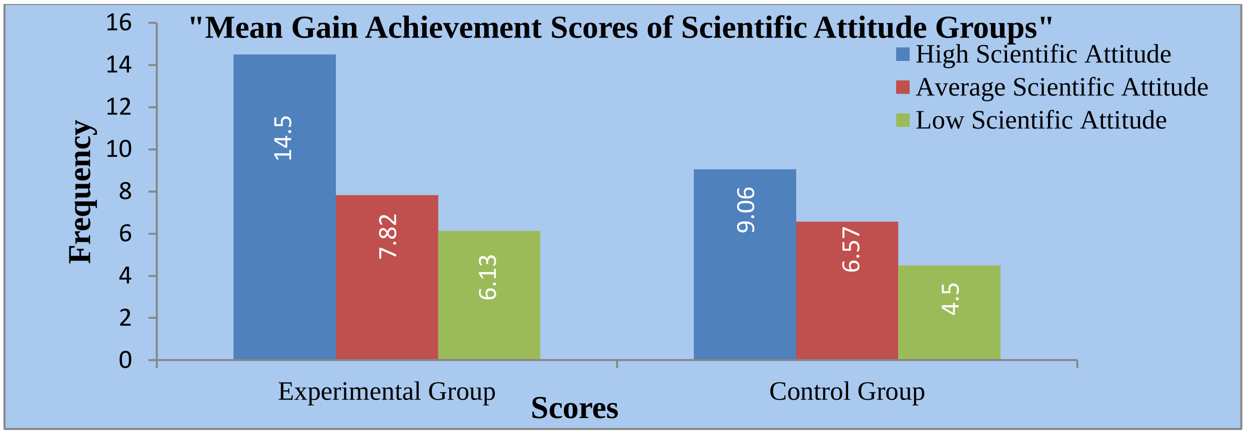

Fig 4: "Bar diagram showing mean gain achievement scores for different scientific attitude groups of experimental and control groups"

Table 5 shows that the mean scientific attitude of the experimental group is 14.5, which leads to a larger mean gain score compared to the average scientific attitude of the experimental group, which is 7.82. When comparing the mean scores of those with strong scientific attitudes to those with average scientific attitudes in the experimental group, the t-ratio has a value of 7.18. This difference is judged statistically significant at the 0.01 level of significance when compared to the table value (t0.01=2.71, df 42). Therefore, if the experimental group shows a high or average scientific attitude, regardless of the categorisation based on other factors, the hypothesis of substantial differences is rejected.

Table 5 indicates that the experimental group, which has a mean of 14.5, has a greater mean gain score compared to the experimental group with a mean of 6.13, which displays a low scientific attitude. At a significance level of 0.01, the t-ratio for the difference in mean gain scores between individuals with high and low scientific attitudes in the experimental group is 8.90. This t-ratio is statistically significant when compared to the critical value from the table (t0.01=2.75, df 30). Consequently, the hypothesis that there are substantial differences is disproven when there is both a high and low scientific attitude in the experimental group, regardless of how the other variables are grouped.

Table 5 indicates that the experimental group, which had a mean scientific attitude of 14.5, exhibited a greater mean gain score compared to the control group, which had a mean scientific attitude of 9.06. 5.33 is the value of the t-ratio that represents the difference in mean scores of strong scientific attitude between the group that was subjected to the experiment and the standard group. A comparison was made between this value and the table value (t0.01=2.75, df 30), and it was found to be statistically significant at the 0.01 level of significance. Therefore, if both the experimental group and control group exhibit a strong scientific attitude, regardless of other factors, the hypothesis of substantial differences is rejected.

Table 5 indicates that the experimental group, which has an average scientific attitude of 7.82, exhibits a higher mean gain score compared to the experimental group with a lower scientific attitude, which has an average of 6.13. The t-ratio for the difference in mean scores of gain between the average and low scientific attitude groups in the experimental group is 3.19. This value was compared to the table value (t0.01=2.71, df 42) and judged to be statistically significant at the 0.01 level of significance. Therefore, the hypothesis that there are substantial differences in the average and low scientific attitude of the experimental group, regardless of how the group is divided based on other characteristics, is rejected.

As can be seen in Table 5, the average scientific attitude of the experimental group, which indicates a mean gain score of 7.82, is significantly greater than the average scientific attitude of the control group, which indicates a mean gain score of 6.57. Between the experimental and control groups' average scientific attitude gain mean scores, the t-ratio is 2.12. This result was considered statistically significant at the 0.05 level when compared to the table value (t0.01=2.68, df 54). So, when looking at the average scientific attitude of the experimental group compared to the control group, we can reject the hypothesis that there are substantial differences between the two groups. This holds true regardless of how we group the variables.

According to the findings shown in Table 5, the experimental group's average scientific attitude, which has a mean score of 7.82, has a higher mean gain score than the control group's low scientific attitude, which has a mean score of 4.5. A t-ratio of 5.11 was found to represent the difference between the control group's low scientific attitude and the experimental group's average gain mean scores on this measure. When compared to the table value, this was shown to be significant at the 0.01 level of significance (t0.01=2.71, df 42). Consequently, when comparing two groups based on other factors, we may reject the hypothesis of large differences if the experimental group has a average scientific attitude and the control group has a bad one.

Table 5 indicates that the experimental group, which has a mean scientific attitude of 6.13, exhibits a greater mean gain score compared to the control group, which has a mean scientific attitude of 4.5. The t-ratio for the difference in mean scores of the experimental group with a low scientific attitude and the control group with a low scientific attitude is 2.47. This value was compared to the table value (t0.01=2.75, df 30) and was judged to be statistically significant at a significance level of 0.05. Therefore, if both the experimental group and control group exhibit a low scientific attitude, regardless of other variables, the hypothesis of substantial differences is rejected.

According to Table 5, the control group with a strong scientific attitude, which has an average of 9.06, has a higher average gain score compared to the control group with a low scientific attitude, which has an average of 4.5. The difference in the mean scores of the control group for high and low scientific attitude is 5.92, as shown by the t-ratio. Based on the comparison with the table value (t0.01=2.75, df 30), this result was determined to be statistically significant at the 0.01 level. Therefore, the hypothesis of substantial differences is rejected when considering the high and low scientific attitude of the control group, regardless of how the other variables are grouped.

Table 5 indicates that the control group, which had a mean scientific attitude of 9.06, had a greater mean gain score compared to the control group, which had an average scientific attitude of 6.57. In the control group, a t-ratio of 3.46 indicates that there is a significant difference in mean gain scores between the average and low scientific attitude groups. At the 0.01 level of significance, this result was determined to be statistically significant when compared to the table value (t0.01=2.71, df 42). With the control group's average and high scientific attitude taken into account, we can reject the hypothesis of large differences, independent of any other characteristics-based categorization.

According to Table 5, the control group has an average scientific attitude with a mean of 6.57, which demonstrates a higher mean gain score compared to the control group with a low scientific attitude, which has a mean of 4.5. The t-ratio for the difference in mean scores of gain between the average and low scientific attitude groups in the control group is 2.96. This value was compared to the table value (df 42, $t_{0.01}$=2.71) and judged to be statistically significant at the 0.01 level of significance. Therefore, the hypothesis of significant differences is rejected when considering the average and low scientific attitude of the control group, regardless of how the group is categorized based on other characteristics.

Table 5 indicates that the experimental group, with a mean scientific attitude of 6.13, exhibits a lower mean gain score compared to the control group, which has a higher scientific attitude with a mean of 9.06. The t-ratio for the difference in mean scores of gain between the average and low scientific attitude groups in the control group is 4.37. This result was compared to the table value (df 30, $t_{0.01}$=2.75,) and judged to be statistically significant at the 0.01 level of significance. Therefore, if the experimental group has a low scientific attitude and the control group has a high scientific attitude, regardless of other factors, the hypothesis of ssignificant differences is rejected.

Table 5 and Figure 4 shows that there was no significant difference in student achievement in science at the 0.05 level of significance when comparing the remaining combination groups, which consisted of the average scientific attitude of the experimental group with the high scientific attitude of the control group, or the low scientific attitude of the experimental group with the average scientific attitude of the control group.

Discussion

According to the results of this research, students performed better in science when taught using a brainstorming technique rather than the more traditional method of education. Hence, hypothesis **H_1**: The conclusion that There exists no significant difference between the groups taught using the brainstorming instructional strategy and conventional instructional strategy on achievement in science is rejected. This finding is in line with what Adewale (2000) found: a strong correlation between using brainstorming as a teaching tool and students' final grades. Students who were given the opportunity to brainstorm outperformed those who were given more traditional strategies, according to research by Adewale (2008). According to Salamat and Kharashah (2010), students' success scores are positively impacted by the brainstorming technique. Students' proficiency in composing descriptive paragraphs is substantially impacted by the Brainstorming Technique, as shown by Fransisca and Zainuddin (2012). Research by Odoh (2013) has shown that students' performance improves when they apply brainstorming techniques. There was a statistically significant difference in the average academic performance in favour of the brainstorming group, according to Owo, Idode, and Ikwut (2016). Following therapy with brainstorming based on the learning cycle 5-E model, Sari, Muchlis, and Hidayah (2018) found that students' learning outcomes increased. According to Al-Filgona and Sakiyo (2020), students who were taught social studies using scaffolding and brainstorming instructional models outperformed their counterparts in the group taught using the standard technique in terms of both achievement and learning retention. The use of brainstorming as an educational approach has a notable impact on the performance of lower primary school kids, as shown by Adeyemi and Adesola (2021). When compared to the traditional technique, Ogbaga and Osuafor (2023) found that student's academic success scores improved when they used the think-pair-share and brainstorming tactics.

The results show that the group with a strong scientific mindset outperformed the groups with average and low scientific attitude. Hence, hypothesis **H_2:** When it comes to scientific accomplishment, that there exists no significant difference between the groups having high, moderate and low scientific attitude on achievement in science. The following multiple research supports the findings. In their research on students’ attitudes toward scientific education, Bayram and Comek (2009) established that performance in chemistry class greatly depends on the student’s attitude toward science. Students' good attitudes towards science are positively correlated with their academic success in science, according to research by Narmadha and Chamundeshawari (2013). In Lecap’s (2015) work, one is able to synthesize scientific views towards knowledge and academic performance patterns. Regarding students’ scientific mindset and the science success scores, the study of Srivastava (2015) proved that they are in a positive correlation. Ahju (2017) also found a strong positive relationship between students’ scientific mindset and science success scores. These results were further reinforced by interaction effects. Results showed that the experimental group of pupils had a more positive outlook on science and performed better academically (Sahin & Yilmaz, 2020). A somehow positive relationship exists between students' attitudes towards science and their achievements in scientific classes, as Mao, Cai, Chen and Fan (2021) discovered in their research. Sharma and Yadav (2023) postulated that students who are optimist or scientific-titled are more likely to excel in class science.

The findings of this research show that both instructional methodologies and scientific mindset in science students are significant predictors of their achievement in science using the mean gain scores. Hence, **H_3:** there is no significant interaction effect of both instructional strategies and scientific attitude on science achievement. The findings are supported by studies of Karakuyu (2010) and Khan and Mahmood (2012) who pointed out the efficacy of the inquiry-based approach compared to traditional methods of teaching when it comes to the development of scientific attitudes in biology class. You and Koo (2016) have also found in their study that the experimental group who was instructed through learner-generated graphical representation performed significantly better than the control group in all aspects of scientific attitude sub-indexes including curiosity, openness, criticism, cooperativity, willingness, and persistence. Ahuja (2017) discovered a strong positive correlation between students' scientific mindset and their science success scores. These results were further corroborated by interaction effects. In their study, Sahin and Yilmaz (2020) discovered a substantial and moderate link between the academic performance and attitudes of the students in the experimental group. The study was contradicted by the finding of Mehar and Singh (2018) revealed that cooperative learning strategy and attitude towards science were not found to significantly interact with each other to exercise the effect of science achievement. Adisha and Rohaeti (2024) according to which there is no observable distinction in the scientific attitudes of students towards thermochemical material between the experimental and control group.

Findings

The current investigation yielded the following findings:

1. The efficacy of the brainstorming teaching method in scientific education was shown to surpass that of the standard instructional strategy, as evidenced by the superior performance of students.
2. The average gain score of the science group with a strong scientific attitude was greater than that of the groups with average and low scientific attitudes in science.
   (i) The average gain accomplishment scores in the science of the high scientific attitude group were substantially higher than those of the average scientific attitude group.
   (ii) The average accomplishment scores in science for the strong scientific attitude group were considerably higher than those of the low scientific attitude group.
   (iii) The average scientific attitude group had considerably better mean gain accomplishment ratings in science compared to the low scientific attitude group.
3. There was a notable relationship between instructional tactics and a scientific mindset that had a major impact on accomplishment in science. Further analysis revealed that:
   (i) The experimental group, which was taught using the brainstorming instructional technique, showed significantly higher mean gain scores compared to the students with average and low scientific attitudes.
   (ii) The group that received instruction using the brainstorming instructional technique and had a high scientific attitude showed significantly higher mean gain scores compared to the control group, which had high, average,

and low scientific attitudes. (taught through conventional instructional strategy).

(iii) The group having average scientific attitude taught through brainstorming instructional strategy exhibited higher mean gain scores than that of students having low scientific attitude of experimental group.

(iv) The students having average scientific attitudes in the experimental group exhibited higher mean gain scores than those with a high, average and low scientific attitude in the control group.

(v) The low scientific attitude group of experimental groups exhibited higher mean gain scores than that of the low scientific attitude of the control group but lower than the mean gain scores high and average scientific attitude group under control groups.

(vi) The group having high scientific attitude taught through conventional instructional strategy exhibited higher mean gain scores than that of groups having average and low scientific attitude of control group.

(vii) The group having average scientific attitude taught through conventional instructional strategy had more over gain scores of 30% with a mean of 11.20 as compared to that of the low scientific attitude of the control group having only 9.28.

Conclusion

As per the presented findings, it can be reflected that the instructional method of brainstorming has been found more effective than traditional methods for secondary school students. Nevertheless, this was seen to be present mainly in students who had been involved in brainstorming sessions as their outcomes surpassed those who were taught under the conventional teaching strategy. Moreover, the study shows that students who possess a scientific attitude got more benefits from the brainstorming method when used to teach them. This is made clear by the greater improvement evidenced in the mean gain scores in science than in the students who have average or low scientific attitudes. The interaction effect between instructional methods (brainstorming vs. conventional) and scientific attitude was found to be significant, suggesting that the effectiveness of the teaching method varied depending on students' scientific attitudes. Based on these findings, this study therefore suggests the need to incorporate brainstorming as an instructional method in the secondary education curriculum in order to increase the performance of students, especially in Science. This recommendation is made on the grounds that from the general observation, it is clear that the technique of brainstorming holds benefits over the traditional approaches to teaching which is based on the scientific predisposition of the students.

Educational Implications

The following are the various education implications of the study: First, having shown the efficiency of brainstorming as an instructional method, it opens the possibility of improving outcomes of learning in secondary schools. Educators may consider integrating brainstorming sessions into their teaching practices to promote active student engagement, critical thinking, and collaborative problem-solving skills. Furthermore, the differences established in the results for different students show awareness of the necessity of making differences between students ‘traits and dispositions when adopting instructional methods. Recognizing and supporting students with high scientific attitudes through methods like brainstorming may be pivotal in nurturing their academic achievements and interest in scientific disciplines. Additionally, attitudes towards science are also introduced as a measurable and essential variable in order to judge the effectiveness of instruction among the students that were studied in the sample population of this research. Educators could benefit from incorporating measures of scientific attitude into their pedagogical approaches to better align teaching methods with students' needs and motivations. Last but not the least, the recommendation of brainstorming as one of the effective instructional tools that should be practised in science education, therefore, has the potential of helping, promote educational reforms which are aimed at fostering students' performance and on the overall, help secondary schools students to appreciate scientific knowledge.

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