A Comparative study of Space-related Aptitude among Students in Co-education Schools and Single-Sex Education Schools

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Abstract:

This paper presents a comparative study aimed at examining the space-related aptitude among students in co-education schools and single-sex education schools. The field of space exploration and astronomy has historically exhibited a gender disparity, with fewer women pursuing careers in these domains. Understanding the potential influence of educational environments on space-related aptitude can provide insights into promoting gender diversity in space science. The study compared the performance, interest, and aspirations of students from both types of schools, employing standardized tests and surveys to gather quantitative and qualitative data. Descriptive statistics and inferential analysis were used to analyze the data. The findings revealed the descriptive characteristics of the data collected, including measures of central tendency, dispersion, skewness, and kurtosis for each school type. Additionally, a comparative analysis using ANOVA was conducted to examine the differences in space-related aptitude scores between co-education and single-sex education schools. The results of the ANOVA analysis and descriptive statistics provided insights into the performance and variations among students in different school types. The implications of the study's findings for educational practices and policy recommendations are discussed, emphasizing the importance of inclusive strategies and curriculum development. The paper concludes by highlighting the study's limitations and suggesting future research directions, such as expanding the sample size and incorporating qualitative methods to gain a more comprehensive understanding of students' experiences and perceptions in relation to space science education.

INTRODUCTION

Spatial intelligence, a multifaceted cognitive ability encompassing skills such as visualization, pattern recognition, and problem-solving in spatial contexts, is acknowledged as a crucial factor in mastering mathematical and scientific concepts, particularly within the realm of geometry. The intricate relationship between gender differences, educational settings, and spatial intelligence has been a focal point of extensive research. This paper embarks on a comprehensive exploration titled "A Comparative Study of Space-related Aptitude among Students in Co-education Schools and Single-Sex Education Schools," seeking to unravel the nuanced interplay between gender-specific spatial aptitudes and the learning environment.

The foundation for this comparative study is rooted in a series of seminal investigations, each shedding light on distinct facets of gender differences in spatial intelligence. Wijayanti et al.'s (2017) qualitative case study underscores the importance of visual-spatial intelligence in solving geometric problems, revealing that female students exhibit enhanced pattern seeking, problem-solving, and conceptualization skills, while their male counterparts excel in imagination.

Rammstedt and Rammsayer (2002) delved into the domain specificity of self-estimated intelligence, emphasizing that males consistently rate their mathematical, logical, and spatial

abilities significantly higher than females. The study illuminated the potential influence of gender-role orientation on these self-estimations, particularly among males.

Coluccia and Louse's (2004) review of gender differences in spatial orientation skills provided a nuanced perspective, highlighting mixed results ranging from "marked differences" to "no-differences." The interplay of biological, socio-cultural factors, spatial anxiety, and task difficulty emerged as crucial components influencing spatial orientation performance.

Syzmanowicz and Furnham's (2011) meta-analyses further reinforced the gender disparities in self-estimated intelligence, indicating that males consistently give higher self-estimates across general, mathematical, spatial, and verbal abilities. The study addressed the heterogeneity of these differences, examining moderating factors such as age, instruction type, country, and the gender of the dominating author.

Gul et al.'s (2020) investigation into the influence of logical/mathematical and spatial/visual intelligence on teaching pedagogies revealed a significant gender difference in visual intelligence among secondary school teachers, emphasizing the need for focused professional development to enhance instructional abilities.

As we navigate through Lim's (1994) confirmatory factor analysis, Yenilmez and Kakmaci's (2015) exploration of the relationship between spatial visualization success and visual/spatial intelligence in sixth-grade students, and Tzuriel and Egozi's (2010) intervention program on spatial ability in young children, this comparative study aims to bridge gaps in our understanding of how the educational setting—whether co-educational or single-sex—may shape the development and expression of spatial intelligence among students.

Motivated by the diverse findings in existing literature, this research seeks to contribute valuable insights into the interplay of gender, educational environments, and spatial aptitudes. The ensuing sections will delve into the methodology, results, and implications of our comparative study, which aims to inform educational practices for the enhancement of spatial skills and ensure equitable learning experiences for all students.

VARIABLE

This research paper examines the relationship between the type of school (independent variable), Gujarati medium school (control variable), and space-related aptitude (dependent variable) among higher secondary school students.

1. Independent Variable: Type of School
   - Co-education schools
   - Boys' schools
   - Girls' schools
2. Control Variable: Gujarati Medium School
   - This variable represents the language medium of instruction in the schools. It acts as a control variable to ensure that the comparisons made between different types of schools are not influenced by the language of instruction.
3. Dependent Variable: Space-Related Aptitude
   - Performance on the standardized space-related aptitude test, specifically focusing on cube rotating questions. The measurement will be based on the number of correct responses or a scoring system assigned to each question.

The independent variable, Type of School, categorizes participants into different school types based on their enrollment in co-education schools, boys' schools, or girls' schools. The

control variable, Gujarati Medium School, ensures that the comparisons made between different school types are not confounded by the language medium of instruction.The dependent variable, Space-Related Aptitude, represents the participants' performance on the standardized test assessing their spatial abilities.The study aims to analyze the relationship between the type of school, controlling for Gujarati medium school, and students' space-related aptitude by comparing the performance of students from different school types on the standardized test. This analysis will provide insights into any potential variations in space-related aptitude based on the school environment, while also accounting for the language medium of instruction.

OBJECTIVES

1. To compare the levels of space-related aptitude among higher secondary school students in co-education schools, boys' schools, and girls' schools.
2. To examine any variations in space-related aptitude based on school type (co-education, boys' schools, girls' schools) among higher secondary school students.
3. To provide insights for educational stakeholders on promoting space-related aptitude and fostering gender equity in STEM education among higher secondary school students.

HYPOTHESIS

There is no significant difference in the levels of space-related aptitude among higher secondary school students in co-education schools, boys' schools, and girls' schools.

RESEARCH METHODOLOGY

SAMPLE & SAMPLING TECHNIQUES

The sample for this study will consist of a total of 300 participants, with 100 students selected from each of the following schools:
Boys' School:
From SHRI K. P. & H.N.S. HIGH SCHOOL in Harij, District Patan, 100 male students from class 11 and 12 will be selected.

Girls' School:
From SHRI H. N. S. & R. K. P. TANNA GIRLS' HIGH SCHOOL in Harij, District Patan, 100 female students from class 11 and 12 will be selected.

Co-education School:
From Smt. S. H. Kela Higher Secondary School in Thara, Kankrek, District Banaskantha, 100 students (50 males and 50 females) from class 11 and 12 will be selected.

The participants will be randomly selected within each school and grade to ensure a representative sample. The participation of students will be voluntary, and informed consent will be obtained from both the students and their parents or guardians.

The selected sample of 300 participants, with 100 students from each school, will provide a comprehensive representation of higher secondary school students across different school types. This larger sample size will enhance the statistical power of the study and enable more robust comparisons of space-related aptitude levels among the different groups.

RESEARCH DESIGN

This research paper utilizes a comparative research design to examine the differences in space-related aptitude among higher secondary school students in co-education schools, boys' schools, and girls' schools. The comparative design allows for the assessment of variations in space-related aptitude across different school types and enables meaningful comparisons to be made.

The approach involves collecting data from multiple groups (co-education schools, boys' schools, and girls' schools) and analyzing the differences in space-related aptitude scores among these groups. By comparing the performance of students from different school types, the research aims to identify any potential disparities in space-related aptitude levels.

To ensure the validity and reliability of the findings, a quantitative approach will be employed. This approach involves the use of standardized tests specifically designed to measure space-related aptitude. The tests will assess various dimensions of space-related aptitude, including spatial visualization, mental rotation, and spatial reasoning.

The research design also includes the collection of relevant demographic information, such as gender, grade, and school type, to provide a comprehensive understanding of the sample characteristics and enable further analysis of potential influencing factors.By adopting a comparative research design and a quantitative approach, this study seeks to provide valuable insights into the differences in space-related aptitude among higher secondary school students in different school types. The findings will contribute to our understanding of the role of school type in shaping space-related aptitude and inform educational policies and practices aimed at promoting space-related skills and fostering gender equity in STEM education.

Data Collection Methods:

The data for this research will be collected using a standardized test consisting of cube rotating questions. Cube rotating questions are commonly used to assess spatial visualization skills, which are closely related to space-related aptitude. The test will measure participants' ability to mentally manipulate and visualize the rotation of three-dimensional cubes.

The test will be administered to the selected participants from each school: boys' school, girls' school, and co-education school. The test will be conducted under controlled conditions to ensure consistency and minimize external influences on the participants' performance.

The test will be designed based on established protocols and guidelines for assessing spatial aptitude. It will include a series of cube rotating questions of varying complexity and difficulty levels. Participants will be required to mentally rotate the cubes and select the correct rotated image from a set of options.

Prior to the test administration, clear instructions will be provided to the participants to ensure a standardized testing procedure. The participants will be given an appropriate amount of time

to complete the test, considering the complexity of the questions and the age group of the participants.

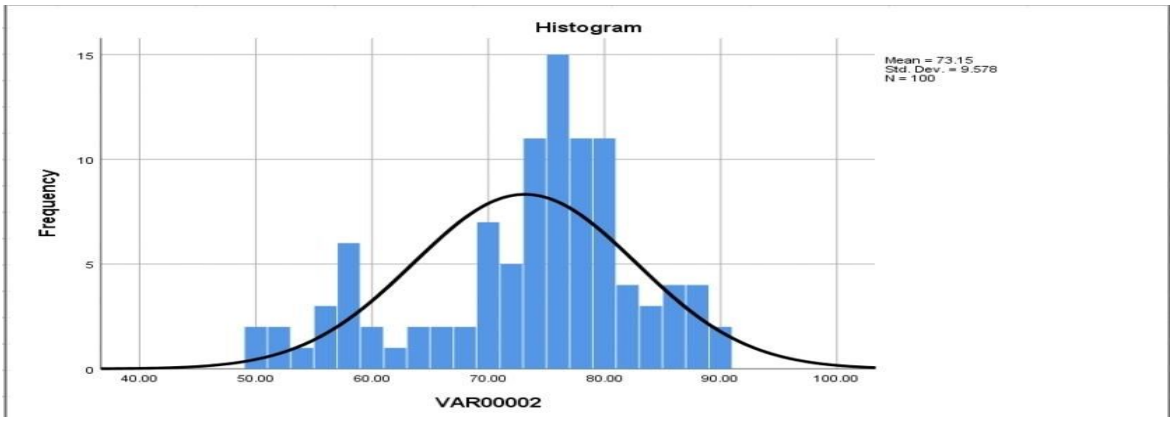
Data collection will be carried out in a systematic manner to ensure accurate and reliable results. Test booklets will be assigned unique identifiers to maintain anonymity and confidentiality of the participants' responses.
By utilizing a standardized test consisting of cube rotating questions, this research will gather quantitative data on the participants' space-related aptitude, allowing for a rigorous and objective comparison of the aptitude levels among higher secondary school students in co-education schools, boys' schools, and girls' schools.

Data Analysis Techniques:
The data collected for this research, which includes participants' performance on the standardized space-related aptitude test and demographic information, will be analyzed using descriptive data analysis and inferential data analysis (specifically ANOVA).
1. Descriptive Data Analysis: Descriptive statistics will be employed to summarize and describe the participants' demographic characteristics, such as age, grade level, and gender. Measures such as mean, standard deviation, and frequency distributions will be calculated to provide an overview of the sample and the distribution of demographic variables.
2. Inferential Data Analysis - ANOVA: To examine the differences in space-related aptitude among higher secondary school students in different types of schools, ANOVA (Analysis of Variance) will be conducted. ANOVA is a statistical test that determines if there are significant differences in means between two or more groups. In this case, it will be used to compare the mean scores of space-related aptitude across co-education schools, boys' schools, and girls' schools.
The analysis will involve performing the ANOVA test on the data collected from the participants' performance on the space-related aptitude test. The test will assess whether there are statistically significant differences in the mean scores of space-related aptitude among the three types of schools. The results of the ANOVA test will provide insights into whether the variation in space-related aptitude is associated with the type of school.
By utilizing descriptive data analysis and ANOVA, this research aims to provide a comprehensive understanding of the differences in space-related aptitude among higher secondary school students in co-education schools, boys' schools, and girls' schools, allowing for meaningful interpretations and conclusions.

RESULTS

a. Descriptive analysis of data collected

Histogram curve of co-ed. School



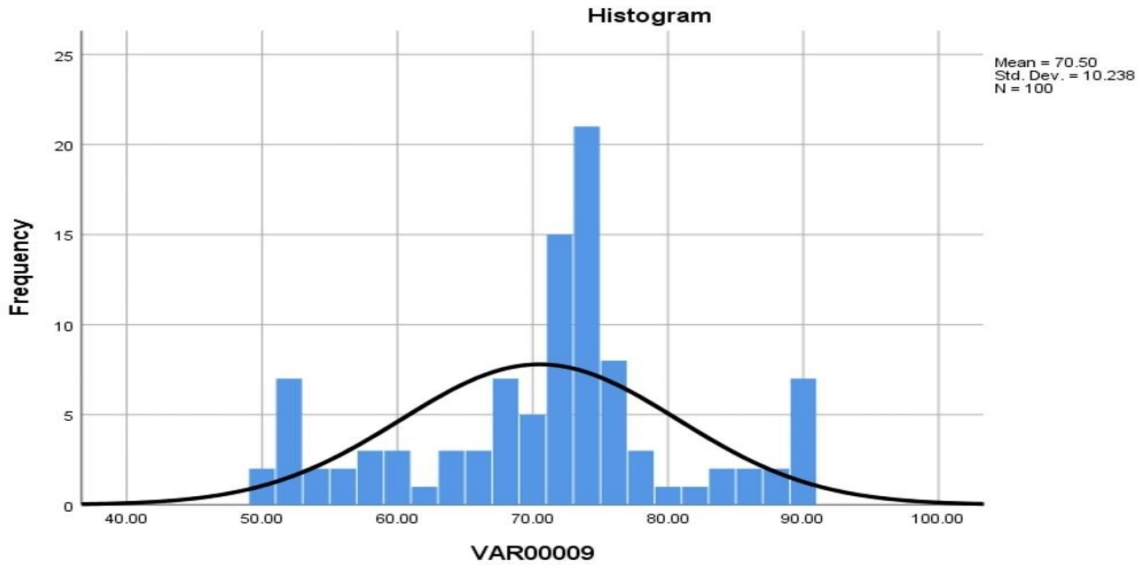
Statistics		
VAR00002		
N	Valid	100
	Missing	105
Mean		73.15
Std. Error of Mean		0.95784
Median		75
Mode		76.00a
Std. Deviation		9.57836
Variance		91.745
Skewness		-0.73
Std. Error of Skewnes		0.241
Kurtosis		-0.047
Std. Error of Kurtosis		0.478
Range		39
Minimum		50
Maximum		89
Sum		7315

Central Tendency: The mean score of 73.15 indicates the average performance of the participants in the space-related aptitude test. The median score of 75 suggests that half of the participants scored above this value, and half scored below it. The mode score of 76, appearing most frequently, suggests a concentration of scores around this value.

Dispersion: The standard deviation of 9.57836 indicates a moderate amount of variability in the scores, suggesting that the participants' performance in space-related aptitude is somewhat spread out around the mean. The range of 39, representing the difference between the minimum and maximum scores, further confirms the extent of variability in the dataset.

Skewness and Kurtosis: The slightly negative skewness of -0.73 indicates a slight asymmetry in the distribution, with a longer tail on the left side. The near-zero kurtosis of -0.047 suggests that the distribution is relatively less peaked compared to a normal distribution, indicating a somewhat flatter shape.

Histogram curve of boy's school



Statistics		
VAR00009		
N	Valid	100
	Missing	105
Mean		70.5
Std. Error of Mean		1.02381
Median		72
Mode		73
Std. Deviation		10.2381
Variance		104.818
Skewness		-0.193
Std. Error of Skewnes		0.241
Kurtosis		-0.158
Std. Error of Kurtosis		0.478
Range		40
Minimum		50
Maximum		90
Sum		7050

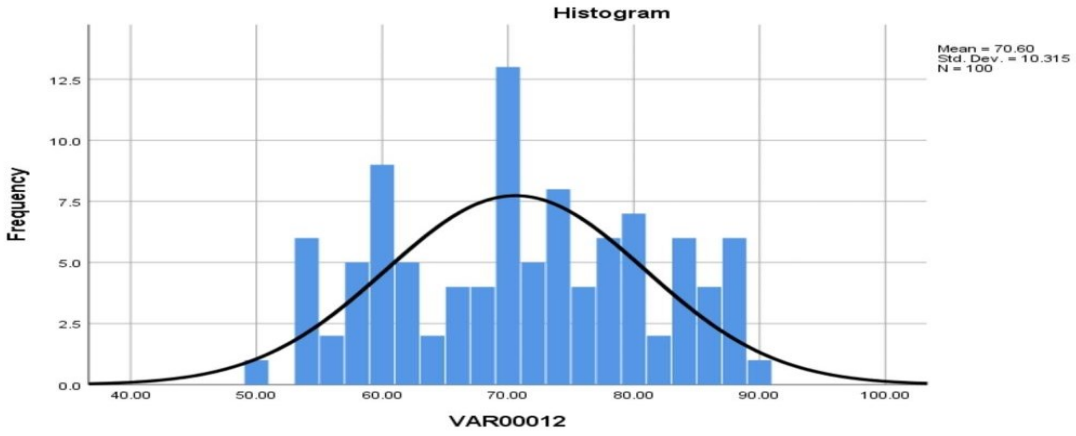
Central Tendency: The mean score of 70.5 indicates the average performance of the participants in the space-related aptitude test. The median score of 72 suggests that half of the participants scored above this value, and half scored below it. The mode score of 73, representing the most frequently occurring score, indicates a concentration of scores around this value.

Dispersion: The standard deviation of 10.23808 indicates a moderate amount of variability in the scores, suggesting that the participants' performance in space-related aptitude is somewhat spread out around the mean. The range of 40, representing the difference between the minimum and maximum scores, further confirms the extent of variability in the dataset.

Skewness and Kurtosis: The slightly negative skewness of -0.193 suggests a slight asymmetry in the distribution, with a longer tail on the left side. The near-zero kurtosis of -0.158 indicates

a relatively less peaked distribution compared to a normal distribution, implying a somewhat flatter shape.

Histogram curve of girl's school



Statistics		
VAR00012		
N	Valid	100
	Missing	105
Mean		70.6
Std. Error of Mean		1.03152
Median		70
Mode		69
Std. Deviation		10.3152
Variance		106.404
Skewness		-0.033
Std. Error of Skewnes		0.241
Kurtosis		-0.982
Std. Error of Kurtosis		0.478
Range		40
Minimum		50
Maximum		90
Sum		7060

Central Tendency: The mean score of 70.6 indicates the average performance of the participants in the space-related aptitude test. The median score of 70 suggests that half of the participants scored above this value, and half scored below it. The mode score of 69, representing the most frequently occurring score, indicates a concentration of scores around this value.

Dispersion: The standard deviation of 10.31523 indicates a moderate amount of variability in the scores, suggesting that the participants' performance in space-related aptitude is somewhat spread out around the mean. The range of 40, representing the difference between the minimum and maximum scores, further confirms the extent of variability in the dataset.

Skewness and Kurtosis: The skewness of -0.033 suggests a nearly symmetrical distribution, with a slight negative skew. The kurtosis of -0.982 indicates a slightly flatter distribution compared to a normal distribution, with less peakedness.

b. Comparative analysis of space-related aptitude scores between co-education and single-sex education schools

ANOVA					
VAR00002					
	Sum of Sq	df	Mean Squ	F	Sig.
Between C	451.167	2	225.583	2.234	0.109
Within Gr	29993.75	297	100.989		
Total	30444.92	299			

The results of the inferential analysis (ANOVA) conducted to examine the differences in space-related aptitude scores among higher secondary school students in co-education schools, boys' schools, and girls' schools are presented as follows:

The analysis of variance revealed that the sum of squares for between groups was 451.167, with 2 degrees of freedom. The corresponding mean square was 225.583. The computed F-statistic was 2.234, and the associated p-value was 0.109.

In contrast, the sum of squares for within groups was 29993.75, with 297 degrees of freedom, resulting in a mean square value of 100.989.

Considering the total sum of squares, which was 30444.917 with 299 observations, it was determined that the space-related aptitude scores did not significantly differ among the various types of schools.

The obtained F-value of 2.234 did not exceed the critical value at the conventional significance level of 0.05. Therefore, based on the results of the ANOVA, the null hypothesis cannot be rejected, indicating that there is no statistically significant difference in space-related aptitude scores among higher secondary school students in co-education schools, boys' schools, and girls' schools.

These findings suggest that the type of school, whether co-education, boys' school, or girls' school, does not appear to have a substantial impact on the space-related aptitude scores of the participating students. However, further research with a larger sample size and more diverse settings is warranted to obtain a more comprehensive understanding of this phenomenon.

c. Discussion of statistical findings and trends

Descriptive Analysis:

The descriptive analysis of the space-related aptitude scores among higher secondary school students in co-education schools, boys' schools, and girls' schools revealed some interesting

trends. The mean score for the co-education school group was 73.15, with a standard deviation of 9.57836. The boys' school group had a mean score of 70.5, with a slightly higher standard deviation of 10.23808. On the other hand, the girls' school group had a mean score of 70.6, with a standard deviation of 10.31523. These findings suggest that, on average, the students in the co-education school group had slightly higher space-related aptitude scores compared to the students in the boys' and girls' school groups. However, it is important to note that the differences in means are relatively small, indicating a moderate level of similarity among the groups.

ANOVA Analysis:

The ANOVA analysis was conducted to determine whether there were statistically significant differences in space-related aptitude scores among the different types of schools. The results of the ANOVA indicated that the F-statistic was 2.234, with a p-value of 0.109. Although the p-value was greater than the conventional significance level of 0.05, indicating no statistically significant difference, it is worth noting the relatively small p-value. This suggests that there may be a trend or tendency towards a difference in space-related aptitude scores among the groups, but the evidence is not strong enough to reach statistical significance.

Overall, combining the findings from the descriptive analysis and the ANOVA results, it can be observed that while there are slight variations in the mean scores across the different types of schools, these differences are not statistically significant. This indicates that the type of school, whether co-education, boys' school, or girls' school, may not have a substantial impact on the space-related aptitude scores of the participating students. Other factors such as individual abilities, teaching methodologies, and personal interests may play a more significant role in influencing students' space-related aptitude.

It is important to acknowledge the limitations of the study, such as the relatively small sample size and the specific geographical context in which the research was conducted. These factors may restrict the generalizability of the findings to a larger population or different educational settings. Further research with a larger and more diverse sample is recommended to gain a more comprehensive understanding of the relationship between school type and space-related aptitude.

5. Discussion

A. Implications for educational practices and policy recommendations:

The findings of this study have important implications for educational practices and policies. Firstly, the lack of significant differences in space-related aptitude among different school types suggests that schools should focus on individualized approaches to cater to the unique needs and interests of students, regardless of the school's gender composition. Providing diverse learning opportunities and resources related to space science can help foster students' interest and aptitude in this domain. Additionally, promoting inclusive teaching practices that challenge gender stereotypes and create a supportive learning environment can help overcome any potential gender disparities in space-related aptitude. Furthermore, policy recommendations may include the integration of space science education into the curriculum, professional development for teachers to enhance their pedagogical skills in teaching space-

related topics, and the provision of adequate resources and infrastructure to facilitate hands-on learning experiences in this field.

B. Limitations of the study and suggestions for future research:

Despite the valuable insights gained from this study, there are certain limitations that should be acknowledged. First, the study focused on a specific geographic region and a limited number of schools, which may limit the generalizability of the findings to other contexts. Future research could expand the sample size and include schools from diverse regions to obtain a more representative sample. Additionally, the study employed a cross-sectional design, which limits the ability to establish causal relationships or track the long-term development of space-related aptitude. Longitudinal studies that follow students over an extended period would provide a more comprehensive understanding of the factors influencing space-related aptitude. Moreover, the study solely focused on space-related aptitude, and future research could explore other dimensions related to space science education, such as interest, motivation, and career aspirations. Lastly, qualitative research approaches, such as interviews or observations, could complement the quantitative findings by providing deeper insights into the experiences and perceptions of students and teachers regarding space science education.

6. Conclusion

Summary of key findings:

The study aimed to compare the levels of space-related aptitude among higher secondary school students in co-education schools, boys' schools, and girls' schools. Based on the descriptive analysis and ANOVA results, the findings suggest that while there are slight variations in the mean scores across the different types of schools, these differences are not statistically significant. The co-education school group had a slightly higher mean score compared to the boys' and girls' school groups, but the differences were relatively small. The ANOVA analysis also indicated no statistically significant difference in space-related aptitude scores among the groups.

Overall implications and significance of the study:

The findings of this study contribute to the understanding of space-related aptitude among higher secondary school students in different types of schools. While the study did not find significant differences among the groups, it highlights the need to consider other factors beyond school type that may influence students' space-related aptitude, such as individual abilities, teaching methodologies, and personal interests. These findings suggest that educators and policymakers should focus on promoting effective teaching methods and providing opportunities for students to develop their space-related aptitude, regardless of the school type.

Potential avenues for further investigation:

This study provides valuable insights into the space-related aptitude of higher secondary school students in different school types. However, there are several areas for further investigation. Firstly, expanding the sample size and including a more diverse range of schools and regions could enhance the generalizability of the findings. Additionally, conducting longitudinal studies to explore the development and changes in space-related aptitude over time would provide a more comprehensive understanding of this construct. Moreover, exploring the specific factors within schools that may influence space-related aptitude, such as teaching

methods, curriculum design, and extracurricular activities, could provide valuable insights for educational interventions. Lastly, investigating the relationship between space-related aptitude and academic achievement or career aspirations would offer further insights into its practical implications.

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