



An investigation of the relationship between metacognitive skills and mathematics achievement of secondary school students

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Abstract

The study aimed to investigate the link between metacognitive skills and the mathematics achievement of secondary school students in Prayagraj District. A sample of 600 students from ICSE, CBSE, and UP Board schools was gathered, utilizing a self-designed mathematics achievement test alongside the metacognitive skills scale. The findings unveiled several significant insights. Firstly, there was no discernible variation in metacognitive skills among secondary school students based on their respective boards (ICSE, CBSE, or UP Board), suggesting a uniformity in these skills across different educational boards. Secondly, the study identified a notable relationship between mathematics achievement and metacognitive skills across all three boards. For ICSE students, a strong positive correlation ($r=0.908$, $p<0.05$) was found between mathematics achievement and metacognitive skills. Similarly, CBSE students exhibited a strong positive correlation ($r=0.872$, $p<0.05$), while students of the UP Board demonstrated a highly significant positive correlation ($r=0.959$, $p<0.05$). The study emphasizes the importance of metacognitive skills in the context of mathematics achievement and suggests that educational strategies should integrate the teaching of these skills to enhance students' overall academic performance in mathematics.

Keywords: Metacognitive skills, mathematics achievement

Introduction

Education is of vital importance in the overall development of students and in the wellbeing of societies. The basic goal of education is to enhance the potential of an individual to the maximum. We observe that some of the bright and intelligent students are not able to score good marks. Metacognitive skills empower the learners to enhance their performance. If a student has to experience learning in the holistic manner, then the self-regulating skills of planning, implementation, monitoring and evaluating are crucial.

In the twenty-first century, mathematics is now essential to success in every aspect of life. Without mathematics, it is impossible to consider any scientific investigation (Pandey, B.D., 2017). The three Rs—reading, writing, and arithmetic—make up mathematics. Every student needs to accomplish a few essential goals and objectives in their daily lives. To accomplish these goals, mathematics serves as a base of operations. One of the most crucial objectives in learning mathematics is to improve one's mathematical knowledge, which involves understanding of mathematical ideas and problem-solving abilities. (Abella H. B. & Maandig R., 2023) Mathematics achievement and metacognition have a complicated and nuanced relationship. The capacity to consider and control one's own cognitive functions, such as organizing, observing, and assessing one's own thoughts, is known as metacognition. Metacognition is essential to a student's capacity to learn, solve problems, and do well in mathematics.

It is important to understand that there is a reciprocal relationship between metacognition and achievement in mathematics. Mathematical excellence can improve metacognitive abilities since success frequently fosters self-assurance and a deeper comprehension of one's learning processes. On the other hand, better metacognition can result in better mathematics performance. By imparting

explicit metacognitive methods and building a supportive learning environment, educators play a critical part in encouraging metacognition in students. Math achievement can be raised by encouraging pupils to analyze their ideas, pose questions, and be conscious of their learning processes. Toraman C. *et al* (2020) were of the view that there exists a strong and positive correlation between achievement in mathematics and metacognition. Ozsoy G & Ataman A. (2009) [17] also point out that students in metacognitive treatment group gained both in their ability to solve mathematical problem and their metacognitive abilities.

Present Study

The main objective of this study is to assess the metacognitive skills of secondary school students from different educational boards and explore how these skills relate to their Mathematics achievement in the ICSE, CBSE, and UP boards. The hypothesis suggests that there will be a correlation between students' metacognitive scores and their scores in mathematics achievement.

Methodology

In the proposed work Descriptive Survey Method has been used. The descriptive survey research, as John W. Best (1980) states, involves events that have already taken place. The only elements that the researcher manipulates are his methods of observation and description in which he analyses relationship. This allows a researcher to provide insights into the why and how of research.

Participants

The study comprised of secondary school students of Prayagraj District. The study included 600 secondary school students of ICSE, CBSE and UP Board school. The

researcher used a stratified random sampling technique for the selection of blocks, schools and students.

Basic Information		No. of Respondents	
		Frequency	Percentage
Board	ICSE	187	31.2
	CBSE	215	35.8
	UP Board	198	33
	Total	600	100

Instruments

Metacognitive Skills Scale - Madhu Gupta and Suman (2017) Scale was used having reliability of 0.763.

Mathematics achievement test - Self-constructed achievement mathematics achievement test for secondary school students was prepared. A total of 13 sub-units from the mathematics curriculum recommended by the Boards of Secondary Education for students in class IX were used to create 160 objective type items with a variety of levels of difficulty. Multiple choice questions, true and false

questions, fill in the blanks, and matching types were the four categories that made up the test. After item analysis a total of 45 items were eliminated from the test, leaving 115 test items that met the specified criteria for inclusion in the final test. This careful curation ensures that the final test consists of items that are appropriate in terms of difficulty and have the ability to differentiate between students with varying levels of achievement. The obtained reliability coefficient for the test was 0.76.

Result and Discussion

Metacognitive Skills of CBSE, ICSE and UP Board students

When examining the gathered data, the results were analyzed using a significance level (p) 0.05. One way analysis of variance is used to find out whether there is difference in metacognitive skills of ICSE, CBSE and UP board students as well as four dimensions of it. Results of the analysis have been shown in table no. 1

Table 1: Analysis of Variance (ANOVA) showing Metacognitive Skills of CBSE, ICSE and UP Board students

Dimensions		Sum of Squares	df	Mean Square	F	P
Planning Skill	Between Groups	215.42	2	107.71	3.76*	0.02
	Within Groups	17079.91	597	28.60		
	Total	17295.33	599			
Implementation Skill	Between Groups	25.48	2	12.74	1.41	0.24
	Within Groups	5373.	597	9.00		
	Total	5399.17	599			
Monitoring Skill	Between Groups	226.30	2	113.15	4.38*	0.01
	Within Groups	15421.65	597	25.83		
	Total	15647.96	599			
Evaluation Skill	Between Groups	63.72	2	31.86	1.65	0.19
	Within Groups	11460.98	597	19.19		
	Total	11524.69	599			
Overall Metacognitive Skills	Between Groups	773.54	2	386.77	1.79	0.16
	Within Groups	128453.45	597	215.16		
	Total	129226.99	599			

*Significant at 0.05 level

The analysis used an F-ratio test, which resulted in an F-value of 1.79. The study concluded that this value is not significant at the 0.05 level because it is less than the critical value of 2.99 required for significance. Therefore, it states that there is no significant difference in metacognitive skills among students from these boards. The F value of specific dimensions of metacognitive skills, including implementation skill (1.41) and evaluating skill (1.65) states that there is no significant difference, however, there are significant differences in the F value of the two other dimensions: planning skill (3.76) and monitoring skill (4.38). The reason for overall insignificant difference in metacognitive skills of secondary school students on the basis of educational board may be due to the fact that, the teaching patterns across different boards might be similar, and individual differences among students, such as motivation, cognitive abilities, and prior knowledge, could impact the development of metacognitive skills regardless

of the educational board. The similar study was conducted by Jageshwari, S. and Chandrasekeran, V. (2014) [12], which found no significant difference in metacognitive awareness among students based on their locale. Jaleel, S. and Premchandra, P. (2016) [13] also concluded that type of management of school does not influence the metacognition ability of students.

Relationship between achievement in mathematics and metacognitive skills of CBSE, ICSE and UP Board student

It was hypothesized that CBSE, ICSE and UP Board students differ from one another on the basis of their relationship between achievement in mathematics and metacognitive skills. This null hypothesis has been tested with the help of an achievement tool and the results of analysis have been shown in table no. 2

Table 2: Relationship between achievement in mathematics and metacognitive skills of CBSE, ICSE and UP Board secondary school students.

Board	Indicator	N	Mean	SD	P	R
CBSE	Achievement in Mathematics	215	69.28	15.59	0.00	0.908*
	Metacognition Skills		159.78	14.94		
ICSE	Achievement in Mathematics	187	69.71	17.77	0.00	0.872*

	Metacognition Skills		161.68	15.88		
UP	Achievement in Mathematics	198	65.85	14.54	0.00	0.959*
	Metacognition Skills		158.90	13.09		

*Significant at 0.05 level

The correlation coefficient for achievement in mathematics and metacognitive skills of CBSE Board students in table no. 02 above is 0.908, which is significant at the 0.05 level. The ICSE Board students' achievement in mathematics and metacognitive abilities have a 0.872 correlation coefficient, which is significant at the 0.05 level. Similarly, the UP-Board students' achievement in mathematics and metacognitive skills have a 0.959 correlation coefficient,

which is also significant at the 0.05 level. The null hypothesis that states "There is no significant relationship between achievement in mathematics and metacognitive skills of CBSE, ICSE, and UP Board students" is therefore rejected. This suggests that metacognitive abilities and mathematics achievement of CBSE, ICSE, and UP Board students have a substantial relationship. The graphical representation of the table is given in Fig no. 1, 2 & 3

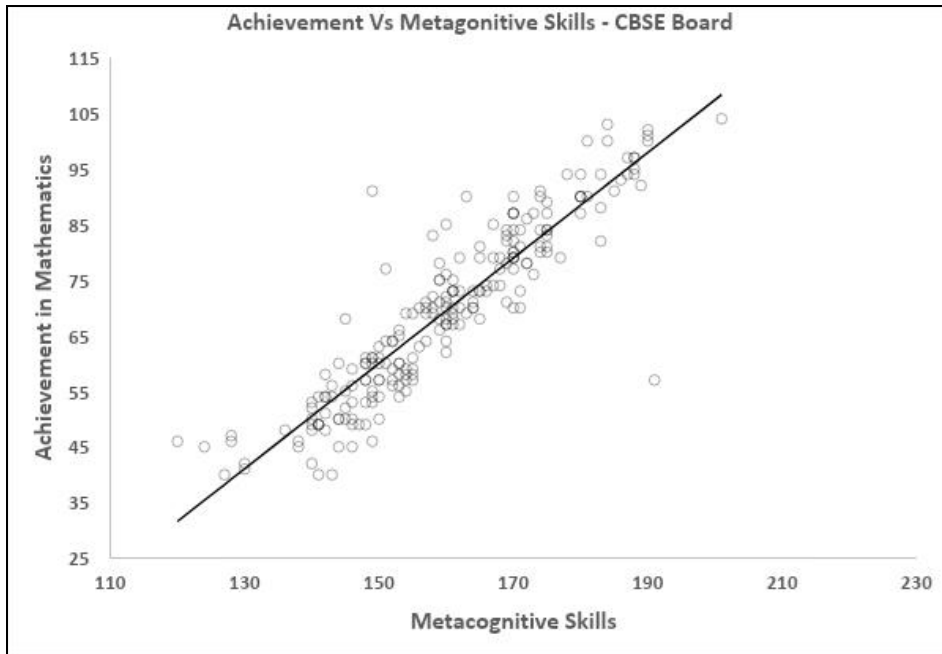


Fig 1: showing correlation between achievement in mathematics and metacognitive skills of CBSE secondary school students.

The mean mathematics achievement among CBSE students, who made up 36% of the sample, was 69.28, whereas the mean metacognitive skills score was 159.78. Students at CBSE secondary schools have a high correlation between mathematics proficiency and metacognitive abilities, as seen

in Fig 1. These findings highlight the significance of taking the educational board into account when analyzing the relationship between mathematics achievement and metacognitive abilities among secondary school pupils.

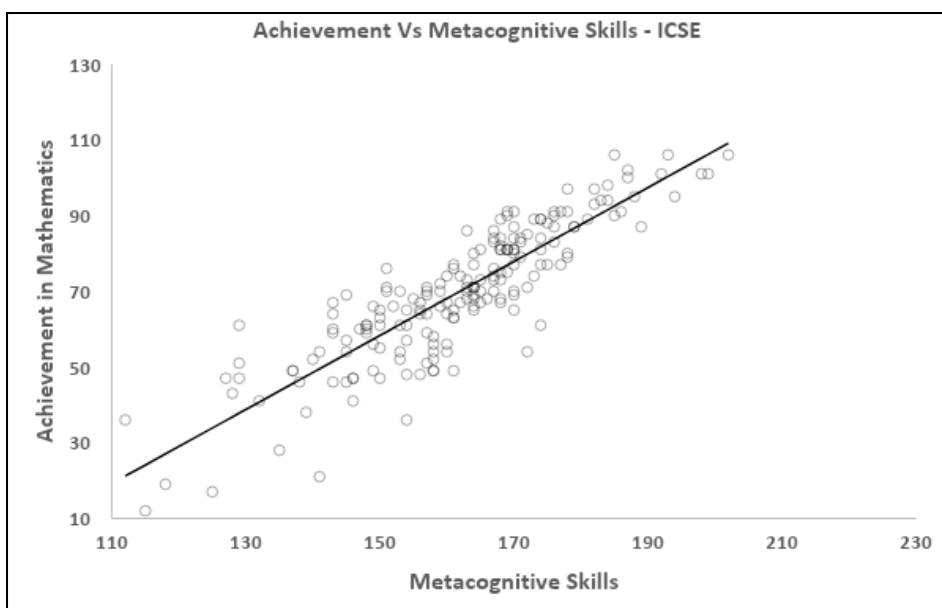


Fig 2: showing correlation between achievement in mathematics and metacognitive skills of ICSE secondary school students.

The mean mathematics achievement for the 31% of ICSE students in the sample was 69.71, and the average metacognitive skills score was 161.68. Fig 3 from the ICSE secondary school students' achievement in mathematics and metacognitive abilities are significantly correlated. The

correlation line, which is rising upward from left to right, demonstrates the substantial association between ICSE Board secondary school students' mathematical achievement and metacognitive abilities.

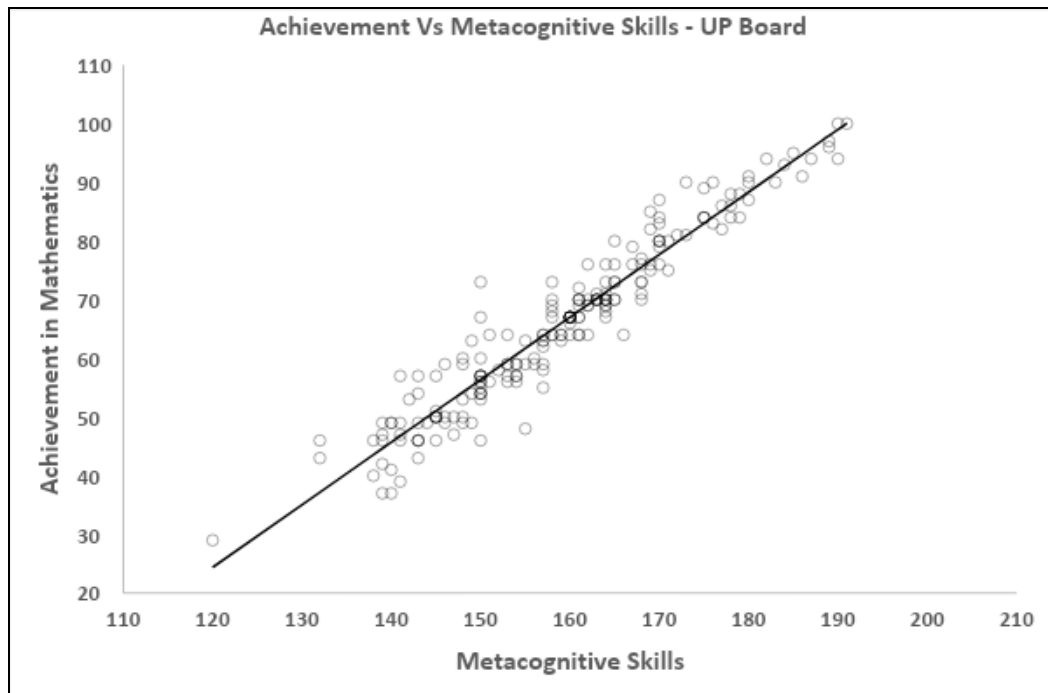


Fig 3: showing correlation between achievement in mathematics and metacognitive skills of UP Board secondary school students.

The mean mathematics achievement for the 33 percent of UP Board students in the sample was 65.85, while the average metacognitive skill score was 158.90. Fig 3 of pupils from UP Board secondary schools demonstrates a statistically significant relationship between math proficiency and metacognitive abilities. A substantial association between math proficiency and metacognitive abilities of UP Board secondary school students can be seen in the upwardly sloping line of correlation that runs from left to right.

Similar study was conducted by *Kumar S. and Sharma A. (2019)* ^[15] concluded that there exists a significance difference in achievement in mathematics when metacognition skills are applied. *The results are in accordance with prior studies (Borkowski and Thorpe 1994; Case et al. 1992; Desoete et al. 2001a, b; Kirby and Ashman 1984; Lucangeli and Cornoldi 1997; Schoenfeld 1992) that have shown a connection between mathematics achievement and metacognitive skills.*

Conclusion

It was noted that a significant and positive correlation existed between metacognitive skills and mathematics achievement. This indicates that metacognition can serve as a valuable tool for the development of mathematical skills. As a result, it is recommended that metacognitive skill instruction be included in all educational processes. Numerous studies support this notion, suggesting that teaching students' metacognitive skills may lead to improvements in their academic performance (Cardelle-Elawar 1992 ^[4]; Silver 1987; Ozsoy and Ataman 2009) ^[17]. The study further revealed a strong correlation between mathematics achievement and metacognitive skills among

students of CBSE, ICSE, and UP boards. This suggests that metacognitive skills play a crucial role in students' performance in mathematics. During the literature review conducted for this study, it was observed that metacognitive skills are frequently studied in relation to language and mathematics. However, metacognitive skills can also be studied, particularly in connection with subjects such as social sciences, science, and arts.

References

1. Acharya S. Metacognitive Skills and Academic Achievement of Higher Secondary School Students. *Pedagogy of Learning*,2021:7(4):E-ISSN: 2395-7344.
2. Appiah JB, et al. Mathematics achievement in high schools, the role of the teacher-student relationship, students' self-efficacy, and students' perception of mathematics. *Int Electron J Math Educ*,2022. Available from: <https://www.iejme.com>
3. Bhairab Datt Pandey. A study of mathematical achievement of secondary school students. *Int J Adv Res*,2017:5(Dec):1951-1954. ISSN 2320-5407. Available from: www.journalijar.com
4. Cardelle-Elawar M. Effects of teaching metacognitive skills to students with low mathematics ability. *Teach Teach Educ*,1992:8:109-121.
5. Chaudhary B. A study of Academic Achievement of 10+1 students in relation to their metacognition. *Int J Prof Stud*,2017:(3):e-ISSN: 2455-6270. Available from: <http://www.ijps.in>
6. David H, Qasim SH. Metacognitive skills and Learning Styles enhance the achievement in mathematics of secondary school students. *Int J Humanit Soc Sci Invent*,2023:12(11):94-98.

7. David H, Qasim SH. Metacognitive Skills and Achievement in Mathematics: Nature of Relationship. *Adhigam*,2024;30:162-170.
8. Flavell JH. Metacognitive and cognitive monitoring: A new area of cognitive developmental inquiry. *Am Psychol*,1979;24:143-158.
9. Hooda M, Devi R. Type of school, locality and gender as determinant of achievement in mathematics among secondary school students. *Int J Adv Res Manage Soc Sci*,2017;6(01). ISSN: 2278-6236.
10. Hassan NM, Rahman S. Problem Solving Skills, Metacognitive Awareness, and Mathematics Achievement: A Mediation Model. *New Educ Rev*,2020:204–212.
11. Hughes J, Kwok O. Influence of student-teacher and parent-teacher relationships on lower achieving readers' engagement and achievement in the primary grades. *J Educ Psychol*,2007;99(1):39-51. <https://doi.org/10.1037/0022-0663.99.1.39>
12. Jageshwari AS, Chandrasekaran V. Promoting Metacognitive awareness among higher secondary students. *Scholarly Res J Interdiscip Stud*,2014: ISSN 2278-8808.
13. Jaleel S, Premachandran. A Study on the Metacognitive Awareness of Secondary School Students. *Univ J Educ Res*,2016;4(1):165-172. Available from: <http://www.hrpub.org>.
14. Jennifer AL. Metacognition: An overview. *Educ Resour Inf Cent (ERIC)* - U.S. Department of Education,2003. ED 474 273.
15. Kumar M, Sharma A. A study of Mathematics Achievement of secondary school students in relation to Metacognitive awareness, gender and Type of School. *J Emerg Technol Innov Res (JETIR)*, 2019, 6(06):ISSN - 2349-5162.
16. Ozsoy G. An investigation of the relationship between metacognition and mathematics achievement. *Asia Pac Educ Rev*,2011;12:227-235.
17. Ozsoy G, Ataman A. The effect of metacognitive strategy training on mathematical problem-solving achievement. *Int Electron J Elem Educ (IEJEE)*,2009;1(2):67–82.