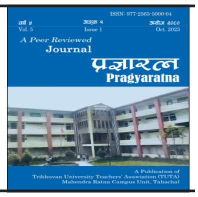
DOI: https://doi.org/10.3126/pragyaratna.v6i2.70585

Established by INASP in 2007. Managed by Tribhuvan University Central Library.

Contents lists available at NepJol

Pragyaratna

A Peer-Reviewed, Open Access Journal



Gender Differences in Metacognitive Skills in Mathematics Learning

Krishna Chandra Paudel [a] ✉

✉kcpaudel@trinitycollege.edu.np

[a] Faculty of Education, Tribhuvan University, Mahendra Ratna Campus

Article Info | **Abstract**

Received: August 4, 2024

Accepted: September 13, 2024

Published: October 22, 2024

Students' weak mathematical metacognitive skills can reduce their drive to learn, potentially leading to underwhelming outcomes in mathematics. This study investigated mathematical metacognition levels among high school students and examined potential gender differences. A quantitative approach was employed, surveying 402 randomly selected students from four secondary schools of Kathmandu district. Metacognition was assessed using 18 items adapted from the Junior Metacognitive Awareness Inventory (Jr MAI). Results revealed strong student awareness of interest impacts on learning but weak engagement in self-questioning about outcomes. Significant gender differences emerged, with males demonstrating higher overall metacognition scores (mean = 67.655) compared to females (mean = 64.399), (t = -2.875, p = 0.004, d = 0.2886). Girl students exhibited greater inconsistency in metacognitive abilities. The study highlights the need for targeted interventions considering both general metacognitive development and gender-specific approaches. Implications include adapting teaching strategies to individual metacognitive awareness levels and developing interventions for areas of lower usage. Future research should explore factors contributing to gender differences and investigate effective strategies for promoting metacognitive development across all students, regardless of gender.

Keywords: *Gender differences, knowledge of cognition, metacognition, regulation of cognition, self-regulated learning*

Introduction

Metacognition, often described as "thinking about thinking," is a crucial cognitive process that enables individuals to understand and regulate their own learning. It is a regulatory system that allows individuals to understand and control their own cognitive performance. Through metacognition, people are able to take charge of their own learning by monitoring and evaluating their thinking in order to make adjustments that improve their performance. Flavell (1979), a pioneer in metacognition research, defined it as "knowledge about and regulation of one's cognitive activities in learning processes". This concept encompasses both the awareness of one's cognitive processes and the ability to control and adjust these processes to optimize learning outcomes. In the context of secondary education, metacognition plays a pivotal role in students' academic success and personal growth.

The importance of metacognition in learning is well-established in educational psychology. Schraw and Moshman (1995) proposed a framework in which metacognition is composed of two key elements: knowledge of cognition and regulation of cognition. Knowledge of cognition includes what individuals understand about their own cognitive processes or cognition in general, whereas regulation of cognition involves the activities that help students control their learning. For secondary school students, developing strong metacognitive skills can significantly enhance their ability to plan, monitor, and evaluate their learning strategies, leading to improve academic performance across various subjects (Veenman et al., 2006).

Some studies have highlighted the positive correlation between metacognitive awareness and academic achievement among secondary school students. For instance, Sperling et al. (2012) found that students with higher levels of metacognitive awareness tend to perform better in standardized tests and demonstrate greater problem-solving abilities. Moreover, Zimmerman (2002) emphasized the role of self-regulated learning, a concept closely related to metacognition, in fostering independent and lifelong learning skills. As educators and researchers continue to explore effective ways to cultivate metacognitive skills in secondary education, it becomes increasingly important to assess and understand the current levels of metacognitive awareness among students in this age group.

In view of the inconsistent finding on gender differences in metacognition, the present study aims to identify the relation between metacognition and gender in Nepalese secondary level students. This research seeks to determine the relation of mathematical metacognition of secondary level schoolchildren with respect to their gender. To achieve this objective, the following research questions have been set.

1. Is there gender differences on knowledge of cognition and regulation of cognition amongst secondary level students?
2. Is there any association between secondary school students' mathematical metacognition and their gender?

Review of Related Literature

Metacognitive skills are crucial components of self-regulated learning, enabling students to plan, monitor, and evaluate their cognitive processes effectively. These skills, as outlined by Schraw and Moshman (1995), encompass planning (selecting appropriate strategies and allocating resources), monitoring (self-testing skills and comprehension), and evaluation (appraising the products and regulatory processes of learning). Flavell's (1979) theoretical framework further categorizes metacognitive knowledge into three variables: person (understanding one's own capabilities), task (comprehending the nature and demands of different tasks), and strategy (knowing when and how to use various cognitive strategies). This theoretical foundation emphasizes that students with well-developed metacognitive skills are better equipped to navigate complex learning situations, adapt their approaches, and ultimately achieve higher academic success.

Research has consistently demonstrated the positive impact of metacognitive skills on student performance across various academic domains. For instance, Veenman et al. (2006) found that metacognitive skillfulness accounts for 40% of the variance in learning performance, independent of intellectual ability. Moreover, Pintrich and De Groot (1990) showed that learners who use metacognitive strategies such as planning, monitoring, and modifying their cognition are more likely to perform better on academic tasks than those who don't. The development of these skills is particularly critical during secondary education, as students face increasingly complex academic challenges. As Zimmerman (2002) notes, fostering metacognitive skills not only enhances immediate academic performance but also promotes lifelong learning capabilities, preparing students for future educational and professional endeavors.

Gender differences in mathematical metacognition among secondary level students have been a subject of considerable research, yielding mixed results. Some studies suggest that there are significant disparities in metacognitive awareness and skills between male and female students, while others find minimal or no differences. Ozsoy and Ataman (2009) found that female secondary school students demonstrated higher levels of mathematical metacognitive knowledge and regulation compared to their male counterparts. This finding aligns with research by Zimmerman and Martinez-Pons (1990), who reported that girls tend to use more self-regulated learning strategies, including goal-setting and planning, which are key components of metacognition. However, it is important to note that these differences may be influenced by sociocultural factors and stereotypes rather than inherent cognitive abilities.

Conversely, other researchers have found no significant gender differences in mathematical metacognition at the secondary level. For instance, Akin (2016) conducted a study on high school students and concluded that there were no statistically significant differences between male and female students in terms of their metacognitive awareness in mathematics. Similarly, Ciascai and Lavinia (2011) found that gender did not play a significant role in metacognitive skills related to problem-solving in mathematics and sciences. These conflicting findings highlight the complexity of the relationship between gender and mathematical metacognition, suggesting that other factors such as individual differences, educational environment, and cultural context may play more crucial role in shaping students' metacognitive abilities in mathematics.

The existing empirical and theoretical researches indicate that metacognition is a critical factor for students' academic achievements. While there is a substantial body of work on this topic worldwide, studies in the Nepalese context are limited. Therefore, further research is needed to determine the level of mathematical metacognition among students and investigate any related demographic factors. This study could help address the current gap in the research.

Methodology

Research design

The researcher gathered the data for this study through a survey methodology. Employed a quantitative research design, as recommended by Creswell and Creswell (2017), to collect the numerical data. The core purpose of this quantitative approach, as highlighted by Johnson and Onwuegbuzie (2004), is to examine causal relationships within an objective, impartial framework.

Research site and sample

A total 402 secondary level students from four schools in Kathmandu, Nepal were randomly selected as the participants of the study. The sample consisted 173 (43.03%) girls and 229 (56.97 %) boys.

Tools and validation

This study employed a descriptive survey design with a quantitative approach to examine students' metacognition levels in mathematics. To measure these levels, the researchers utilized an adapted version of the Junior Metacognitive Awareness Inventory (Jr. MAI), originally developed by Sperling et al. (2002). This instrument comprises two sub-scales: Knowledge of Cognition and Regulation of Cognition. The Knowledge of Cognition sub-scale assesses students' awareness of their strengths and weaknesses, as well as their knowledge about strategies and how to use them. This includes measures of declarative, procedural, and conditional knowledge. The Regulation of Cognition sub-scale evaluates students' ability to plan, implement, monitor, and evaluate their use of strategies. The adapted instrument consisted of 18 items, each rated on a 5-point Likert scale ranging from 1 ("*the statement does not describe me*") to 5 ("*the statement describes me very well*"). Sample items include "*I ask myself if I learned what I wanted to learn*" and "*I think about what I need to learn before I start working*." This comprehensive tool was used throughout the data collection process to gather insights into students' mathematical metacognition.

To confirm the questionnaire was suitable for the Nepalese context, the researchers translated the items from the Junior Metacognitive Awareness Inventory (Jr. MAI) into the local Nepali language. During this translation process, the researchers made necessary language adjustments while preserving the core meaning of the items. The accuracy of the translation was then verified through a back-translation process, where the Nepali version was translated back into English with the help of translators. After this, the researchers prepared the scales for a pilot study.

The pilot study was conducted among 80 secondary-level mathematics students who were not a part of the main study sample. The internal consistency reliability of the Self Efficacy scale, as measured by Cronbach's alpha, was found to be 0.92, indicating high reliability. Further analysis showed the item mean was 3.51, the item variance was 1.05, each correlated item-total correlation value exceeded 0.3, and all values in the "Cronbach's alpha if item deleted" analysis were less than the overall test reliability.

Further analysis strengthened the suitability of the questionnaire for this study. The extension range determined through principal component analysis was 0.64 to 0.92, with no values falling below 0.3. The component matrix revealed that all items had factor loadings greater than 0.4. These results collectively indicated that each item in the questionnaire was appropriate for the study, requiring no further modifications to the scale. Based on these findings, the researchers proceeded to use the instrument in the study context as it was. The surveys were subsequently administered during regular classroom hours, ensuring a familiar and comfortable environment for the participants.

Analysis and interpretation procedure

The researcher utilized the Statistical Package for the Social Sciences (SPSS version 20) to analyze the collected data. The analysis involved calculating descriptive statistics, including minimum, maximum, mean, standard deviation, and variance. Additionally, the researcher performed inferential statistics through an Independent Samples t-test. The results obtained from these statistical analyses were then interpreted in the context of findings from previous empirical studies and theoretical inputs.

Results and Discussion

The statistical analysis suggests that students employ their metacognitive knowledge and strategies during the learning process. Table 1 presents the means and standard deviations for the items of the Jr MAI (Junior Metacognitive Awareness Inventory) used in this study. Based on the data, the metacognitive strategy that appears to be used the least by the students is "*I ask myself if I learned what I wanted to learn*", while the metacognitive knowledge most commonly used by the secondary school students is "*I learn more when I am interested in the topic*".

Table 1. *Means and standard deviation of items*

Items	Mean	Std. Deviation
"I ask myself if I learned what I wanted to learn	3.0995	1.25145
I think about what I need to learn before I start working	3.5299	1.20280
I ask myself how well I am doing while I am learning something	3.7040	1.13412
I think of several ways to solve a problem and then choose the best one	3.5274	1.19871
I ask myself if there was an easier way to do things after I finish a task	3.7363	1.06175
I draw pictures of diagrams to help me understand while learning	3.4378	1.20364
I use different learning strategies depending on the task	3.3010	1.13060
I decide what I need to get done before I start a task	3.5050	1.10822
I occasionally check to make sure I'll get my work done on time	3.5746	1.08752
I know when I understand something	4.0697	.98625
I learn more when I am interested in the topic	4.3980	.89096
I really pay attention to important information	4.0871	1.03064
I can make myself learn when I need to	3.9801	1.01096
I learn best when I already know something about the topic	4.2388	.94100
I know what the teacher expects me to learn	3.4478	1.14247
I try to use ways of studying that have worked for me before	3.8085	.96349
I use my learning strengths of make up for my strength	3.6940	1.07495
I sometimes use learning strategies without thinking"	3.1144	1.05785

The "*knowledge of cognition*" subscale of the metacognition assessment includes the following items: "I ask myself if I learned what I wanted to learn"; "I ask myself how well I am doing while I am learning something"; "I know when I understand something"; "I learn more when I am interested in the topic"; "I can make myself learn when I need to"; "I learn best when I already know something about the topic"; "I know what the teacher expects me to learn"; "I try to use ways of studying that have worked for me before" and "I use my learning strengths of make up for my strength". As presented in Table 1, the items that make up the "knowledge of cognition" subscale have means ranging between 3.0995 and 4.398, suggesting a high level of metacognitive knowledge among the students.

The "*regulation of cognition"* subscale of the metacognition assessment includes the following items: "I think about what I need to learn before I start working", "I think of several ways to solve a problem and then choose the best one", "I ask myself if there was an easier way to do things after I finish a task", "I draw pictures of diagrams to help me understand while learning", "I use different learning strategies depending on the task", "I decide what I need to get done before I start a task", "I occasionally check to make sure I'll get my work done on time", "I really pay attention to important information", and "I sometimes use learning strategies without thinking". The metacognitive strategies included in the "regulation of cognition" scale seem to be moderately (mean = 3.1144) and highly (mean = 4.0871) used by the secondary school students.

Table 2. *Independent sample t-test between boys and girls on each Item*

Items	t	Sig. (2-tailed)
"I ask myself if I learned what I wanted to learn	-3.781	.000
I think about what I need to learn before I start working	-2.330	.020
I ask myself how well I am doing while I am learning something	-1.225	.221
I think of several ways to solve a problem and then choose the best one	-.860	.390
I ask myself if there was an easier way to do things after I finish a task	-1.080	.281
I draw pictures of diagrams to help me understand while learning	-1.825	.069
I use different learning strategies depending on the task	-1.793	.074
I decide what I need to get done before I start a task	-2.970	.003
I occasionally check to make sure I'll get my work done on time	-2.651	.008
I know when I understand something	-1.334	.183
I learn more when I am interested in the topic	-1.115	.266
I really pay attention to important information	-2.665	.008
I can make myself learn when I need to	-2.158	.032
I learn best when I already know something about the topic	-.034	.973
I know what the teacher expects me to learn	-1.099	.272
I try to use ways of studying that have worked for me before	-1.031	.303
I use my learning strengths of make up for my strength	-1.697	.090
I sometimes use learning strategies without thinking"	.305	.761

The differences in metacognitive skills between boys and girls appear to be limited to specific areas of metacognitive knowledge and skills. As shown in Table 2, these differences occur in two items that measure the knowledge of cognition component. Accordingly, there are significant differences in metacognitive knowledge between male and female students in certain aspects: "*I ask myself if I learned what I wanted to learn*" (t= -3.781, p<0.01); and "*I can make myself learn when I need to*" (t= -2.158, p< 0.05). Out of the nine items that measure the knowledge of cognition component, significant differences were found for only two of the items, as shown in the table 2.

The analysis indicates that monitoring and planning strategies may be used differently by girls and boys. The data analysis revealed significant differences between male and female students on the following items that measure the regulation of cognition component: "*I think about what I need to learn before I start working*" (t= -2.330, p < 0.05); "I decide what I need to get done before I start a task" (t= -2.970, p < 0.01); and "*I occasionally check to make sure I'll get my work done on time*" (t= -2.651, p< 0.01). From all the nine items that measures the regulation of cognition, significant differences were found only for three items shown in the table 2.

Table 3. *Independent sample t-test of male and female on scale*

	Gender	N	Mean	Std. Deviation	CV	t	df	Sig. (2-tailed)	d
Metacognitive Awareness	Female	173	64.399	11.623	0.18	-2.878	400	0.004	0.2886
	Male	229	67.655	10.928	0.16				

Table 3 revealed that the mean metacognition score for female students was 64.399, while for male students it was 67.655. This indicates that the mean metacognition score of male students was higher than that of female students. The standard deviation and coefficient of variation (CV) of female students' metacognition were 11.623 and 0.18 respectively, while for male students they were 10.928 and 0.16 respectively. This suggests that there are gender differences in metacognition, with some students exhibiting greater metacognitive abilities than others. The higher CV for female students implies they exhibited more inconsistent metacognition relative to their male counterparts.

An independent samples t-test was conducted to statistically test the difference in metacognition between female and male students. The t-statistic was -2.875 with 400 degrees of freedom, and the p-value was 0.004 (< 0.05). This indicates that the mean mathematics metacognition was statistically significantly different between female and male students. The effect size (d=0.2886 < 0.8) for the female-male comparison showed a statistically significant difference in mathematics metacognition between the two groups.

These findings align with research highlighting metacognition's importance in secondary education (Veenman et al., 2006). The metacognitive knowledge of the students were found in high level. The high levels of metacognitive knowledge indicates that adolescents are capable of sophisticated metacognitive thinking (Kuhn, 2000). However, the lower engagement in self-questioning about learning outcomes suggests a need for explicit instruction in this area (Schraw et al., 2006).

The gender differences identified contribute to ongoing debates about metacognitive abilities across genders. While some studies found no significant differences (Sperling et al., 2002), our results align more with research suggesting males may have advantages in certain metacognitive domains (Bidjerano, 2005). The moderate to high use of regulation of cognition strategies is encouraging, as these have been linked to improved academic performance (Coutinho, 2007). However, gender differences in planning and monitoring strategies suggest educators may need to provide differentiated support, aligning with Pintrich and Zusho's (2002) recommendations for tailored metacognitive interventions.

Conclusion and Implications

The findings of this study shed light on the metacognitive processes of secondary school students, revealing both strengths and areas for improvement. Students demonstrated a high level of metacognitive knowledge, with means ranging from 3.0995 to 4.398 on the knowledge of cognition sub-scale. They showed particular awareness of how interest influences their learning, with the item "*I learn more when I am interested in the topic*" scoring highest. However, students were least likely to involve in self-questioning about their learning consequences, as evidenced by the low score for "*I ask myself if I learned what I wanted to learn*." In terms of regulation of cognition, students reported moderate to high use of metacognitive strategies, with means between 3.1144 and 4.0871.

Gender differences emerged as a significant factor in metacognitive abilities. Male students demonstrated higher overall metacognition scores (mean = 67.655) compared to female students (mean = 64.399), with a statistically significant difference (t = -2.875, p = 0.004). This difference had a moderate effect size (d = 0.2886). Notably, female students showed greater inconsistency in their metacognitive abilities, as indicated by a higher coefficient of variation. Specific gender differences were observed in certain aspects of metacognitive knowledge and regulation of cognition. For instance, significant differences were found in items related to self-reflection on learning outcomes and the ability to self-motivate, as well as in planning and monitoring strategies. These results underscore the complex nature of metacognition and highlight the need for targeted interventions that consider both general metacognitive development and gender-specific approaches in secondary education.

These findings have important implications for academic practice and forthcoming research. Teachers should be cognizant of the varying degrees of metacognitive awareness among students and adapt their pedagogical approaches accordingly, ensuring that differentiated instruction addresses individual needs and promotes the development of metacognitive skills. They should consider developing targeted interventions to enhance students' metacognitive skills, particularly in areas where usage is lower, such as self-reflection on learning outcomes. The gender differences observed suggests that personalized approaches may be necessary to support both male and female students in developing their metacognitive abilities. Furthermore, the inconsistency in girls' metacognition highlights the need for more personalized support to help them develop more stable metacognitive skills. Future research should explore the underlying factors contributing to these gender differences and investigate effective strategies to promote metacognitive development across all students, regardless of gender. Additionally, longitudinal studies could provide insights into how metacognitive abilities evolve throughout secondary education and beyond.

References

Akin, A. (2016). Metacognitive Awareness of Secondary School Students in Mathematics. *Journal of Educational Sciences Research*, 6(1), 33-45.

Bidjerano, T. (2005). Annual Meeting of the Northeastern Educational Research Association, Kerhonkson, NY.

Ciascai, L., & Lavinia, H. (2011). Gender differences in metacognitive skills. A study of the 8th grade pupils in Romania. *Procedia-Social and Behavioral Sciences*, 29, 396-401.

Coutinho, S. A. (2007). The relationship between goals, metacognition, and academic success. *Educate*, 7(1), 39-47.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, 34(10), 906-911.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher*, 33(7), 14-26.

Kuhn, D. (2000). Metacognitive Development. *Current Directions in Psychological Science*, 9(5), 178-181.

Ozsoy, G., & Ataman, A. (2009). The effect of metacognitive strategy training on mathematical problem solving achievement. *International Electronic Journal of Elementary Education*, 1(2), 67-82.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, 82(1), 33-40.

Pintrich, P. R., & Zusho, A. (2002). In A. Wigfield & J. S. Eccles (Eds.), Development of achievement motivation (pp. 249-284).

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review*, 7(4), 351-371. https://doi.org/10.1007/bf02212307

Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting Self-Regulation in Science Education: Metacognition as Part of a Broader Perspective on Learning. *Research in Science Education*, 36, 111-139. https://doi.org/10.1007/s11165-005-3917-8

Sperling, R. A., Howard, B. C., Miller, L. A., & Murphy, C. (2002). Measures of Children'S Knowledge and Regulation of Cognition. *Contemporary Educational Psychology*, 27, 51-79. https://doi.org/10.1006/ceps.2001.1091

Sperling, R. A., Richmond, A. S., Ramsay, C. M., & Klapp, M. (2012). The measurement and predictive ability of metacognition in middle school learners. *The Journal of Educational Research*, 105(1), 1-7.

Veenman, M. V., Van Hout-Wolters, B. H., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning*, 1(1), 3-14.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, 41(2), 64-70.

Zimmerman, B. J., & Martinez-Pons, M. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology*, 82(1), 51-59.