Study of Metacognition among Senior Secondary Students in relation to their Problem-Solving ability and Self-Esteem

*Navdeep Kaur and Monkia Rai**

Abstract

The study's major goal is to examine how students in secondary schools use metacognition in relation to their capacity for problem-solving and their sense of self. Metacognition is a specialized concept in psychology that refers to the understanding of one's own cognitive processes. Metacognition helps to develop the Problem-Solving ability of a learner, which can be applied in solving the obstacles of life in an effective manner. Metacognition also bears a relationship with the self-esteem of a person. The present study was undertaken in the context of metacognition, problem-solving and self-esteem. Following a descriptive research design 200 secondary school students of Amritsar were chosen as sample through simple random sampling. The data was collected with the help of standardized tools prepared by Punita Govil (Meta Cognition Inventory), L.N. Dubey (Problem-Solving ability test) and G.P Thakur (Self-Esteem Inventory). The results of the study showed that while male and female students' abilities to solve problems were comparable, female students' metacognition skills were much higher. However, male students' self-esteem was much higher than that of female students. It was also found out that metacognition does not have any impact on the Problem-Solving ability, however there is positive and negative impact of Metacognition on Self-Esteem

Keywords: *Metacognition, Problem-Solving Ability, Self-Esteem, Descriptive Research Design*

Introduction

Education is a tool for helping people reach their intrinsic potential. It helps people to not only recognize their own potential but also to put it to use for the betterment of society and themselves. In terms of research on student performance and achievement in classroom settings, self-regulated learning is a relatively new concept (Xiao, Yao & Wang, 2019) Self-regulated learners have the ability to organise and structure favourable learning settings, plan and manage the time and effort to be spent on tasks, and focus their mental energy on achieving personal objectives. One essential attribute of self- regulated learners is metacognition and use of metacognitive strategies. The following section dwells upon the construct of metacognition positioning it in the broader concept of cognition.

Cognition involves the capacity to make sense of the self and the world, through action and language. Meaningful learning is a generative process of representing and manipulating concrete things and mental representations, rather than mere storage and retrieval of information. It also deals with metacognitive activities and problem-solving abilities. This is a process that begins in infancy, and develops through independent

as well as mediated activities. For the enhancement of problem-solving ability in learners, various activities should be included in the curriculum. National Education Policy (2020) lays particular emphasis on cognitive capacities such as critical thinking and problem-solving ability through exposure and experiential learning. It states that these result in positive learning outcomes such as increased creativity and innovation, problem-solving abilities, teamwork, communication skills, critical thinking and higher-order thinking skills, more in-depth learning and mastery of curricula across fields, and improvements in social and moral awareness. Hence, cognitive abilities are essential for the effective development of learners.

An important aspect of cognition is metacognitive skills and abilities of learners which is the foremost demand of twenty-firstcentury. The word 'Metacognition' was first used in psychology by cognitive researcher and psychology professor Flavell (1970). Flavell was the first to identify that learners can intentionally guide themselves in terms of procedures needed for information recall, classification, and retention. Metacognition, according to Flavell, is the ability to recognize one's own cognitive knowledge and regulate the cognitive knowledge in daily learning tasks.

Image: 1 Concept of Metacognition

(Source: https://moonpreneur.com/blog/wp-content/uploads/2023/03/metacognition.png)

Metacognitive abilities can forecast achievement in learning and other spheres of life. Numerous facets of cognition, such as memory, attention, communication, problem-solving, and intelligence, are also known to be significantly influenced by metacognition.

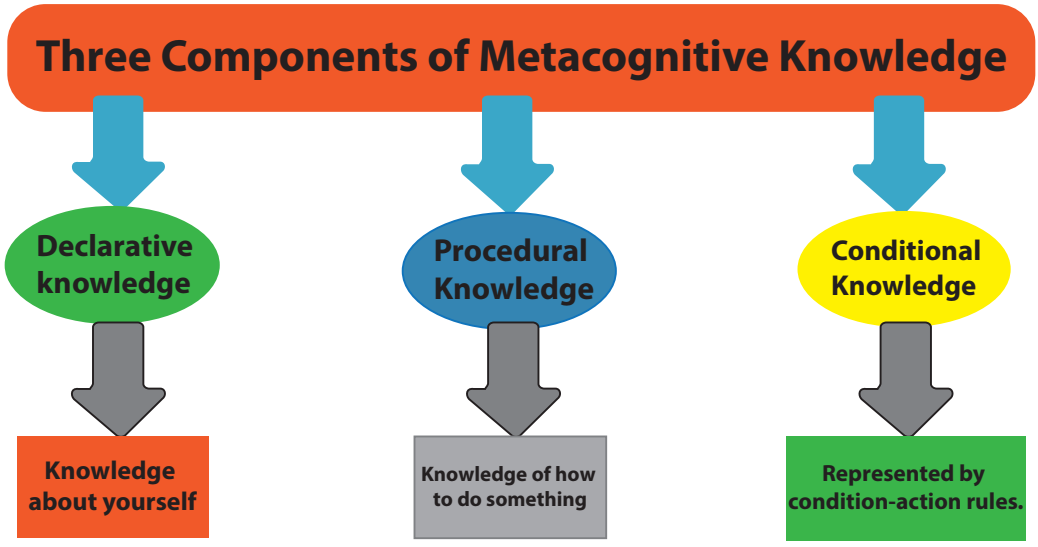

Image: 2 Components of Metacognitive Knowledge

(Source: Metacognition - Practical Psychology (practicalpie.com)

Metacognitive knowledge or 'meta-knowledge is defined as the "knowledge individuals have of their own cognitive processes and their ability to monitor and reflect on them" (Fluer, Bredeweg & Bops, 2021). Metacognition helps to develop the problem-solving ability of a learner, which can be beneficial to solve the obstacles of the life in an efficient manner. Herein, a problem exists when the individual is in a state that differs from the desired end state and there is a perceived need to achieve the specified objectives or reach a particular goal. Problem-solving in continuance then is the identification and application of knowledge and skills that result in goal attainment. Problem-solving abilities involve identification of the problem and understanding its nature followed by formulation and carrying out of the chosen solution. An efficient blend of analytical and creative thinking is necessary for effective problem-solving. Problem-solving abilities are related with cognition and metacognition in complex manner.

Another crucial factor to consider is self-Esteem. One reason for wide spread interest in self-esteem is the notion that poor self-esteem might account for school failure for some children (Paul and Conger, 1984).

Self-esteem refers to one's evaluation of one's own qualities. It is an individual's perception of how they value and perceive themselves. For example, an eight-year-old boy might have a concept of himself as someone who fights a lot. If he values his ability to fight and stand up for him, that quality might add to his self-esteem in a positive manner. If he is unhappy about himself and his tendency to get into conflicts, then his aggressive nature might impact his self-esteem adversely. The main components of high self-esteem are: (Khalek, 2016)

- Compassion, Acceptance, and Respect
- Integrity, honesty (with subtlety and empathy)
- Genuine emotional expression
- Positive reinforcement, assistance, and gratitude

- Forgiveness; allowing and learning from mistakes

Hence, Metacognition, Problem-Solving Ability and Self Esteem are crucial factors that have a complex relationship with each other and can impact learning and cognition in significant ways.

Review of Related Literature

There have been several researches on the study of metacognition, problem-solving skills, and self-esteem in the fields of psychology and education.

Research by Nbina and Viko (2010) demonstrates that teaching secondary school students how to use a metacognitive self-assessment technique improved their achievement in Chemistry and also markedly increased their sense of self-efficacy. The study's findings also showed that there was no statistically significant difference between male and female students exposed to the self-assessment skills training in terms of their mean achievement scores or mean self-efficacy scores in Chemistry. The recommendation that follows from the study is that teachers should provide senior secondary school pupils with pertinent metacognitive self-assessment tools that are useful for learning. These abilities, which have been shown to increase task execution confidence, also raise the self-efficacy of the students and help them stay focused on the activity.

The metacognitive and affective model of self-regulated learning put forth by Efklides (2011) describes it as a dynamic process that examines the impact of emotions, motivation, metacognition, and cognition on self-regulated learning. Students' abilities, motivation, emotions, and metacognitive skills, as well as their metacognitive, affective, and emotional experiences with academic tasks influence their decisions on the techniques they will employ. Therefore, research into how these connections affect students' performance is crucial. Anderson (2011) conducted a study on, "Relationship of Self-efficacy, metacognition and performance" to examine the relationships among self-efficacy, metacognition and performance. Regression analysis showed that the relationship between self-efficacy and performance was not mediated by metacognition. However, another analysis showed that the relationship between metacognition and performance was fully mediated by self-efficacy. This suggests that students with effective metacognitive strategies also have strong belief in their capabilities to successfully perform a task. These findings lend support to training programs for students that enhance self-efficacy and strengthen their metacognitive strategies and skills.

The above specified studies mostly deal with the relationship of self-efficacy and metacognition and not with problem solving ability of students. However, problem solving ability tends to be a major variable in understanding the metacognition processes in an effective manner. This can be identified as a major research gap. A few pertinent studies in this area are as follows.

Sharei, Kazemi, and Jafari (2012) undertook a research to understand how students' abilities to solve mathematical problems relate to their emotional intelligence and metacognitive skills. A random selection of sixty male and forty female students was the statistical sample for the study. The results show a substantial correlation between the general scores of metacognitive abilities, emotional intelligence skills, and some of its components and mathematical problem-solving ability. Regarding the students' gender specificity, the findings indicate notable distinctions between male and female students in three domains. Male students outperformed female students in the domains of problem-solving and metacognitive skills, while female students achieved higher emotional intelligence scores. Metacognition then was a better predictor than emotional intelligence in this study.

In order to ascertain epistemological beliefs, metacognitive strategy use, and link between

epistemological beliefs and metacognitive strategies of primary education teacher trainees, Jena and Ahmed (2013) designed their study as a descriptive survey study. A total of 820 teacher candidates were chosen from the primary education departments of seven education faculties. The data were gathered using the Metacognition Inventory and the Epistemological Beliefs Scale. The results demonstrated that the beliefs of primary school teacher candidates regarding "learning depends on effort" had grown and changed more than their views regarding "learning depends on skills" and "there is only one truth." Although there were notable differences between their beliefs about gender, grade, and university attendance, no significant relationship was found between the students' beliefs and academic achievement. On the basis of these researches it can be recommended that metacognition and mature epistemological beliefs should be conveyed to teachers and teacher educators, along with strategies for helping students acquire these skills over the course of their formal education. To increase the students' capacity for learning, teachers should raise their students' metacognitive awareness. Students are more likely to perform well in class if they are aware of effective learning techniques. Teachers are in charge of establishing a metacognitive learning environment in the classroom. With the teacher acting as a facilitator, (s) he should let the students come to their own understanding through independent exploration and investigation. Additionally, she can employ techniques to promote metacognition in the classroom.

Another study "Metacognition and Academic Performance of Rural Adolescents" was undertaken by Narang and Saini (2013) to study the impact of metacognition on academic performance of rural adolescents (13-16 years). The sample comprised of 240 rural adolescents from rural schools of Ludhiana. To assess the academic performance of the subjects, the aggregate percentage of marks obtained by the students in the last school examination was procured from the concerned teachers. Results revealed that the major proportion of students with high level of metacognition also performed above average in academics. Further analysis depicted that both the components of metacognition -'Knowledge of Cognition' and 'Regulation of Cognition' significantly contributed towards the Self-Esteem and Problem-Solving ability of secondary school students.

Talekar (2016) conducted a study to determine Mumbai secondary school pupils' levels of metacognitive awareness by studying 120 pupils enrolled in Mumbai's SSC Board secondary schools. The results indicated that the metacognitive awareness of the majority of pupils was average. Hence, schools must support in-class activities that enable students to evaluate the material they are studying and consider how they are learning it. These kinds of exercises will move the educational system towards a child-centered approach. Additionally, it will support the pupils' development of skills for lifetime learning since students will be able to recognize their areas of strength and weakness and take appropriate action.

The purpose of Fooladvand, Yarmohammadian, and Zirakbash's (2017) systematic review method study was to determine how cognitive and metacognitive methods affected academic accomplishment. The existing research on the impact of cognitive and metacognitive methods on academic accomplishment, both nationally and internationally, comprised their review. According to the findings of several studies (Ozcakma, Koroglu, Korkmaz & Bolat, 2021: Stanton, Sebesta & Dunlosky 2021) learning methods like cognitive and metacognitive strategies have had the most impact on students' academic performance in various courses at schools and at universities.

Generally speaking, learning strategies of all kinds (cognitive and metacognitive) are highly effective on the degree of learning in various courses (experimental sciences, mathematics, and English language) for

all learners (males and females), in all studies (experimental, quasi-experimental, relational, or correlational). Using a sample of 200 B.Ed. students, Sawhney (2018) investigated the relationship between self-efficacy and metacognition among aspiring teachers enrolled in rural and urban programmes. According to the findings of their study, students in urban areas outperformed students in rural areas in terms of mean scores in KOC (knowledge of cognitive process), ROC (regulation of cognitive process), and overall metacognition. The self-efficacy of B.Ed. students studying in urban and rural areas of institutions did not significantly differ from one another. Thus, it can be proposed that enhancing self-efficacy and metacognitive awareness may be a useful strategy for raising learning and performance across the lifespan. In this context, role of teachers is quite significant. Students' behavior and decisions are influenced by their teachers along with their parents, the home environment, and the community. A learner can succeed if he is well-versed in his own idea of knowledge, which includes both acquired and current knowledge as well as the control of his cognitive processes. The urban students' favourable association between self-efficacy and metacognition further demonstrated how the location of the institution helped the learners not only comprehend the task, activity, or topic, but also cultivate positive beliefs about accomplishing the goal.

Kukreja, Saini, and Vig (2020) conducted research to examine gender disparities in the interaction between intellectual capacities, metacognition, and academic achievement in rural teenagers (aged 13 to 16). The study was carried out government schools in villages of Ludhiana. The results indicate that the 'metacognitive skills' of the rural teenagers had a substantial impact on their 'academic performance' but it was not possible to determine how their 'intellectual abilities' affected their performance. Students will succeed academically if they have well-developed metacognitive knowledge and metacognitive regulation skills, and if they apply their metacognition. As such, it is critical to evaluate students' metacognition using a variety of methods and, if needed, to devise strategies for helping them become more metacognitive. Consequently, it is also crucial to identify pupils who require direct assistance in metacognition and who lack basic understanding of how to manage their learning. This is particularly important in courses with large class size because there is little chance for teachers to interact personally with each student. As a result, they are able to ascertain the kinds of metacognitive knowledge and regulatory abilities that the students can apply during their learning. Therefore, efforts must be focused on helping students, regardless of their 'intellectual capacity', acquire and improve their metacognitive awareness and skills in order to improve academic achievement.

Another study by Guner and Erbay (2021) delves into the metacognitive techniques middle school pupils employed when working through challenges on their own. Thirty-seven eighth-grade middle school pupils made up the study group. One non-routine word problem was given to the students, and their written responses were compiled. Following their solution to the challenge, the students completed a self-monitoring questionnaire asking them to reflect on the metacognitive techniques they had used. A recommendation arising from the study's findings is that middle school pupils can benefit from a variety of interventions aimed at fostering metacognitive abilities. For example, instructional activities can be designed to necessitate the use of metacognitive strategies from students themselves, and they can be motivated to do so. It is important to look at the possibilities of structuring the curriculum so that middle school pupils are exposed to these seemingly 'non-routine' tasks more frequently.

Study by Oyovwi & Iroriteraye (2022) conducted in Nigeria with the goal of improving scientific students' academic

attainment and retention rate through the application of metacognitive strategies employed a quasi-experimental design used - a non-equivalent control group pre-test post-test design with intact classes. The sample consisted of 221 science students. One of the tools used in the investigation was the Science Achievement Test. Based on the findings, it was concluded that the best method for teaching and learning science is metacognition. The study suggested, among other things, that educators should employ metacognitive strategies when instructing students in the Science curriculum. In light of the study, it is recommended that the government and educational stakeholders arrange for instructors/teachers to receive training on the proper application of metacognitive approach in real classroom instruction. When examining the curriculum - curriculum planners, developers, and educators should consider this approach to ensure that students are adequately taught relevant skills that will enable them to engage effectively in metacognition.

After going through all the above literature, it can be observed that most of the researches have been done on professional identity, academic achievement, positive thinking, intellectual abilities, motivation, epistemological beliefs, scientific attitude, mathematical creativity, enhancing environmental ethics, teaching arithmetic and geometry and science in relation to metacognitive skills and metacognitive strategies, but studies on problem-solving skills and self-esteem in relation to metacognition are extremely rare. Moreover, the majority of research has not been done in India, but conducted abroad. In India, researches on metacognition is still in its early stages of development and not many researchers have explored this field.

Helping students develop metacognition is one of the most critical challenges facing educators as it is becoming increasingly clear that many academic tasks would benefit from metacognitive awareness and skills. Effective learning requires metacognition. When compared to kids who have low metacognitive abilities, those who have strong metacognitive abilities perform better academically. Metacognitive training may help students who struggle with metacognition to become more proficient in it.

Apart from metacognition the second key variable is the capacity for problem-solving. Problem solving is an intricate behaviour. No matter how much expertise or knowledge a problem-solver possesses, every new problem scenario is different in some aspects and necessitates the innovative application of techniques for formulating, addressing, and resolving the issue at hand. The third significant variable in this research is Self-esteem. Having positive self-esteem empowers an individual to place trust in themselves and have the motivation and courage to try new things. It enables the individual to accept who they are in spite of their shortcomings. Additionally, when an individual respects themselves, other children and adults do the same. In order to understand how adolescent students' metacognition relates to their capacity for problem-solving and sense of self-worth, the researchers undertook this study. In the light of the analysis of the literature cited above it is apparent that there are research gaps despite the buzz across the constructs of 'meta-cognition' and 'problem solving' skills in the field of cognitive psychology yet there the researches on the interconnections between 'metacognition', 'problem-solving' and 'self-esteem' are sparse. The research aims to fill this gap.

Objectives

1. To study the difference in meta-cognition of secondary school male and female students.
2. To study the difference in the problem-solving ability of secondary school male and female students.
3. To investigate the difference in self-esteem between secondary school male and female students.

4. To investigate the relationship between metacognition and senior secondary students' problem-solving abilities.
5. To investigate the relationship between senior secondary students' metacognition and self-esteem.
6. To investigate the association between senior secondary students' problem-solving skills and self-esteem.
7. To investigate the interactional effect of problem-solving ability and self-esteem on senior secondary students' metacognition.

Hypotheses

1. There is no significant difference in metacognition between secondary school male and female students..
2. There is no significant difference in problem-solving abilities between secondary school male and female students..
3. There is no significant difference in self-esteem between secondary school male and female students..
4. There is no significant association between metacognition and problem-solving skills of senior secondary students.
5. There is no significant association between senior secondary students' metacognition and self-esteem.
6. There is no significant relationship between problem-solving ability and self-esteem of senior secondary students.
7. There is no significant interactional effect of problem-solving ability and self-esteem on metacognition of senior secondary students.

Tools and Techniques

Three types of tools have been used in this research as given below.

- Punita Govil's (2003) Meta Cognition Inventory (MCI).
- L. N. Dubey's (2006) Problem Solving Ability Test (PSTET-D).
- G. P. Thakur's (1989) Self-Esteem Inventory (SEI).

Study design

The study falls under Descriptive Research design.

Sample

The sample of this study comprised of 200 students (100 Girls + 100 Boys) of class 12. For this study, investigator used Random Sampling technique to select the sample.

Statistical Analysis

The data was analyzed by using appropriate statistical techniques such as Mean, SD, T-Test, coefficient correlation and Two-way ANOVA.

Results and Conclusion

Mann-Whitney test was applied for testing the significance of the following three null hypotheses, laid down in the present study:

- $H_0$1: There is no significant difference in metacognition between secondary school male and female students..
- $H_0$2: There is no significant difference in problem-solving abilities between secondary school male and female students..
- $H_0$3: There is no significant difference in self-esteem between secondary school male and female students..
- $H_0$1: (a) There is no significant difference in self-esteem (self) of secondary school male and female students..
- $H_0$2: (b) There is no significant difference in self-esteem (society) of secondary school male and female students.

Table:1: Mann-Whitney Test for studying significance of difference between Mean Scores of Male and Female students in respect of Different Variables (n=100 each)

Variables	Mean Scores		Mean Difference (Female-Male)	Test Statics	P-value	Remarks
	Females	Males				
Metacognition (MTCG)	97.36	81.73	15.63	7445.0	< 0.0001	***
Problem-Solving (PRSL)	7.47	7.79	-0.32	4490.5	0.20917	Not Significant
Self-Esteem (Self) (SESL)	139.26	150.47	-11.21	3860.0	0.00533	**
Self-Esteem (Society) (SESC)	137.98	145.93	-7.95	4037.0	0.01863	*

**Significant at 5% probability level; **Significant at 1% probability level; **Significant at 0.1% probability level; NS: Non-Significant.*

Main conclusions from Table 1:

- Among female students, mean score in metacognition was 97.36, whereas among male students, the mean score was only 81.73. Thus, there was a difference of 15.63 in the mean scores of metacognition. Computed value of Mann-Whitney test statics was computed to be 7445.0, which was associated with an exceedingly small (< 0.0001) p-value. Therefore, as per the test procedure, the observed difference (= 15.63) in the mean scores happened to be highly significant (at 0.1% probability level), thereby implying that on an average, metacognition score of female students was highly significantly than that of male students. Accordingly, the first null hypothesis ($H_0$1) is rejected.
- In respect of problem-solving ability, mean score of female students was 7.47, whereas that of male students was marginally higher at 7.79. Thus, there was a difference of only 0.32 in the mean scores of problem-solving abilities. Computed value of Mann-Whitney test statics was computed to be 4490.5, which was associated with the p-value of 0.20917. Since the p-value was higher than the threshold value of 0.05; therefore, as the first procedure, the observed difference (-0.32) in the mean scores was statistically non-significant. Thus, on an average, problem solving abilities of female and male students were at per with each other. Accordingly, the second null hypothesis ($H_0$2) could not be rejected.
- Next, with respect to Self-Esteem (Self), mean score among females was 139.26, whereas the males were higher (through a difference of 11.21) at 150.47. Value of Mann-Whitney test statics for the difference was computed to be 3860.0, which was associated with a very small (= 0.00533) value of p. Therefore, the observed difference (=11.21) in the mean score happened to be highly significant (at 1% probability level), thereby implying that on an average, self-esteem (self) of male students was highly significantly more than that of female students. Thus, the third null hypothesis [$H_0$3 (a)] is rejected.
- Similarly, with respect to Self-Esteem (Society), mean scores among females was 137.98, whereas that among male was higher (through a difference of 7.95) at 145.93. The computed value of Mann-Whitney test statistic for this difference was 40.37.0, which was associated with a fairly low (=0.01863) value of p. Since the

p-value was less than the threshold value of 0.05 (but more than 0.01); therefore, the observed difference (=7.95) in the mean scores happened to be statistically significant (but only at 5% probability level). This implied that on an average, self-esteem (society) of male students was also significantly higher than that of female students. Accordingly, the fourth null hypothesis [$H_0$4 (b)] is also rejected.

Testing Significance of Relationship between Mean Scores of different Parameters: Evidence from Correlation Analysis:

Help of Correlation analysis was sought to examine validity, or otherwise, of the next three hypotheses of the study, viz:

- $H_0$4: There is no significant association between metacognition and problem-solving skills of senior secondary students.
- $H_0$5: There is no significant association between senior secondary students' metacognition and self-esteem.
- $H_0$5: (a) There is no significant association between metacognition and self-esteem (self) of senior secondary students.
- $H_0$5 (b) There is no significant association between metacognition and self-esteem (society) of senior secondary students.
- $H_0$6: (a) There is no significant association between senior secondary pupils' problem-solving skills and self-esteem (self).
- $H_0$6 (b) There is no significant association between senior secondary pupils' problem-solving ability and self-esteem (Society).

To fulfill this purpose, an inter-correlation matrix among the parameters (pooled over male and female students) was generated, as presented in Table 2.

Table 2: Matrix of Inter-Correlation Coefficients between different Parameters (n=200)

Parametres	Metacognition	Problem-Solving	Self-Esteem (Self)	Self-Esteem (Society)
MTCG	1.000	0.072	-0.163	-0.086
PRSL	0.072	1.000	-0.054	-0.033
SESL	-0.163	-0.054	1.000	0.313
SESC	-0.086	-0.033	0.313	1.000

Critical values of r: 0.139 at 5% probability level; 0.182 at 1% probability level; and 0.231 at 0.1% probability level.

Main Conclusions from Table 2:

- Coefficient of correlation between metacognition (MTCG) and problem-solving ability (PRSL) of the senior secondary students was computed to be a mere 0.072, which failed to cross the threshold value of 0.139 (at 5% probability level). As a result, it may be concluded that there was no significant association between metacognition and problem-solving skill in senior secondary pupils. And, therefore, the fourth null hypothesis (H04) could not be rejected.
- Coefficient of Correlation between metacognition (MTCG) and self-esteem (Self: SESL) was computed to be -0.163, which in magnitude was more than the threshold value of 0.139 (at 5% probability level), but could not exceed the threshold value of 0.182 (at 0.1% probability level). It could thus be said that there exists a significant inverse relationship (at 5% probability level) between metacognition and self-esteem (Self) of senior secondary students. However, the coefficient of correlation between metacognition (MTCG) and self-esteem (Society: SESC) turned out to be -0.086 only, which (in magnitude) could not cross the threshold value of 0.139 (at 5% probability level). This implies that there does not exist any significant relationship between metacognition and

self-esteem (Society) of senior secondary students. Accordingly, the null hypothesis [H05 (a)] could be rejected in respect to the relationship between metacognition and self-esteem (Self), but the hypothesis [H05 (b)] could not be rejected in respect of the relationship between metacognition and self-esteem (Society).

- Coefficient of correlation between problem-solving ability (PRSL) and self-esteem (Self: SESL) was computed to be -0.054. Similarly, the coefficient between problem-solving ability and self-esteem was computed to be -0.033. Values of both the correlation coefficient were tested to be non-significant (because these could not exceed the threshold value of 0.139. Thus, there does not exist significant relationship between problem-solving ability and self-esteem (whether Self or Society). Hence, the sixth null hypothesis [viz. H06 (b)] could not be rejected.
- Finally, as per the analysis, coefficient of correlation between the two types of self-esteem (SESL & SESC) was computed to be 0.313, which happened to cross even the 0.1% critical value of 0.231. This implies that there exists very strong direct relationship between the two types of self-esteem.

Testing significance of interaction effect of Problem-Solving ability and Self-Esteem on Metacognition: Evidence from Two-Way ANOVA technique

Finally, an attempt was made to examine validity of the last hypothesis, viz.

- $H_0$7: There is no significant interaction effect of problem-solving ability and self-esteem on metacognition of senior secondary students.

For this purpose, two-way ANOVA technique was used, wherein the response variable was metacognition score, while the two factors were the levels of problem-solving ability of self-esteem, respectively. Main findings from the analysis are presented as follows:

Table 3: Table of Mean values of Metacognition Score at different levels of Problem-Solving ability and Self-Esteem

Levels of Problem-Solving	Levels of Self-Esteem		Mean Score
	Negative	Positive	
Very Low	89.42	87.37	88.36
Low	102.42	92.29	96.96
Average	NA#	95.00	95.00
Mean Score	91.06	88.17	89.54

None of the observations belonged to this category

Table: 4:Two-Way Analysis of Variance of Metacognition Scores in relation to different levels of Problem-Solving ability and Self-Esteem

Source of Variation	df	Sum of Squares	Mean Square	F-Value	P-value of F	Remarks
Problem-Solving	2	1730.98	865.49	2.696	0.06998	NS
Self-Esteem	1	477.15	477.15	1.486	0.22425	NS
Problem-Solving X Self-Esteem Interaction	1	366.69	366.69	1.142	0.28649	NS
Residuals	195	62596.78	321.01	-	-	-
Total	199	65171.6	-	-	-	-

Main Conclusion from the above Two Tables:

- As per Table: 3, there were three levels of problem-solving ability, viz. 'Very Low', 'Low' and 'Average'. Similarly, there were two levels of Self-Esteem, viz. 'Negative' and 'Positive'.
- Mean values of metacognition score at 'Very Low', 'Low' and 'Average' levels of problem-solving ability were observed to be 88.36, 96.96 and 95.00, respectively (Table: 3).
- F-Value for the levels of problem-solving ability (at 2 and 195 degree of freedom) was computed to be 2.696. This value was associated with a p-value of 0.06998 (Table: 4). Since the p-value was more than the critical value of 0.05; therefore, mean values of metacognition score did not differ at the different levels of problem-solving ability.
- Similarly, mean values of metacognition score at 'Negative' and 'Positive' levels of self-esteem were calculated 91.06 and 88.17, respectively (Table: 3).
- F-Value for the levels of Self-Esteem (at 1 and 195 degree of freedom) was computed to be only 1.486. This value of F was associated with p-value of 0.22425 (Table: 4). Since the p-value was substantially more than the critical value of 0.05; therefore, mean values of metacognition score did not differ at the different levels of self-esteem as well.
- As regards interaction effect of problem-solving ability and self-esteem on metacognition score, the value of F (at 1 and 195 degree of freedom) was obtained to be a mere 1.142 (Table: 4). Since its p-value (= 0.28649) was far higher than the critical value of 0.05, it can be concluded that the interaction effect was statistically non-significant. Hence, the seventh hypothesis (H07) could not be rejected.

Conclusion

The results of the study show that while male and female students' abilities to solve problems were comparable, female students' metacognition skills were much higher. Additionally, male students' self-esteem was much higher than that of female students. At the interaction level, metacognition has no impact on the problem-solving ability, but there is a 'Positive' and 'Negative' impact of metacognition on self-esteem. In sync with the previous researches it can be recommended that metacognition and mature epistemological beliefs should be conveyed to teachers and teacher educators, along with strategies for helping students acquire these skills (like problem solving ability and self-esteem) over the course of their formal education. To increase their students' capacity for learning, teachers should raise their students' metacognitive awareness. Students are more likely to perform well in class if they are aware of effective learning techniques. Teachers are in charge of establishing a metacognitive learning environment in the classroom and with the teacher acting as a facilitator, she should let the students acquire their own understanding through independent exploration and investigation.

Educational Implications of the Study

1. Metacognitive thinking strategies did not demonstrate substantial predictability. The study's findings successfully proved that skilled problem solvers think in a structured fashion, and to some extent, this structure could be quantified. According to the findings of the present study, there is a significant correlation between metacognition and self-esteem, as well as metacognition and problem-solving capacity of students based on their gender. At the start of each lesson, teachers should create a checklist for their students.
2. The intervention period of the current study was too short to allow for independent mastery of the metacognitive strategies taught. Future studies investigating the impact of self-esteem and problem-

solving ability on metacognition would benefit from a longer implementation period. This would increase opportunities to personalize scaffolding and to increase the likelihood of students developing automaticity of skills and strategies.

3. The researcher's observations of at-risk students and improvements in their pre and post scores suggest potential for further investigations. Researchers must improve the study design and data collection procedures in order to closely monitor and account for the learner's trips.
4. The present study indicated that students with high self-esteem and problem-solving abilities performed better in metacognition. Teachers should take note of this discovery. Students should be psychologically trained, especially at a young age, to boost their self-esteem and problem-solving abilities, hence improving their metacognition.
5. Overall, this study will help the teachers to design the teaching methodology on the basis of problem-solving ability and self-esteem for the students. Higher-Order thinking skills (HOTS) are what teachers are striving for in the classroom, so this study will help in the development of HOTS among students.

References

Anderson. (2011). Relationship of Self-efficacy, Metacognition and Performance. *American Psychological Association*, Vol. 137 (3), Page No. 421-442.

Fleur, S., D., Bredeweg, B., & Bos, D., B., W. (2021). Metacognition: Ideas and Insights from Neuro- and Educational Sciences. *Nature Partner Journal: Science of Learning*. Retrieved from https://doi.org/10.1038/s41539-021-00089-5

Efklides A. (2011). Interactions of Metacognition with Motivation and affect in Self-Regulated Learning: The MASRL Model. *Educational Psychologist*, Vol. 46(1), Page No. 6–25. Retrieved from file:///C:/Users/admin/Downloads/Efklides%20MASRLmodel.pdf

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. American Psychologist, *Vol.* 34(10), Page No. 906–911.

Fooladvand, M., Yarmohammadian, M., H. & Zirakbash, A. (2017). The Effect of Cognitive and Metacognitive Strategies in Academic Achievement: A Systematic Review. *New Trends and Issues Proceedings on Humanities and Social Sciences.* Vol. 01, Page No. 313-322. Retrieved from https://www.researchgate.net/publication/321482588

Government of India, (2020). National Education Policy 2020. Delhi: Ministry of Human Development, Government of India.

Guner, P., & Erbay, N., H. (2021). Metacognitive Skills and Problem-Solving. *International Journal of Research in Education and Science*. Vol. 7 (3), Page No. 715-734. Retrieved from https://www.researchgate.net/publication/351791699_Metacognitive_Skills_and_Problem-Solving

Jena, C., P. & Ahmed, L. (2013). Meta-Cognitive Strategy Usage and Epistemological Beliefs of Primary School Teacher Trainees: An explorative study. *Journal of International Letters of Social and Humanistic Science*. Vol. (9), Page No. 1-10. Retrieved from Meta Cognitive Strategy Usage and Epistemological Beliefs of Primary School Teacher Trainees: An Explorative Study (researchgate.net)

Khalek, A., M., A. (2016). *Introduction to the Psychology of Self-Esteem*. Nova Science Publishers, Inc. Page No. 1-23. Retrieved from https://www.researchgate.net/publication/311440256_Introduction_to_the_Psychology_of_self-esteem

Kukreja, N., Saini, S. & Vig, D. (2020). The Gendered interplay between Intellectual abilities, Metacognition and Academic Performance of Rural Adolescents. *The Pharma Innovation Journal*, Vol. 9(1), Page No. 129-134. Retrieved from https://www.thepharmajournal.com/archives/2020/vol9issue1/PartB/8-12-50-926.pdf

Narang & Saini. (2013). Metacognition and Academic Performance of Rural Adolescents, *Stud Home Com Sci*, Vol. 7(3), Page No. 167-175. Retrieved from http://krepublishers.com/02-Journals

Nbina, J.B. and Viko, B. (2010). Effect of Instruction in Metacognitive Self-Assessment strategy on Chemistry Students Self-Efficacy and Achievement. *Academia Arena*, Vol. 2(11), Page no. 1-10. Retrieved from https://www.bing.com/search?pglt=41&q=Effect+of+instruction+in+Metacognitive+self-assessment+strategy+on+Chemistry+Students+self-efficacy+and+achievement+pdf.

Ozçakmak, H., Koroglu, M., Korkmaz, C., & Bolat, Y. (2021). The Effect of Metacognitive awareness on Academic Success. African Educational Research Journal. Vol. 9(2), age No. 434-448. Retrieved from https://files.eric.ed.gov/fulltext/EJ1297101.pdf

Paul and Conger (1984). Effect of Metacognition strategies on Academic Achievement and Self-Esteem of Students. *Journal of Educational Research and Psychology*, Vol. (13), Page No. 413-430.

Sawhney, N. (2018). "Study of Metacognition and Self-Efficacy among B.Ed. Students in relation to their Location of their Institution". *Scholarly Research Journal for Interdisciplinary Studies*. Vol. 3(12), Page No. 1216-1228.

Sharei, M., Kazemi F., Jafari M. (2012). Investigation the Effect of Emotional Intelligence skills and Metacognitive capabilities on student's Mathematical Problem Solving. *International Research Journals*, Vol. 1(2), Page No. 31-39.

Stanton, J. D., Sebesta A. J., Dunlosky J. (2021). Fostering Metacognition to Support Student Learning and Performance. *CBE Life Science Education*. Vol. 20(2), Doi: 10.1187/cbe.20-12-0289. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8734377

Talekar, P.S. (2016). A Study of Metacognitive Awareness among Secondary School Students in Mumbai. PARIPEX - *Indian Journal of Research*, Vol 5(5), Page No. 54-55.

Xiao, S., Yao, K., & Wang, T. (2019). The Relationship of Self-Regulated Learning and Academic Achievement in University Students. SHS Web of Conferences. Retrieved from https://doi.org/10.1051/shsconf/201960.