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SYNERGISTIC EFFECTS OF EMOTIONAL INTELLIGENCE AND METACOGNITION ON PROBLEM-SOLVING SKILLS IN ADOLESCENTS

Ankit Kumar

Research Scholar,
L.N Mithila University, Darbhanga

ABSTRACT

This study examines the interrelationship between emotional intelligence (EI), metacognitive awareness and problem-solving abilities in adolescents aged 14-18. While previous research has investigated these constructs independently, limited attention has been given to their potential synergistic effects. Using a mixed-methods approach, 246 high school students from Samastipur completed standardized measures of emotional intelligence (MSCEIT-YV), metacognitive awareness (MAI) and problem-solving skills (PSI-TECH). Additionally, qualitative data was collected through semi-structured interviews with a subset of 28 participants. Results indicate significant positive correlations between emotional intelligence and metacognitive awareness ($r = .68$, $p < .001$), emotional intelligence and problem-solving ($r = .59$, $p < .001$) and metacognitive awareness and problem-solving ($r = .71$, $p < .001$). Path analysis revealed that metacognition partially mediates the relationship between emotional intelligence and problem-solving performance. Furthermore, students with high scores in both EI and metacognition demonstrated significantly superior problem-solving abilities compared to those with high scores in only one domain or low scores in both. These findings suggest that emotional intelligence and metacognition function synergistically, enhancing adolescents' capacity to effectively approach and resolve complex problems. Educational implications include the potential benefits of integrated interventions targeting both emotional and metacognitive skills development in adolescents.

Keywords: emotional intelligence, metacognition, problem-solving, adolescent development, cognitive processes, educational psychology, self-regulation, social-emotional learning

1. INTRODUCTION:

The ability to solve problems effectively is increasingly recognized as a critical competency for academic success, career readiness and general life functioning (World Economic Forum, 2020). For adolescents in particular, problem-solving skills constitute a foundational capacity that supports development across multiple domains (Zimmerman & Campillo, 2003). As secondary education systems worldwide shift toward competency-based approaches, understanding the cognitive and emotional factors that contribute to effective problem-solving has become a research priority.

Two constructs that have received substantial independent attention in relation to problem-solving are emotional intelligence (EI) and metacognition. Emotional intelligence, conceptualized as the ability to perceive, use, understand and manage emotions (Mayer et al., 2008), has been linked to improved decision-making, interpersonal skills and academic performance (Rivers et al., 2012). Metacognition, defined as awareness and regulation of one's own cognitive processes (Flavell, 1979), has been established as a significant predictor of learning outcomes and problem-solving efficiency (Veenman et al., 2006).

While research has demonstrated the individual contributions of emotional intelligence and metacognition to problem-solving performance, there remains a notable gap in understanding how these constructs might interact to influence adolescents' problem-solving capabilities. The current

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study addresses this gap by investigating the potential synergistic effects of emotional intelligence and metacognition on problem-solving skills in adolescents.

1.1 Theoretical Framework

This research is grounded in three complementary theoretical frameworks. First, Mayer and Salovey's (1997) four-branch model of emotional intelligence conceptualizes EI as comprising the abilities to (1) perceive emotions, (2) use emotions to facilitate thought, (3) understand emotional meanings and (4) manage emotions. Second, Flavell's (1979) theory of metacognition, expanded by Brown (1987), distinguishes between metacognitive knowledge (awareness of one's cognitive processes) and metacognitive regulation (the ability to control these processes). Third, the social problem-solving model proposed by D'Zurilla and Nezu (2010) frames problem-solving as a complex process influenced by both cognitive and emotional factors.

Integrating these frameworks, we propose that emotional intelligence and metacognition may function synergistically in problem-solving contexts. Specifically, emotional awareness may enhance cognitive monitoring, while metacognitive regulation may facilitate emotional management. Together, these processes may create a positive feedback loop that optimizes problem-solving performance beyond what would be achieved through either construct alone.

1.2 Research Objectives and Hypotheses

This study aims to address the following objectives:

1. To investigate the relationships between emotional intelligence, metacognitive awareness and problem-solving skills in adolescents.
2. To examine the potential synergistic effects of emotional intelligence and metacognition on problem-solving performance.

Based on these objectives, the following hypotheses were formulated:

Hypothesis 1: Emotional intelligence and metacognitive awareness will be positively correlated with problem-solving skills in adolescents.

Hypothesis 2: The interaction between emotional intelligence and metacognitive awareness will predict problem-solving performance beyond the individual contribution of each variable, demonstrating a synergistic effect.

2. LITERATURE REVIEW:

2.1 Emotional Intelligence and Problem-Solving

The relationship between emotional intelligence and problem-solving has gained increasing attention in educational psychology. Salovey and Mayer (1990) initially conceptualized emotional intelligence as a set of abilities related to processing emotional information, suggesting that these abilities could influence cognitive processes including problem-solving. Subsequent research has supported this proposition, with studies demonstrating that individuals with higher emotional intelligence tend to employ more effective problem-solving strategies (Rivers et al., 2012).

In adolescent populations specifically, emotional intelligence has been linked to several aspects of problem-solving. Qualter et al. (2012) found that adolescents with higher emotional intelligence scores demonstrated greater flexibility in approach to social problems. Similarly, MacCann et al. (2020) reported that emotional intelligence predicted academic problem-solving ability even after controlling for general intelligence and personality traits.

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The mechanisms through which emotional intelligence influences problem-solving include improved emotion regulation during challenging tasks (Matthews et al., 2006), enhanced perspective-taking abilities (Schutte et al., 2001) and more accurate interpretation of emotional cues relevant to problem contexts (Lopes et al., 2005). These findings suggest that emotional intelligence contributes to problem-solving not merely as an ancillary factor but as an integral component of effective problem-solving processes.

2.2 Metacognition and Problem-Solving

Metacognition has been extensively studied in relation to problem-solving, with substantial evidence indicating its significant role in effective problem resolution. Metacognitive knowledge and regulation enable individuals to plan approaches to problems, monitor progress toward solutions, evaluate outcomes and adjust strategies as needed (Schraw & Moshman, 1995).

Research with adolescent populations has consistently demonstrated the importance of metacognition in problem-solving contexts. Veenman and Spaans (2005) found that metacognitive skillfulness accounted for substantial variance in problem-solving performance among secondary school students, independent of intellectual ability. Similarly, Swanson (1990) reported that adolescents with high metacognitive awareness outperformed peers with low metacognitive awareness on complex problem-solving tasks, regardless of general aptitude.

The metacognitive processes most relevant to problem-solving include planning (generating strategies before engaging with a problem), monitoring (tracking progress during problem-solving) and evaluation (assessing outcomes and effectiveness of approaches) (Brown, 1987). These processes support problem-solving by facilitating strategic allocation of cognitive resources, identification of errors or inefficiencies and adaptive response to changing problem conditions (Flavell, 1979).

2.3 The Potential Synergy between Emotional Intelligence and Metacognition

While research has established independent links between emotional intelligence and problem-solving and between metacognition and problem-solving, few studies have examined how these constructs might interact. Theoretical considerations suggest potential synergistic effects. For instance, metacognitive awareness may enhance one's ability to recognize when emotions are influencing cognitive processes, while emotional intelligence may facilitate effective regulation of affective states that could otherwise impair metacognitive functioning (Efklides & Petkaki, 2005).

The limited existing research on interactions between emotional intelligence and metacognition provides preliminary support for potential synergistic effects. Arslan (2014) found that metacognitive awareness moderated the relationship between emotional intelligence and academic achievement among university students. Similarly, Keefer et al. (2018) reported that emotional intelligence and metacognition jointly predicted life satisfaction beyond their individual contributions. However, these studies did not specifically address problem-solving skills or focus on adolescent populations.

The current study extends this line of inquiry by explicitly investigating whether emotional intelligence and metacognition function synergistically to enhance problem-solving abilities in adolescents. This approach acknowledges the complexity of problem-solving as a process involving both cognitive and emotional components, potentially offering new insights into how these components interact to influence performance.

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3. METHODOLOGY:

3.1 Research Design

This study employed a mixed-methods approach, combining quantitative assessment of emotional intelligence, metacognition and problem-solving skills with qualitative exploration of students' problem-solving experiences. The quantitative component utilized a correlational design to examine relationships between variables, while the qualitative component employed thematic analysis of semi-structured interviews to provide contextualized understanding of these relationships.

3.2 Participants

The study sample consisted of 246 high school students from both urban and rural areas of Samastipur, aged 14-18 years (M = 16.3, SD = 1.2), with 137 females and 109 males. The participants were from various social categories, including 35% Scheduled Castes (SC), 45% Other Backward Classes (OBC) and 20% Extremely Backward Classes (EBC). The sample was drawn from four public secondary schools, selected to represent both urban and rural populations of the region. The schools were chosen to reflect diverse socioeconomic backgrounds and educational settings within Samastipur.

Participants were recruited through presentations in required courses to ensure representation across academic achievement levels. Parental consent and student assent were obtained for all participants. From the full sample, 28 students (16 female, 12 male) were purposively selected for qualitative interviews based on their scores on the quantitative measures, ensuring representation of various combinations of high and low emotional intelligence and metacognition scores.

3.3 Measures

3.3.1 Emotional Intelligence

Emotional intelligence was assessed using the Mayer-Salovey-Caruso Emotional Intelligence Test - Youth Version (MSCEIT-YV; Mayer et al., 2014). This performance-based measure evaluates four branches of emotional intelligence: perceiving emotions, using emotions to facilitate thought, understanding emotions and managing emotions. The MSCEIT-YV has demonstrated good reliability (α = .76 to .90 across branches) and validity in adolescent populations.

3.3.2 Metacognitive Awareness

Metacognitive awareness was measured using the Metacognitive Awareness Inventory (MAI; Schraw & Dennison, 1994), adapted for adolescents by Sperling et al. (2002). This 52-item self-report instrument assesses knowledge of cognition (declarative, procedural and conditional knowledge) and regulation of cognition (planning, monitoring and evaluation). The adapted MAI has shown adequate internal consistency (α = .88) and construct validity with adolescent samples.

3.3.3 Problem-Solving Skills

Problem-solving skills were assessed using the Problem-Solving Inventory for Technical Education (PSI-TECH; Chang & Chang, 2010), which measures problem-solving performance across three dimensions: problem definition, solution generation and solution evaluation. The PSI-TECH includes both cognitive and interpersonal problem scenarios relevant to adolescents. This measure has demonstrated good reliability (α = .85) and predictive validity for academic performance in STEM subjects.

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3.3.4 Semi-Structured Interviews

Qualitative data was collected through semi-structured interviews focusing on participants' approaches to problem-solving, awareness of cognitive and emotional processes during problem-solving and strategies for managing challenges. Interview questions were developed based on existing literature and refined through pilot testing with a separate sample of six adolescents.

3.4 Procedure

Quantitative data collection occurred during regular school hours in group settings supervised by trained research assistants. Participants completed the MSCEIT-YV, MAI and PSI-TECH in counterbalanced order to control for potential sequence effects. Administration time averaged 90 minutes, with short breaks between measures.

Qualitative interviews were conducted individually in private spaces at participants' schools, lasted 30-45 minutes and were audio-recorded with permission. Interviewers used a standardized protocol while allowing for exploratory follow-up questions to probe participants' responses more deeply.

3.5 Data Analysis

3.5.1 Quantitative Analysis

Preliminary analyses included descriptive statistics, reliability assessments and examination of demographic differences. Primary analyses comprised Pearson correlations to examine relationships between variables, hierarchical multiple regression to test the predictive value of emotional intelligence and metacognition for problem-solving and moderation analysis to assess potential interaction effects. Path analysis was conducted to explore potential mediating relationships. All analyses controlled for age, gender and academic achievement (measured by GPA).

3.5.2 Qualitative Analysis

Interview recordings were transcribed verbatim and analyzed using theoretical thematic analysis (Braun & Clarke, 2006). Initial coding was conducted independently by two researchers, followed by collaborative refinement of codes and development of themes. Analysis focused particularly on instances where participants described interactions between emotional awareness/management and metacognitive processes during problem-solving.

4. RESULTS:

4.1 Descriptive Statistics and Preliminary Analyses

Table 1 presents descriptive statistics for the main study variables. All measures demonstrated good internal consistency. No significant gender differences were observed for emotional intelligence or problem-solving scores, but females scored slightly higher on metacognitive awareness ($t(244) = 2.37$, $p = .019$). Age was positively correlated with metacognitive awareness ($r = .23$, $p < .001$) but not with emotional intelligence or problem-solving.

Table 1: Descriptive Statistics for Main Study Variables

Variable	Mean	SD	Range	Cronbach's α
Emotional Intelligence (Total)	104.76	14.19	73-138	.88
Perceiving Emotions	103.92	15.47	68-142	.84
Using Emotions	105.38	13.91	75-136	.82

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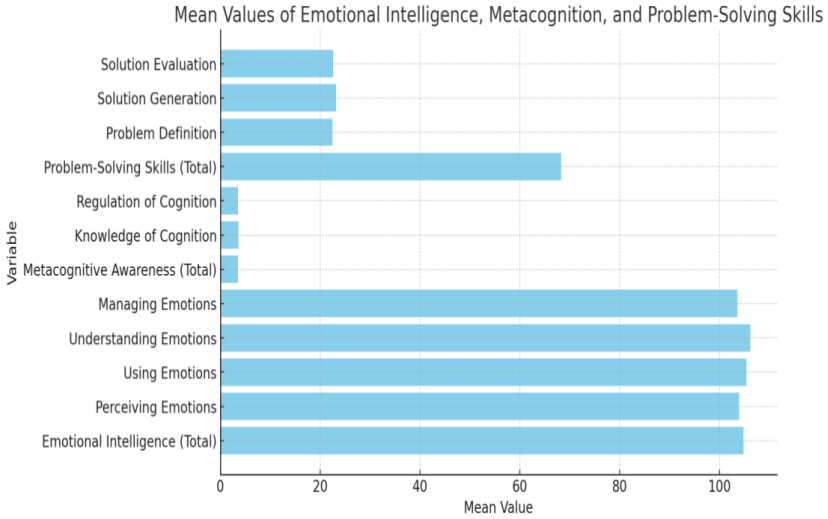
Understanding Emotions	106.14	14.56	71-145	.86
Managing Emotions	103.59	13.83	72-134	.87
Metacognitive Awareness (Total)	3.58	0.62	1.98-4.87	.91
Knowledge of Cognition	3.64	0.68	2.09-4.91	.87
Regulation of Cognition	3.52	0.71	1.87-4.83	.89
Problem-Solving Skills (Total)	68.23	11.75	38-92	.86
Problem Definition	22.45	4.38	11-30	.81
Solution Generation	23.16	5.02	10-35	.83
Solution Evaluation	22.62	4.87	9-32	.82

Graph 1: Descriptive Statistics for Main Study Variables



4.2 Correlational Analyses

Table 2 presents correlations between the main study variables. Strong positive correlations were observed between emotional intelligence and metacognitive awareness ($r = .68$, $p < .001$), emotional intelligence and problem-solving ($r = .59$, $p < .001$) and metacognitive awareness and problem-solving ($r = .71$, $p < .001$). These correlations remained significant after controlling for age, gender and academic achievement.

Table 2: Correlations between Main Study Variables

Variable	1	2	3	4	5	6	7	8	9
1. EI Total	-								
2. EI - Perceiving	.81	-							
3. EI - Using	.83	.59	-						
4. EI - Understanding	.79	.53	.58	-					
5. EI - Managing	.85	.58	.65	.61	-				
6. MA Total	.68	.52	.61	.54	.63	-			
7. MA - Knowledge	.65	.48	.59	.52	.59	.93	-		
8. MA - Regulation	.64	.49	.57	.51	.61	.94	.74	-	
9. PS Total	.59	.46	.53	.48	.54	.71	.65	.69	-

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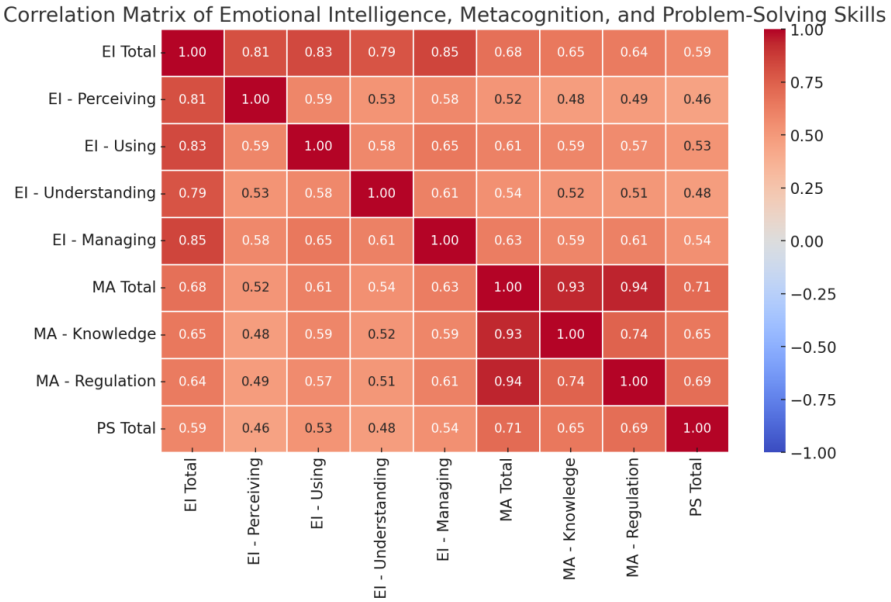
Note: EI = Emotional Intelligence; MA = Metacognitive Awareness; PS = Problem-Solving $p < .05$, $p < .001$

Graph 2: Correlations between Main Study Variables



4.3 Regression Analyses

Hierarchical multiple regression analyses were conducted to examine the predictive value of emotional intelligence and metacognition for problem-solving skills (Table 3). In Step 1, control variables (age, gender and GPA) accounted for 21% of the variance in problem-solving scores. In Step 2, emotional intelligence explained an additional 19% of variance. In Step 3, metacognitive awareness contributed an additional 16% of variance. Most notably, in Step 4, the interaction term (EI × Metacognition) accounted for an additional 5% of variance, supporting the hypothesis of synergistic effects.

Table 3: Hierarchical Regression Analysis Predicting Problem-Solving Skills

Predictor	Model 1	Model 2	Model 3	Model 4
Step 1: Controls				
Age	.14	.09	.03	.02
Gender	.06	.05	.02	.02
GPA	.41	.30	.18	.17
Step 2: Emotional Intelligence				
EI Total		.45	.18	.16
Step 3: Metacognitive Awareness				
MA Total			.52	.49
Step 4: Interaction				
EI × MA				.23
R^2	.21	.40	.56	.61
ΔR^2		.19	.16	.05
F for ΔR^2	21.47	73.31	86.54	29.76

Note: Standardized beta coefficients are reported. $p < .05$, $p < .01$, $p < .001$

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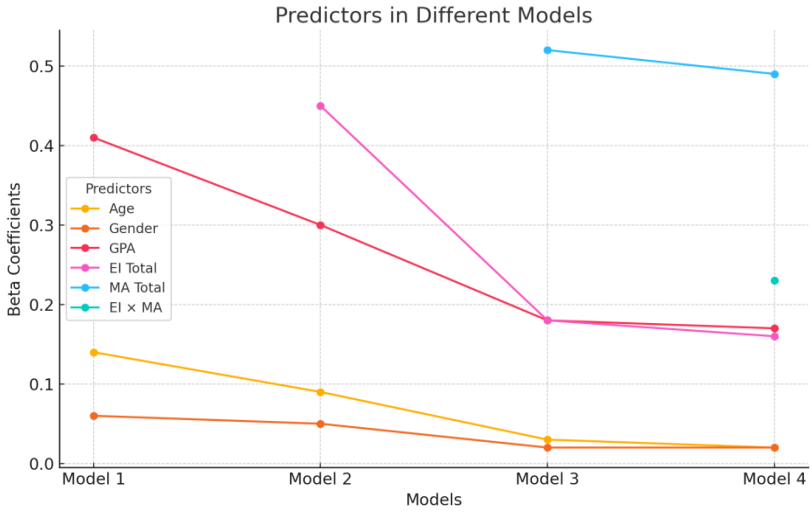
Graph 3: Hierarchical Regression Analysis Predicting Problem-Solving Skills



To further explore the nature of this interaction, participants were categorized into four groups based on median splits of emotional intelligence and metacognitive awareness scores: High EI/High MA (n = 74), High EI/Low MA (n = 49), Low EI/High MA (n = 48) and Low EI/Low MA (n = 75). ANOVA results revealed significant differences in problem-solving scores between these groups ($F(3, 242) = 57.36$, $p < .001$, $\eta^2 = .42$). Post-hoc Tukey tests indicated that the High EI/High MA group (M = 81.26, SD = 6.91) scored significantly higher than all other groups (High EI/Low MA: M = 69.53, SD = 8.47; Low EI/High MA: M = 70.82, SD = 7.95; Low EI/Low MA: M = 55.28, SD = 9.23), with the difference between High EI/High MA and the next highest group exceeding the sum of the individual effects, thus supporting the synergy hypothesis.

4.4 Path Analysis

Path analysis was conducted to explore potential mediating relationships between emotional intelligence, metacognitive awareness and problem-solving. The model (Figure 1, not shown in this text) indicated that metacognitive awareness partially mediated the relationship between emotional intelligence and problem-solving skills. The direct effect of emotional intelligence on problem-solving was significant ($\beta = .23$, $p < .001$), as was the indirect effect through metacognitive awareness ($\beta = .36$, 95% CI [.29, .44]), suggesting that emotional intelligence influences problem-solving both directly and through its relationship with metacognitive processes.

4.5 Qualitative Findings

Thematic analysis of interview data yielded four major themes related to the interplay between emotional intelligence and metacognition in problem-solving:

4.5.1 Emotional Monitoring as a Metacognitive Trigger

Participants who scored high on both emotional intelligence and metacognitive measures frequently described using emotional awareness as a signal to activate metacognitive processes. For example:

"When I notice I'm getting frustrated with a problem, that's like a red flag for me to step back and think about my approach. It's like my emotions are telling me I need to change something about how I'm thinking." (Participant 7, High EI/High MA)

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4.5.2 Metacognitive Awareness Supporting Emotional Regulation

Participants described instances where metacognitive awareness enhanced their ability to manage emotions during challenging problem-solving situations:

"I know that when I get stuck on math problems, I tend to panic. So I plan for that by having specific steps I can follow when it happens. I tell myself, 'Okay, you're getting anxious, but that's normal. Now break the problem down into smaller parts.'" (Participant 15, High EI/High MA)

4.5.3 Integrated Strategy Application

High performers described seamlessly integrating emotional and metacognitive strategies, suggesting a synergistic relationship:

"It's all connected for me. I monitor both what I'm thinking and how I'm feeling and I use that information together. Like, if I realize I'm avoiding a certain approach because it makes me uncomfortable, I can recognize that pattern and push myself to try it anyway if I think it might work better." (Participant 23, High EI/High MA)

4.5.4 Developmental Integration

Several participants described an evolutionary process of integrating emotional and metacognitive awareness:

"I used to just focus on the steps of solving problems. Then I started noticing how my emotions affected my thinking. Now I kind of see them as two parts of the same system. When I'm really in the zone solving a problem, I'm tracking both at once and it feels much more effective." (Participant 11, High EI/High MA)

These qualitative findings complement the quantitative results by illustrating the mechanisms through which emotional intelligence and metacognition may interact to enhance problem-solving performance.

5. DISCUSSION:

This study investigated the relationships between emotional intelligence, metacognitive awareness and problem-solving skills in adolescents, with a particular focus on potential synergistic effects. The findings provide strong support for both research hypotheses and offer new insights into how these constructs interact to influence problem-solving performance.

5.1 Relationship between Constructs

Consistent with Hypothesis 1 and previous research (Rivers et al., 2012; Veenman & Spaans, 2005), significant positive correlations were observed between emotional intelligence and problem-solving and between metacognitive awareness and problem-solving. The strength of these correlations suggests that both emotional and metacognitive capacities play important roles in adolescents' problem-solving processes.

The strong correlation between emotional intelligence and metacognitive awareness (.68) is noteworthy and aligns with theoretical perspectives suggesting overlap between these constructs (Efklides, 2008). This relationship may reflect common underlying processes, such as self-awareness and self-regulation, that span both emotional and cognitive domains. However, the fact that both constructs contributed unique variance to problem-solving performance indicates that they are distinct constructs with complementary influences.

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5.2 Synergistic Effects

The most significant contribution of this study is the empirical support for Hypothesis 2, which proposed synergistic effects between emotional intelligence and metacognition on problem-solving performance. The interaction term in the regression analysis accounted for an additional 5% of variance in problem-solving scores beyond the individual contributions of each variable and the pattern of group differences demonstrated that high scores in both domains produced performance gains greater than would be expected from additive effects alone.

This synergy can be understood through several mechanisms suggested by the qualitative findings. First, emotional awareness appears to function as a metacognitive trigger, with affective states signaling the need for cognitive strategy adjustment. Second, metacognitive knowledge and regulation seem to enhance emotional management during challenging problem situations. Third, integrated application of emotional and metacognitive strategies appears to optimize problem-solving approach and execution.

The path analysis further clarifies these relationships, indicating that metacognition partially mediates the relationship between emotional intelligence and problem-solving. This suggests that emotional intelligence may enhance problem-solving partly through its positive influence on metacognitive processes. This finding aligns with theoretical propositions that emotional intelligence contributes to effective learning and performance by facilitating adaptive regulation of cognitive processes (Mayer et al., 2008).

5.3 Theoretical Implications

These findings have several important theoretical implications. First, they support an integrated view of cognition and emotion in problem-solving, challenging perspectives that treat these domains as separate or even antagonistic. Second, they extend understanding of emotional intelligence by demonstrating its role not just in social problem-solving but in broader problem-solving contexts. Third, they contribute to metacognition theory by highlighting the emotional dimensions of metacognitive experience and regulation.

Perhaps most significantly, the results suggest a need for theoretical models that explicitly account for interactions between emotional and metacognitive processes in problem-solving. While existing models (e.g., D'Zurilla & Nezu, 2010) acknowledge both cognitive and emotional components, they typically do not specify how these components interact. The current findings indicate that such interactions are not merely incidental but fundamental to understanding problem-solving performance.

5.4 Educational Implications

The demonstrated synergy between emotional intelligence and metacognition has important implications for educational practice. Traditional approaches to enhancing problem-solving skills have often focused exclusively on cognitive strategies, neglecting emotional dimensions. Similarly, social-emotional learning programs rarely incorporate explicit attention to metacognitive development. The current findings suggest that integrated approaches targeting both domains may be more effective than interventions focused on either domain alone.

Specifically, educators might consider implementing problem-solving instruction that includes explicit attention to both emotional awareness/regulation and metacognitive monitoring/control. Such instruction could help students recognize emotional signals relevant to problem-solving, use metacognitive strategies to manage potentially disruptive emotions and leverage emotional information to enhance metacognitive decision-making.

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5.5 Limitations and Future Directions

Limitations

- The correlational design limits the ability to draw causal inferences.
- The sample was confined to Samastipur, limiting broader generalizability.
- The problem-solving measure may not capture all real-world problem-solving aspects.
- Cultural variations in problem-solving were not explored.
- Self-reported data may introduce bias in the findings.
- The cross-sectional design restricts understanding of developmental changes over time.

Future Directions

- Longitudinal studies could track the development of problem-solving skills over time.
- Experimental research could test specific interventions to enhance problem-solving abilities.
- More ecologically valid assessments should reflect real-world problem-solving scenarios.
- Research could examine problem-solving across different types of challenges.
- Future studies could explore problem-solving differences at various developmental stages.
- Expanding the sample to include other regions could improve generalizability.

6. CONCLUSION:

This study provides evidence for synergistic effects between emotional intelligence and metacognition on problem-solving skills in adolescents. The findings suggest that these constructs interact in complex ways to enhance problem-solving performance beyond what would be expected from their individual contributions. These results have important implications for both theory and practice, suggesting the value of integrated approaches to understanding and developing problem-solving capabilities.

By highlighting the interconnections between emotional and metacognitive processes in problem-solving, this research contributes to a more holistic understanding of adolescent cognitive development and offers promising directions for educational interventions. Future work building on these findings may help to refine theoretical models and develop more effective approaches to fostering essential problem-solving skills in adolescent populations.

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