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Review

A deep dive into metacognition: Insightful tool for moral reasoning and emotional maturity

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ABSTRACT

The impact of metacognition on pupils' moral ideals and emotional development was investigated as well as it highlights on a collaborative research between metacognition and artificial intelligence that can bridge the gap (emotional, ethical, moral reasoning, common sense) existing in AI. A total of 200 pupils were selected in the study's sample. Participants (100 high metacognitive students and 100 low metacognitive students) were chosen at random and ranged in age from 17 to 21 years old. The influence of metacognition on students' moral ideals and emotional development was studied using a t-test. The outcome reveals that the mean score of moral reasoning on high metacognitive students as 66.77 and for low metacognitive students as 63.08, t value = 3.21, at the 0.01 level, statistically highly significant. The mean emotional maturity score for high metacognitive students was 29.99, while for low metacognitive students was 33.01, t value as 2.81, shows statistically significant at the 0.05 level. This demonstrates that the higher the score, the less emotionally stable the pupils are. The current findings show that metacognitive thinking has a major impact on moral reasoning and emotional maturity, and that as metacognition levels rise, so do moral reasoning and emotional maturity. Metacognition can strengthen the humanistic qualities which are majorly lacking in AI. In addition, there are new avenues being opened in the study of artificial intelligence via metacognitive study which is significant and futuristic.

1. Introduction

Metacognition is a type of higher-order thinking in which the thinker has active control over the process. Self-control, knowledge, monitoring, appraisal, and conscious of one's mental activities are all part of it. The mental action or process of learning knowledge and understanding through thought, experience, and the senses is known as cognition. The hierarchical nature of the psychological processes involved in cognition places metacognition at the top. Metacognition refers to the processes that oversee, manage, and coordinate cognition activities. In cognitive psychology, metacognition is currently a popular issue. Thousands of studies on metacognition have been undertaken during the last 30 years. This study has had a significant impact on the field of learning, particularly reading-based learning. Flavell's work in 1979 is credited with coining the term "metacognition."

The process of thinking about one's own thinking and learning is known as metacognition [1]. Understanding one as a learner, including one's strengths and weaknesses, is also part of met cognition. If you can explain your abilities in academic writing, exam taking, or other sorts of academic labor, you are met cognitively aware [2,3]. Met cognitive processes may be used to learn and think in a variety of domains and situations. Because met cognitive abilities are vital for lifelong learning, they must be taught and addressed with pupils [4,5]. Met cognition is a broad collection of abilities that entails thinking about one's own thoughts. Early metacognitive studies focus on how, when, and why pupils struggle with learning. Metacognition is a late-developing talent in adolescent age, according to these studies. Metacognitive abilities emerge between the ages of 8 and 10 and continue to develop throughout time [6–8]. Metacognition is seen as an essential component of efficient learning. It requires self-control and self-reflection on your strengths, shortcomings, and methods. It is an essential basis in culturally conscious leadership because it emphasizes how you think about a problem or scenario and the strategies you devise to cope with it [9,10]. Many people become so accustomed to receiving cultural awareness from trainers and consultants that they become dependent on the coach, mentor, trainer, or consultant. However, they must learn to be cultural experts in their own right by engaging in metacognitive processes such as adapting, monitoring, self-regulation, and self-reflection [11,12]. Later metacognition research has centered on intervention studies aimed

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at resolving meta comprehension issues. The value of including metacognitive training in three areas has been demonstrated in this research: (1) skills-training and practice in task-specific strategies; (2) self-regulation-instruction in the orchestration, oversight, and monitoring of skills; and (3) awareness-information about a skill's evaluation, rationale, and usefulness [13]. The addition of these metacognitive elements has greatly aided the success of cognitive skills training programmes.

In today's environment of fast change, the importance of moral reasoning and emotional maturity among all age groups, especially youth, seems to decrease drastically. Metacognition entails individual activeness, encouraging learner to be independent, inquiring well, looking for answers to questions, and finding solutions independently [14]. For example, when learning a new language, you may recall memories, facts, and past life experiences to help you complete the task [15,16]. As a result, your internal emotions (metacognitive experience) may be annoyance, disappointment, delight, or contentment. Each of these emotional reactions can have an effect on the process of learning a new language as well as your drive to continue [17,18]. In critical thinking, such as moral judgments, decision-making, and emotional development, metacognition is crucial. Different investigations have suggested that factors other than judgments may also be implicated in the production of moral behavior. Our ability to know what we know, what we don't know, and how to manage and control such thinking is known as metacognition, or "thinking about thinking" [19]. Moral metacognition refers to student's understanding of their own morals. It reflects a person's understanding, insight, or awareness of the nature, principles, and processes of morality (strategies). Moral and emotional judgment positively correlates with moral behavior and emotional maturity. Moral and emotional maturity are critical components of a well-balanced personality. A balanced personality is characterized by a value pattern and emotional maturity [20]. It entails the ability to control upsetting emotions, maintain composure and endurance under duress, and be tolerant and free of neurotic tendencies. Emotional maturity is not only an important determinant of a person's personality, but it also aids in the regulation of an adolescent's development [21]. Even someone who can manage his emotions, tolerate delays, and suffer without self-pity might be emotionally startled".

A person with high moral principles and who is emotionally developed will have a balanced attitude. Physical, emotional, psychological, cultural, social, behavioral, and intellectual changes take place during adolescence. The abruptness of these shifts produces anxiety among them, as well as bewilderment and discontent. Learners with high metacognitive ability are more likely to monitor, control, and regulate their learning behavior, allowing them to attain their learning objectives [22–24]. Similarly, numerous studies have shown that metacognition has a significant impact on critical thinking, problem solving, and achievement [25]. On the contrary some studies also reveal that the Problem based learning had a significant effect on the metacognitive abilities of students' conjecturing process in solving pattern generalization problems [26]. Metacognition and problem-solving skills such as thinking, analyzing, and evaluating are linked. Because metacognition allows students to take charge of their own learning by setting objectives and tracking their progress, it is a powerful tool (e.g., efficiently handling task demands and correcting their weaknesses). Students with high metacognitive competencies are more critical thinkers, achieve better values, and have higher intellectual performance than students with low metacognitive competencies [27–29].

1.1. Metacognition with artificial intelligence

Recent breakthroughs in cognitive computing show that computers can match human performance. We live in an era where AI and machine learning are becoming more commonplace. With the help of AI and its applications, people's lives will not only change, but the education, healthcare and corporate sectors will also be transformed [30]. However, on a fundamental level, artificial intelligence (AI) currently lacks several qualities and skills that are naturally included in a definition of (human) intelligence. These skills include generalizability, adaptability, resilience, explainability, causal analysis, abstraction, common sense reasoning, ethical reasoning [31], and a complex and seamless integration of learning and reasoning supported by both implicit and explicit information [32–34]. These constraints on computing systems lead to metacognitive computation, in which the term "metacognition" gives Artificial Intelligence (AI) a pair of wings with system with a sense of introspection or self-analysis, allowing the system to "think about what it thinks." Metacognition is the deliberate consideration of how you think and learn [35,36]. Below is the Vein Diagram for different strategies that can be used to develop a model that learns by self-analysis of itself and knows the strengths and weaknesses of its own [37,38]. Fig. 1 shows the Vein Diagram for different strategies that can be used to develop a model. See Table 1.

Table 1
Relation between Various Learning strategies for Cognitive based learning.

A	Preparing & Planning for Learning
B	Evaluated Learning
C	Selecting & Using strategies
D	Mentoring Learning
E	Orchestrating strategies
ABCDE	Represents the Metacognitive method.

When we are observing it from vision of machining learning and Artificial Intelligence, we can develop some methods those are analogous to the cognitive strategies to train the machines. These self-analysis processes are a stimulus for personal growth [39]. Metacognitive task-specific self-regulation strategies of planning, monitoring, evaluating, and reflecting tactics allow AI to acquire (human) intelligence's qualities. These processes strengthen AI's abstraction, common sense reasoning, and moral learning-and-reasoning integration.

Meta Cognitive based learning approach is used in our day to day lives, the moment we think of something which Is about to happen in future. We keep various plans and different ways to approach. Similarly, the analogy can be used for machines to teach them with this cognitive approach. Machine thinks about a step, checks if its familiar to the machine if yes it proceeds for sequential next steps else it searches for some hints and gains some information to get to the next step. Once the outcome is achieved it stops till then it keeps searching for the approach to the next step (see Fig. 2).

Step 1: Think about a step (Planning)
Step 2: If Step 1 is familiar jump to the next consecutive step else check out for hints, till the hints are helpful. (Activating prior knowledge and monitoring)
Step 3: If next step is unknown apply knowledge-based learning till the gained information is useful. (Memorization and modeling of learned strategy through evaluation)
Step 4: Check if the next step gives the desired output if yes, end the process else check for the solution to fix. (Guided practice and structured reflection)
Step 5: Know the solution? Start the next step and once the desired output is achieved end the process. (Action and Intervention)

As an outcome, various disciplines have explored the numerous phenomena of metacognition, and many scholars in psychology,

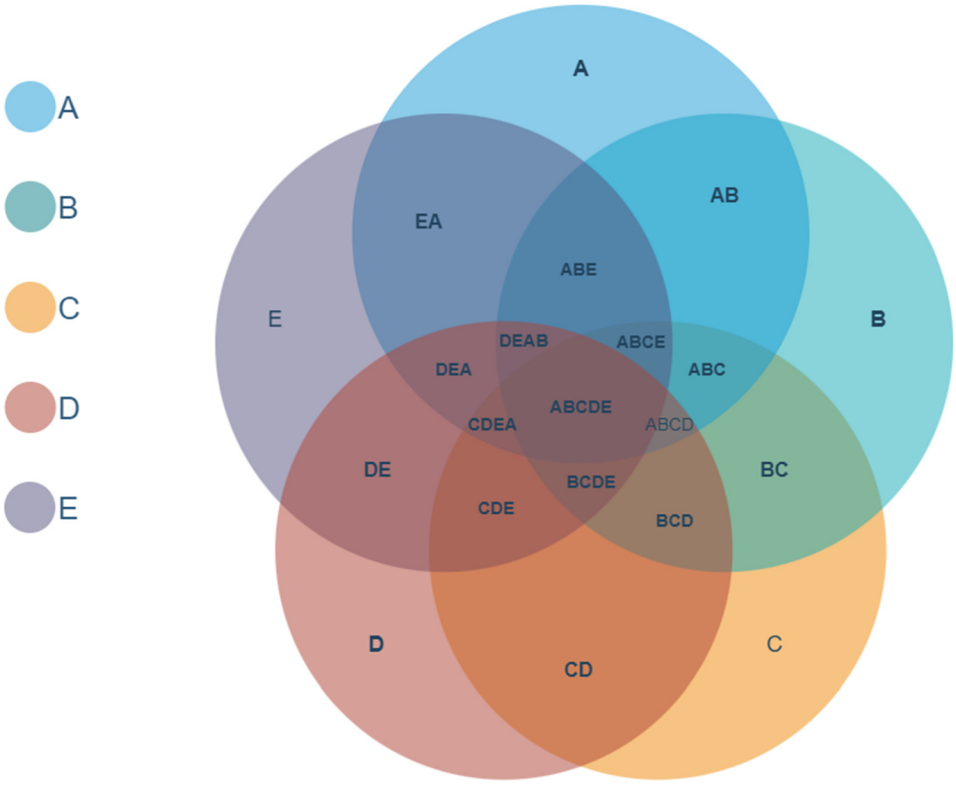

Fig. 1. Vein Diagram for different strategies that can be used to develop a model self-analysis.

computer science, and in engineering have attempted to fill this vacuum by incorporating psychological perspectives and related theories on metacognition into computer science.

The rest of the paper is arranged as follows: Section 2 describes the need and significance of the study and also demonstrates the problem to study the effect of metacognitive thinking upon the moral reasoning and emotional maturity of students. Section 3 describes the methods used in the manuscript. A detailed discussion regarding data analysis is also investigated in this section. Section 4 elaborates finding carried out by implication of the proposed methodology and also, discusses the results. Finally, the impactful findings of this paper are enlightened as conclusion in Section 5.

2. Need and significance of the study

Since the world is getting increasingly competitive, quality and performance are the most important requirements for personal progress and success. Excellence, particularly, in Social, professional and academics, has been seen as an important aspect of life. Metacognition is important in students' life because it allows them to engage in higher-order thinking, which allows them to understand their potential, stamina, and capacity to accomplish goals. Metacognition aids students in understanding how to solve issues effectively while also evaluating their work, allowing them to reach perfection. Moral principles, on the other hand, might assist people in discovering and developing into a better person, as well as the privilege of modifying and transforming their life for the best. It aids youth in instilling positive traits inherited from healthy youth. Moral reasoning and emotional maturity play an important role in positive thinking, decision making, learning, developing a good relationship, avoiding social problems, and maintaining peace in society. High moral reasoning can be accelerated through metacognition, which is a profound belief in an individual's own traits such as assertiveness, optimism, enthusiasm, affection, pride, independence, trust, and emotional and social maturity. These are the reasons behind the present study and give the idea that metacognition may be an effective tool for moral education in academic areas such as schools and educational institutions.

PROBLEM: To study the effect of metacognitive thinking upon the moral reasoning and emotional maturity of students.

OBJECTIVES

1. To Investigate the effect of metacognitive thinking upon the moral reasoning of students.
2. To Investigate the effect of metacognitive thinking upon the emotional maturity of students.

RESEARCH HYPOTHESES

1. There will be no significant effect of metacognitive thinking upon the moral reasoning of the students.
2. There will be no significant effect of metacognitive thinking upon the emotional maturity of the students.

3. Methodology

Independent Variable: Metacognitive Thinking

Dependent Variables: 1) Moral reasoning 2) Emotional maturity

Control Variables: Age, Academic Qualification, Academic achievement

Inclusion Criteria:

- Subjects within age range of 17-21 years were included.
- Undergraduate (Pursuing) students were included.
  The study included subjects between 7.5-9.0 CGPA in +2 from Dayalbagh Educational Institute, Agra.

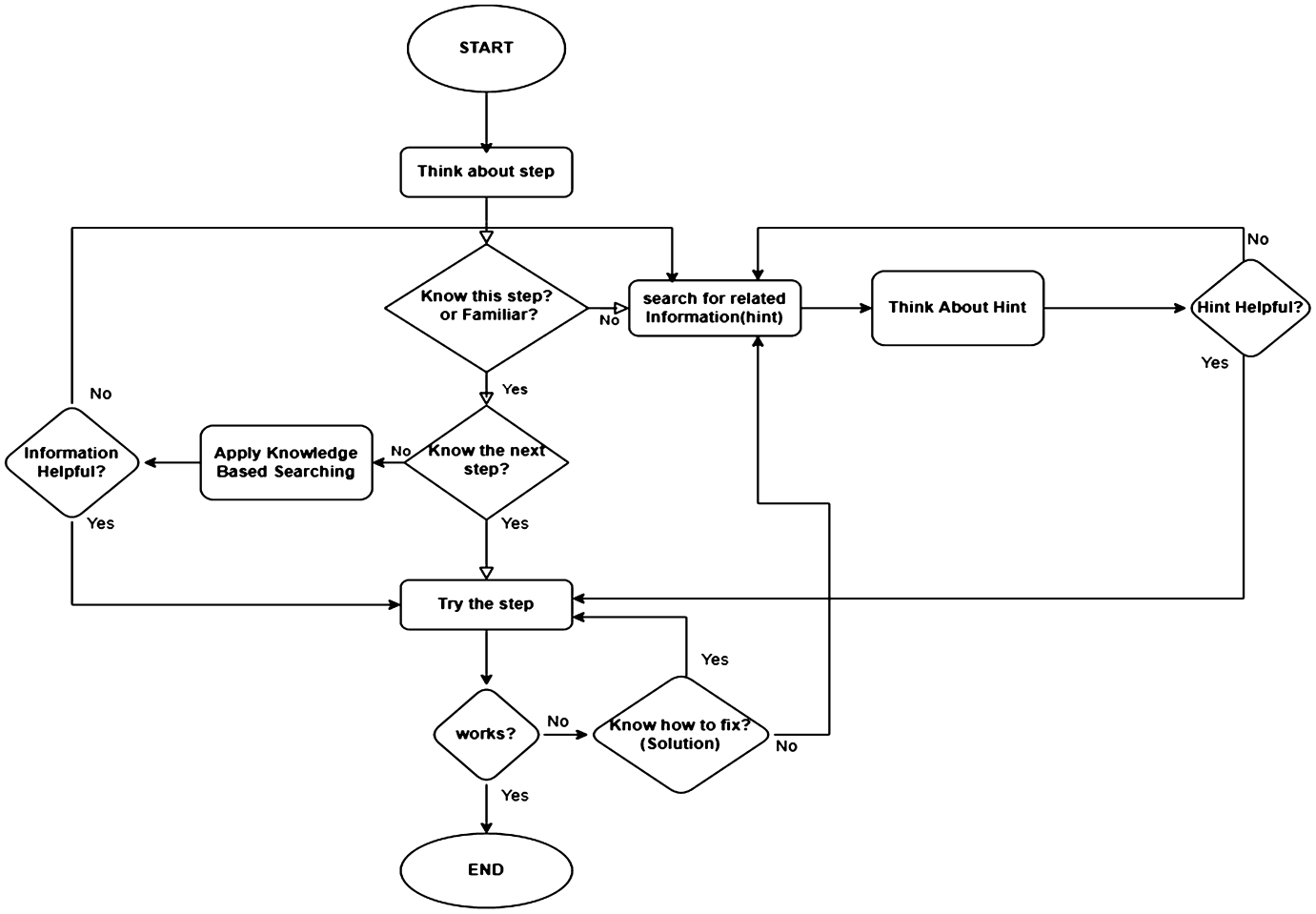

Fig. 2. Basic Flow Diagram for metacognitive based learning approach for machines.

Exclusion Criteria:

- Subjects under the age of twenty and those over the age of twenty-five were excluded from the study.
- Subjects who were +2 and above undergraduate were excluded.
- The study excluded subjects below 7.5 CGPA and above 9.0 CGPA in +2 from Dayalbagh Educational Institute, Agra.

SAMPLE

The current study used 200 participants as its sample. Participants (100 boys and 100 girls) were chosen at random from Dayalbagh Educational Institute in Agra, where they were pursuing their undergraduate degrees in various academic streams. Participants ranged in age from 17 to 21 years old. Total 200 participants have been taken as final sample from target population. Simple random sampling is used, and final participants have been taken on convenience basis for achieving the objective of the study.

TOOLS

1) Metacognitive Thinking Scale: Sandhu and Goel created the Metacognitive Thinking Scale (2010). It gives you an easy approach to assess metacognition on eight different levels (self-awareness, self control, self monitoring, self evaluation, self efficacy, self motivation, resourcefulness and attribution). The split-half reliability is 0.80, while the validity of this scale is 0.76. There were 80 things on the scale (10 for each dimension). Better Metacognitive Thinking is indicated by a higher scale value. Sample item for this scale is ("I am able to expand my intelligence by learning something new every day. I am able to constantly question my own decisions and judgments).
2) The Moral Foundations Questionnaire [40]: Graham, Haidt, and Nosek published The Moral Foundations Questionnaire in 2008. There are 32 items in all. The test's reliability is 0.90, while the test's validity is 0.77. Sample item for this scale is (People should not do things that are disgusting, even if no one is harmed**).**
3) Emotional Maturity Scale [9]: Singh and Bhargava developed the Emotional Maturity Scale (EMS) to assess emotional maturity in 1990. The scale consists of 48 items under five broad categories of emotional maturity 1. Emotional instability-10 items 2. Emotional regression-10 items 3. Personality breakdown-10 items 4. Social maladjustment - 10 items 5. Lack of autonomy-8 items. The scale's test-retest reliability was determined by administering it to a group of 150 male and female collegiate students with age range of 20 to 24 years. Between the two tests, the product moment 'r' was 0.75. Interpretation of Emotional Maturity Scores shows that Higher the score poor level of emotional maturity.

4. Resut and analysis

The present investigator aimed to understand the moral reasoning scores of high and low metacognitive students.

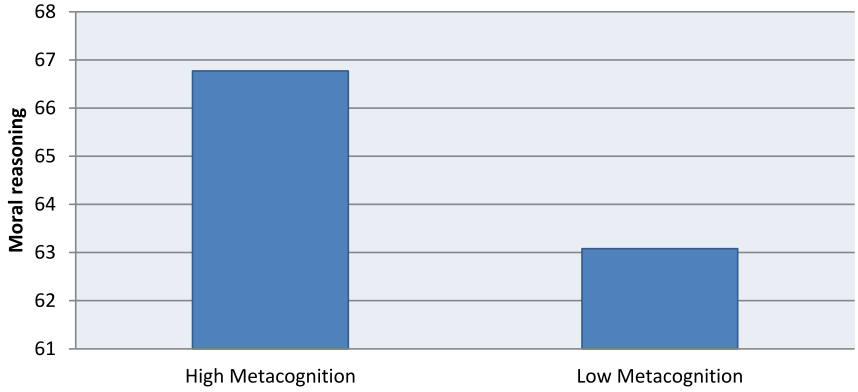

Fig. 3. Mean of moral reasoning scores of high metacognitive and low metacognitive students.

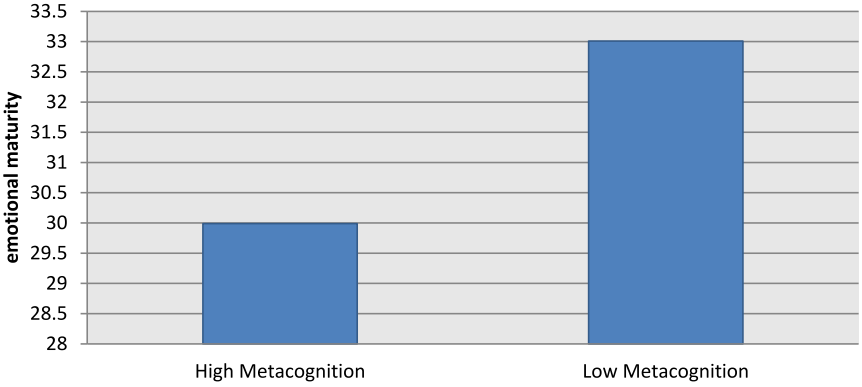

Fig. 4. Mean of emotional maturity scores of high metacognitive and low metacognitive students.

Table 2
Moral reasoning of high and low metacognitive students.

Metacognition	N	df	Moral reasoning		SED	't'
			Mean	SD		
High	100	198	66.77	8.44	1.13	3.21**
Low	100		63.08	7.72		

** $p < 0.01$.

Table 3
Emotional maturity of high and low metacognitive students.

Metacognition	N	df	Emotional Maturity		SED	't'
			Mean	SD		
High	100	198	29.99	9.31	1.42	2.81*
Low	100		33.01	9.86		

* $p < 0.05$.

- The level of significance between the means of the high and low metacognition groups of pupils was determined using the t test.
- Based on the test scores obtained on 100 high metacognitive and 100 low metacognitive students the mean moral reasoning scores were compared between the two groups and significance of their difference was tested.

The mean scores of high metacognitive students (66.77) and low metacognitive students (63.08) are displayed in Table 2 based on the test scores obtained on moral reasoning (100 high metacognitive and 100 low metacognitive students). Moral reasoning score shows the t value = 3.21, statistically highly significant at 0.01 level, which indicates that high metacognitive students have significantly better moral reasoning than low metacognitive students. This investigation has also graphically depicted moral reasoning mean scores of high metacognitive and low metacognitive students in Fig. 3 shows that as the level of metacognition increases moral reasoning scores also increase.

Result based on the test scores obtained on the emotional maturity (100 high metacognitive and 100 low metacognitive students) the mean scores are shown in Table 3 the mean score of high metacognitive as 29.99 and low metacognitive students as 33.01. emotional maturity score shows the t value = 2.81, statistically significant at 0.05 level, which shows that high metacognitive students have significantly better emotional maturity than low metacognitive students because less emotional maturity score shows better emotional stability. This investigation has also graphically depicted emotional maturity mean scores of high metacognitive and low metacognitive students in Fig. 4 shows that as the level of metacognition increases emotional maturity scores also increase.

Findings

The moral ideals of students are significantly influenced by metacognitive thinking. Metacognitive thinking has a similar influence on moral ideals. It's possible that people with strong metacognition have better self-control and are more aware of their own potential, strengths and shortcomings, decision-making, and correct and incorrect judgment. Through self-perception, they can deal effectively with difficult situations such as ethical problems and assess the environment with more rational and logical thinking, since metacognition consists of tactics, planning, knowledge, and past experiences that can help analyze stressful situations. Swanson, Lee, and Gloria conducted a study on metacognition components of moral thinking and action, revealing that moral reasoning and moral behaviors are tightly linked [41]. There is a

significant influence of high and low metacognitive thinking on the emotional maturity of students.

Result also reveals a significant effect of metacognition on emotional maturity. The logic behind it is that metacognition is latent energy. Students with high metacognition have deep thinking about their own capabilities, capacities, and strength, which provide knowledge about their own self and enhance self-efficacy, leading to more emotional maturity than students with low metacognition. Kleitman and Stankov [42] suggested that metacognition enhances social and emotional skills and makes an individual more efficient in interacting with environment and social situations.

Implications

In the present era of a technological revolution with changes in the technology and life style of people, today's environment is drastically changing as never before. Students today are under a great deal of stress as competition intensifies and they confront numerous hurdles in both their academic and social lives. Metacognition may be useful in overcoming these obstacles. Metacognition is a type of top-order mental process based on self-instructional processes that can assist pupils become more motivated and capable of facing problems in all areas of life. As a result, metacognition is often regarded as the foundation for obtaining success and achievement in both social and academic settings. Metacognition usually enhances self-confidence and makes the students perform best according to their potential, which increases self-efficacy, self-management, emotional and social maturity, decision-making, and moral judgment skills that increase moral values. If educational institutes try to organize training and interventional strategies for students, such as recreational and counseling programmes, it may be helpful to facilitate metacognition with a shift in focus from professionals to student. This will eventually boost students' moral reasoning and emotional maturity, which will serve as a foundation for their critical thinking, social emotional, and psychological well-being. This metacognition can be enhanced through Introspection of self cognitions, Self assessment, Self evaluation. As Kletman and Gibson also stated that metacognitive training increases an individual's self-confidence and sense of personal responsibility for his development. Moreover, the implication of metacognition with integration to artificial intelligence will lead to many useful studies for metacognitive computing system [43].

Limitation

Study has certain limitations also. Firstly, the area of study is small, in future similar study with larger area and large population size can be done. Secondly, findings of the study are based on quantitative analysis, in future, qualitative approach as well as mixed method approach can also be used for better understanding of these components.

5. Conclusion

Study findings reveal that metacognitive thinking can be used to accelerate students' emotional maturity and moral reasoning. The conceptual outcome is that students can augment their knowledge by becoming mindful of their own mental process, think when they read, write, solve emotive challenges, and tackle difficulties at school. A counselor can foster this insight by simply updating students about efficient problem-solving tactics and considering the motivational and cognitive attributes of met cognition [44,45]. Learners with a high-level of metacognitive capacity are more likely to observe, manage, and regulate their own thinking as well as learning behavior, allowing them to attain their learning objectives. The Metacognition and problem-solving behavior such as thinking, analyzing, evaluating, are interrelated [20]. Another result revealed that metacognitive training increases academic achievement, emotional maturity, and happiness among students [46]. The present study has future implications as it is evident that metacognitive component is essential in enhancing emotional maturity, socio-cultural adjustments, common sense, emotional self-healing, ethical learning, and moral reasoning, which are directly linked to human attributes. As these human elements are lacking in artificial intelligence, the addition of metacognitive dimension in this aspect can assist in rectifying behavioral errors in artificial intelligence.

Human and animal rights

The authors declare that the work described has not involved experimentation on humans or animals.

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Author contributions

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

Declaration of competing interest

The authors declare that they have no known competing financial or personal relationships that could be viewed as influencing the work reported in this paper.

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